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A STUDY ON VARIABLES SAMPLING PLAN

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ABSTRACT

Under the normality assumption, the usual plans for testing a process is in control versus out of control are based on the noncentral T distributions. It has been shown that they are not robust when the data is not normally distributed. To overcome this problem, we construct approximate robust procedures by extending Huber's robust maxmin test. It is found that the proposed sampling plans are encouraging when the true distribution is slighly away from normal.

Keywords and Phrases: contamination neighborhood, influence function, Jackkife method, least favorable density, variable sampling plan, winsorized standard deviation.

1. INTRODUCTION

A basic question in quality control is to decide whether a lot of manufactured product is acceptable if the items in the lot vary in their quality characteristics. It is reasonably to assume that variability inherented in the production process is random. Hence, based on a sample, sampling plans and rules are needed to decide on the disposition of the lot. An acceptance sampling procedure is obviously intended to protect the consumer against bad quality, but a properly designed procedure will also protect the producer in the sense that good product will be accepted by the plan with high probability.

Many acceptance sampling plans have been proposed. They may be classified as either sampling by attributes or sampling by variables. Due to its simplicity, attribute sampling has been studied in detail, and many elaborations on the basic concept have been proposed. Attribute sampling plans have been widely applied because they are valid under minimal assumptions about the statistical variability of the items in the lot. On the other hand, acceptance sampling by variables is less widely applied, since it is based on strict assumptions about the underlying distribution of the measured quality characteristic. If these assumptions are violated, sampling by variables no longer has correct statistical behavior. Nevertheless, there is continuing interest in variables sampling plan because of its potential efficiency relative to attribute sampling. In order to achieve similar error probabilities, the sample size which is needed for an attribute sampling plan may be considerably larger than for a variable sampling plan.

In acceptance sampling by variables with double specification limits, one has measured quality characteristics $X_1, \cdots, X_n$ when are assumed to be i.i.d. normal observations. It is desired to control the proportion nonconforming, $p=P[X\leq LSL$ or $X\geq USL]$, where LSL and USL are the lower specification limit and upper specification limit, respectively. Typically a small value p_0, the acceptable quality level (AQL), is chosen as the largest value of p associated with good quality lots. A larger value p_1, the lot tolerance percent defective (LTPD), is regarded as unacceptably high by the consumer. The acceptance sampling problem now reduces to testing $\boldsymbol{H}_0$: $p\leq p_0$ against $\boldsymbol{H}_1$: $p\geq p_1$. These hypotheses are equivalent to $\boldsymbol{H}_0$: $\theta=\theta_0$ and $\boldsymbol{H}_1$: $\theta=\theta_1$, where the data are $N(\theta\sigma, \sigma^2)$. The type I and type II error probabilities, α and β, are called the producer's and consumer's risks.

The standard test under normality is based on the noncentral T distribution and codified as MIL-STD-414 (U.S. Department of Defense, 1963). The classical sampling plans are known to be sensitive to nonnormality of the data (Canavos and Koutrouvelis, 1984; Chen and Smith, 1991; Das and Mitra, 1967; Montgomery, 1985; Owen, 1969; Singh, 1969).

The purpose of this paper is to propose variables sampling plans with error probabilities close to nominal values when the underlying distributional assumptions are slightly violated. We apply concepts from robust statistical inference to the problem of acceptance sampling by variables. Section 2 summarizes Huber's (1965, 1981) results on robust hypothesis testing and adapts them to devise a robust plan for variables sampling plan when the scale parameter is known. In Section 3, we propose a generalization for sampling by variables when the scale parameter is unknown. Simulation studies are described in Section 4, and conclusions are set forth in Section 5.

2. HUBER'S MAXIMIN APPROACH

Let $X_1, \cdots, X_n$ be a sample from an unknown probability law F with location parameter μ and scale parameter σ. By the Neyman-Pearson Fundamental Lemma, there exists a most powerful test for testing the simple hypothesis $\boldsymbol{H}_0$: $F=F_0$ against the simple alternative $\boldsymbol{H}_1$: $F=F_1$ for some distribution functions F_0 and F_1. However, this classical likelihood ratio test is not robust in the sense that if the true probability law F differs slightly from the assumed probility law F_0, the size of the test may change dramatically. Likewise, if the true probability law differs slightly from F_1, the power may change dramatically (Huber, 1965).

Huber proposed a robust maximin test for this problem by introducing neighborhoods of the null and alternative distrbutions. Let P_0 and P_1 be the idealized probability laws under the null and alternative hypotheses. Since P_0 and P_1 are really only approximations to the true probability laws, the true laws should be in certain neighborhoods of the idealized laws.

Let $\mathcal{M}$ be the set of all probability measures on the real line. Let $0 \leq \epsilon_0, \epsilon_1, \delta_0, \delta_1 < 1$ be some given numbers, and define

$$\mathcal{P}_0 = \{Q \in \mathcal{M} \mid Q(X < x) \geq (1-\epsilon_0)P_0(X < x) - \delta_0, \ \forall x\}$$

$$\mathcal{P}_1 = \{Q \in \mathcal{M} \mid Q(X > x) \geq (1-\epsilon_1)P_1(X > x) - \delta_1, \ \forall x\}.$$

Then $\mathcal{P}_0$ and $\mathcal{P}_1$ are contamination neighboods corresponding to P_0, P_1, respectively (Huber, 1981). Suppose that the probability law F is in a neighborhood $\mathcal{P}_i$ under the hypothesis $\boldsymbol{H}_i$, $i=0, 1$, and that $\mathcal{P}_0$ and $\mathcal{P}_1$ are disjoint. A robust version of the original testing problem is to test $\boldsymbol{H}_0$: $F \in \mathcal{P}_0$ against $\boldsymbol{H}_1$: $F \in \mathcal{P}_1$.

Huber constructed a size α test which maximizes the minimum power, that is, a test ϕ^* such that $\sup_{F \in P_0} E_F(\phi^*) \leq \alpha$ and $\inf_{F \in P_1} E_F(\phi^*) = \sup_{\phi} \inf_{F \in P_1} E_F(\phi)$. His construction was based on finding a least favorable pair of distributions $Q_i \in \mathcal{P}_i$ such that ϕ^* is the Neyman-Pearson test of Q_0 versus Q_1. Let q_i be the corresponding density function of Q_i, $i=0, 1$. Then the likelihood ratio q_1/q_0 is a truncated version of p_1/p_0, the likelihood ratio for the idealized testing problem.

In acceptance sampling by variables, the idealized distribution are normal. That is, $P_i[X \leq x] = \Phi[(x-\theta_i\sigma)/\sigma]$, $i=0, 1$, where θ_0, θ_1, and σ are known and Φ denotes the standard normal cdf. Let $\mathcal{P}_\delta(P_i)$ be a Kolmogorov neighborhood of P_i, $i=0, 1$. That is, $\mathcal{P}_\delta(P) = \{Q \in \mathcal{M} \mid \sup_x |P[X \leq x] - Q[X \leq x]| < \delta\}$.

The likelihood ratio for the idealized testing problem has the form $p_1(x)/p_0(x) = \exp\{(\theta_1-\theta_0)[-x/\sigma+(\theta_0+\theta_1)/2]\}$. Let $a=(\theta_0-\theta_1)/2$, and let $B=(\theta_0+\theta_1)/2$. Consider a transformation by assuming that $Y=-X/\sigma+B$, where X is a random variable from a normal family with mean $\theta_i\sigma$ and variance σ^2 under $\boldsymbol{H}_i$, $i=0, 1$. Then Y is $N(-a, 1)$ if X is $N(\theta_0\sigma, \sigma^2)$, and Y is $N(a, 1)$ if X is $N(\theta\sigma, \sigma^2)$. Then Huber's maximin test of $\boldsymbol{H}_0$ versus $\boldsymbol{H}_1$ becomes

$$\chi(\boldsymbol{Y}) = \chi(Y_1, \cdots, Y_n) = \begin{cases} 1, & \text{if } n^{-1}\sum_{i=1}^{n} \psi(Y_i) > CV \\ 0, & \text{if } n^{-1}\sum_{i=1}^{n} \psi(Y_i) \leq CV, \end{cases} \qquad (1)$$

where

$$\psi(Y_i) = \begin{cases} -k, & \text{if } Y_i \leq -k \\ Y_i, & \text{if } -k < Y_i < k \\ k, & \text{if } Y_i \geq k \end{cases} \qquad (2)$$

where k is chosen so that the Kolmogorov distance between P_i and Q_i is exactly δ for $i=0, 1$, and CV is the critical value of the test. An application of the Central Limit Theorem hence yields the result that there exits an approximate critical value for the test which is defined by

$$CV_{asymp} = z_{1-\alpha}\sqrt{n^{-}\,\mathrm{Var}_{Q_0^*}\psi(Y)} + E_{Q_0^*}\psi(Y), \qquad (3)$$

where $z_{1-\alpha} = \Phi^{-1}(1-\alpha)$. Routine calculations yield

$$E_{Q_0^*}\psi(Y_i)=a+\frac{2k(c-1)}{c+1}+\phi(k+a)+\phi(-k+a)$$
$$-[\Phi(k+a)+\Phi(k-a)]\left[a+\frac{k(c-1)}{c+1}\right]$$

and

$$\mathrm{Var}_{Q_0^*}\psi(Y_i)=2k^2-a^2-1-\phi(k+a)(k-a)-\phi(k-a)(k+a)$$
$$+[\Phi(k+a)+\Phi(k-a)](1+a^2-k^2)-E^2_{Q_0^*}\psi(Y_i),$$

where $c=\exp(-2ak)$.

Define $\bar{\psi}=n^{-1}\sum_{i=1}^{n}\psi(Y_i)$. Notice that the power of the test $\chi(\boldsymbol{Y})$ against any alternative F is given approximately by

$$\text{power}=P_F(\bar{\psi}>CV)\approx 1-\Phi\left(\frac{CV-E_F\bar{\psi}}{\sigma_F\bar{\psi}}\right).$$

Hence the asymptotic power function against F can be defined as

$$1-\Phi\left[\frac{z_{1-\alpha}\sigma_{Q_0^*}\psi}{\sigma_F\psi}+\frac{\sqrt{n}\,(E_{Q_0^*}\psi-E_F\psi)}{\sigma_F\psi}\right]. \tag{4}$$

The expression might be used to determine the sample size needed to control both producer's and consumer's risks. One would choose n so that asymptotic power against Q_1 is equal to a desired value $1-\beta$.

3. ROBUST TEST WITH ESTIMATED SCALE PARAMETER

In practice, σ is usually unknown. A consistent estimator $\hat{\sigma}$ is used to replace σ which leads to an approximate robust test. If $\hat{\sigma}$ is a scale equivariant estimator, the resulting test will be scale invariant. Moreover, in large samples $\hat{\sigma}$ and σ will be nearly equal, so we might hope that, at least for large n, the proposed test should behave similarly to Huber's test for known σ. The small sample behavior is not guaranteed, of course, and will be investigated in the following section by simulation.

Assume that $X_1, \cdots, X_n$ is a sample from a distribution F, which need not be continuous, with location parameter $\theta_i\sigma$ and unknown scale parameter σ which is in a Kolmogorov neighborhood of $\Phi[(x-\theta_i\sigma)/\sigma]$

under $\boldsymbol{H}_i$, $i=0, 1$. We assume that the two neighborhoods have the same size δ.

Define $\hat{Y}_i=-X_i/\hat{\sigma}+B$, where $\hat{\sigma}$ is a consistent estimator of σ. Notice that an estimator of σ depends on the whole sample, hence the rescaled random variables $\hat{Y}_1, \cdots, \hat{Y}_n$, where $\hat{Y}_i=-X_i/\hat{\sigma}+B$, are no longer i. i. d.. However, if the sample size is sufficiently large, $\hat{Y}_1, \cdots, \hat{Y}_n$ are approximately i. i. d. random variables.

When σ is unknown, the test

$$\varphi(\hat{Y})=\varphi(\hat{Y}_1, \cdots, \hat{Y}_n)=\begin{cases} 1, & \text{if } n^{-1}\sum_{i=1}^{n}\psi(\hat{Y}_i)>CV^* \\ r, & \text{if } n^{-1}\sum_{i=1}^{n}\psi(\hat{Y}_i)=CV^* \\ 0, & \text{if } n^{-1}\sum_{i=1}^{n}\psi(\hat{Y}_i)<CV^* \end{cases}$$

will be used, where the function ψ is given by Eq. (2) and CV^* is the critical value of the test. Define $T_n=n^{-1}\sum_{i=1}^{n}\psi(\hat{Y}_i)$. In order to obtain a test of approximate size α, by the consistency of $\hat{\sigma}$ and the Central Limit Theorem, the approximate asymptotic critical value is therefore defined by

$$\widehat{CV}^*_{asymp}=z_{1-\alpha}\sqrt{\widehat{\mathrm{Var}}_{Q_0}T_n}+E_{Q_0}\psi,$$

where $\widehat{\mathrm{Var}}_{Q_0}T_n$ is an estimator of the variance of T_n under Q_0.

Two methods of estimating the variance of the test statistic T_n are considered, namly the Jakknife method and the influence function method.

The jackknife estimator of the variance of the test statistic T_n is

$$V^J=\frac{\sum_{i=1}^{n}(T_i^*-\bar{T}^*)^2}{n(n-1)},$$

where $T_{ni}=(n-1)^{-1}\sum_{j\neq i}^{n}\psi(\hat{Y}_j)$, $T_i^*=nT_n-(n-1)T_{ni}$, $i=1, \cdots, n$, and $\bar{T}^*$ is the average of the T_i^* (Efron, 1982). The corresponding test therefore rejects the null hypothesis if

$$T_n>E_{Q_0}\psi+z_{1-\alpha}\sqrt{V^J}.$$

Consider a real valued statistic $T_n=T(F_n)$, where T is a functional and F_n is the empirical distribution function of $X_1, \cdots, X_n$. If is sufficiently regular, then

$$\mathcal{L}_F\{\sqrt{n}[T_n-T(F)]\} \longrightarrow N\left[0, \int IF^2(x; T, F)dF(x)\right], \tag{5}$$

provided that some remainder term converges to 0 in probability.

In our problem, the functional T is defined by

$$T(F)=\int \psi\left(-\frac{X}{S(F)}+B\right)dF$$

where $S(F)$ is the functional defining our estimator of the scale parameter.

The actual F is unknown in practice. Among other things, F involves the unknown scale parameter. Therefore, we propose to estimate Var $\bar{\psi}$ by

$$n^{-1}\int IF^2(x; T, F_n)dF_n = n^{-2}\sum_{i=1}^{n} IF^2(X_i; T, F_n)$$

where is computable from the sample. We therefore reject the null hypothesis if

$$T_n > E_{Q_0}\psi + z_{1-\alpha}\sqrt{n^{-2}\sum_{i=1}^{n} IF^2(X_i; T, F_n)}.$$

See Hampel et al. (1986) or Huber (1981) and Chen and Smith (1991) for details.

The influence function approach also leads to a large sample formula for the power of the robust test. Using Eq. (5) to approximate the distribution of the T_n test yields the following asymptotic power function against any alternative F:

$$P_F(T_n > CV_{asymp}) = 1-\Phi\left\{\frac{\sqrt{n}[E_{Q_0^*}\psi(Y)-T(F)]+z_{1-\alpha}\sqrt{\mathrm{Var}_{Q_0}T_n}}{\sqrt{\int IF^2(x; T, F)dF}}\right\}. \tag{6}$$

4. PERFORMANCE OF THE ROBUST TEST

In this section, we study the behavior of various robust acceptance sampling plans by using simulation techniques in both the known scale and unknown scale situations. Various distributions are simulated to investigate the least favorable properties of Q_0 and Q_1 when the scale parameter is estimated.

(1) Parameters in the simulation

We regard the acceptance sampling problem as a test of the hypothesis $\boldsymbol{H}_0$: $F \in \mathcal{P}_0$ versus the alternative hypothesis $\boldsymbol{H}_1$: $F \in \mathcal{P}_1$. When the scale parameter σ is known, Huber's maximin test will be used directly.

We are interested in two types of testing problems, representing different level of quality requirement: (a) $\boldsymbol{H}_0$: $p=0.01$ veasus $\boldsymbol{H}_1$: $p=0.025$. (b) $\boldsymbol{H}_0$: $p=0.01$ versus $\boldsymbol{H}_1$: $p=0.05$. We take $LSL=0$ and some proper values of USL in (5, 7.5).

The tests used in the simulation were designed so that the nominal producer's risk $\alpha=0.05$. For various kinds of quality characteristics, the sample size may be small or large. Hence in the simulation, we consider both small and large sample sizes, namely 20, 50, and 100.

Kolmogorov neighborhoods, both of size δ were used to model departures from normality.

Under the idealized model, X is $N(\theta\sigma, \sigma^2)$ where $\theta=\theta_0$ or θ_1, and $p=P(X<LSL \text{ or } X>USL)=p_0$ or p_1. In the simulation study we use $\delta=0.05$, $\delta=0.01$, and $\delta=0.005$ to simulate small departures from normality. The larger values of δ enable us to examine issues of robutness of our test more clearly, even though they are unrealistic in the acceptance sampling context.

We simulate the test when σ is known (and assumed equal to 1) and when σ is unknown. To estimate σ, we employ the adjusted sample standard deviation S, i.e., choose choose the adjustment factor c^*, so that $S(Q_0)=c^*\sigma(Q_0)=\sigma$ where σ is regarded as a scale factor of q_0. Simulations using an adjusted Winsorized standard deviation (Chen, 1990), not reported here, led to tests with inferior performance.

When σ is unknown, the asymptotic critical value is defined by $\widehat{CV}_{asymp}=E_{Q_0}\psi+z_{1-\alpha}\sqrt{\widehat{\mathrm{Var}}_{Q_0}T_n}$. Therefore, we have to estimate the variance of the test statistic T_n in order to determine the asymptotic critical value of the test. In the simulation, the nonparametric jackknife estimate is used because it is generally applicable. Also, the parametric influence function $\sum_{i=1}^{n} IF^2(X_i, T, F_n)$ is considered.

The simulated distributions were:

(a) $N(\theta_0\sigma, \sigma^2)$, $N(\theta_1\sigma, \sigma^2)$, which define the ideal model;

(b) Q_0 and Q_1, which are the least favorable pair from Huber's theory if σ is given. We want to check if the least favorable property is still true when the scale parameter σ unknown;

(c) $(1-\delta)N(\theta\sigma, \sigma^2)+\delta N(\theta_0\sigma, 9\sigma^2)$ and $(1-\delta)N(\theta_1\sigma, \sigma^2)+\delta N(\theta_1\sigma, 9\sigma^2)$, a popular and widely used model to assess the effects of nonnormality.

These distributions have Kolmogorov distance δ from the normal.

(2) **Simulation study**

Tables 1 and 2 list the significance levels $E_{N_0}\varphi$, $E_{M_0}\varphi$, and $E_{Q_0}\varphi$ (producer's risk) under the three null distributions given in the previous paragraph and the powers $E_{N_1}\varphi$, $E_{M_1}\varphi$, and $E_{Q_1}\varphi$ (1-consumer's risk) under the three alternatives. Tables 3 and 4 list the asymptotic significance levels $E^A_{N_0}\varphi$, $E^A_{M_0}\varphi$, and $E^A_{Q_0}\varphi$ (producer's risk) under the three null distributions given in the previous paragraph and the asymptotic powers $E^A_{N_1}\varphi$, $E^A_{M_1}\varphi$, and $E^A_{Q_1}\varphi$ (1-consumer's risk) under the three alternatives. Where φ is the test function. Each entry of Tables 1, 2, 3 and 4 is based on 1,000 replications.

5. SIMULATION RESULTS

Even though Q_0 doesn't show the property of least favorable, its level is smaller than the level under other distribution most of the time. But for those levels which are larger than $E_{Q_0}\phi$ are all close (or smaller than) the norminal value 0.05.

As we can see from tables, the performance of the test doesn't change too much when the specification limits are getting large. One reason which may explain this is that for the distributions we considered, when the difference between USL and LSL lies in [5.3, 7], we can imagine that the nonconformative region is far at two ends. Chances

Table 1. Level and power of Huber's robust maximin test when σ is known

(a) $p_0=0.01$, $p_1=0.05$, $LSL=0$

	USL											
$\delta=0.005$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.06	0.05	0.04	0.06	0.04
$E_{N_0}\varphi$	0.04	0.05	0.03	0.05	0.05	0.04	0.04	0.04	0.03	0.04	0.04	0.04
$E_{M_0}\varphi$	0.05	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E_{Q_1}\varphi$	0.93	0.99	1.0	0.89	0.99	1.0	0.89	0.99	1.0	0.90	0.99	1.0
$E_{N_1}\varphi$	0.95	1.0	1.0	0.90	1.0	1.0	0.88	0.99	1.0	0.88	0.99	1.0
$E_{M_1}\varphi$	0.93	1.0	1.0	0.88	0.99	1.0	0.89	0.99	1.0	0.90	0.99	1.0
$\delta=0.01$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.05	0.04	0.05	0.05	0.05	0.04	0.04	0.06	0.05	0.05	0.05	0.05
$E_{N_0}\varphi$	0.04	0.03	0.02	0.03	0.03	0.02	0.04	0.02	0.03	0.03	0.03	0.04
$E_{M_0}\varphi$	0.05	0.05	0.03	0.04	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.04
$E_{Q_1}\varphi$	0.91	1.0	1.0	0.84	0.99	1.0	0.84	0.99	1.0	0.86	0.99	1.0
$E_{N_1}\varphi$	0.96	1.0	1.0	0.89	0.99	1.0	0.88	0.99	1.0	0.89	0.99	1.0
$E_{M_1}\varphi$	0.91	1.0	1.0	0.86	0.99	1.0	0.87	0.99	1.0	0.89	0.99	1.0
$\delta=0.05$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.06	0.05	0.04	0.05	0.06	0.05	0.06	0.05	0.05	0.07	0.04	0.04
$E_{N_0}\varphi$	0.02	0.00	0.00	0.02	0.01	0.00	0.01	0.01	0.00	0.02	0.01	0.00
$E_{M_0}\varphi$	0.02	0.01	0.01	0.02	0.01	0.00	0.02	0.01	0.00	0.02	0.01	0.00
$E_{Q_1}\varphi$	0.59	0.93	0.99	0.51	0.82	0.98	0.48	0.83	0.98	0.50	0.83	0.98
$E_{N_1}\varphi$	0.82	0.99	1.0	0.73	0.97	1.0	0.69	0.96	1.0	0.72	0.97	0.99
$E_{M_1}\varphi$	0.81	0.99	1.0	0.74	0.97	1.0	0.68	0.97	1.0	0.71	0.96	1.0

Table 1. Level and power of Huber's robust maximin test when σ is known (Continued)

(b) $p_0=0.01$, $p_1=0.025$, $LSL=0$

	USL											
$\delta=0.005$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.05	0.03	0.05	0.05	0.04	0.04	0.05	0.04	0.06	0.04	0.06	0.05
$E_{N_0}\varphi$	0.05	0.05	0.03	0.05	0.05	0.03	0.04	0.04	0.04	0.06	0.04	0.03
$E_{M_0}\varphi$	0.05	0.05	0.04	0.05	0.04	0.05	0.05	0.04	0.04	0.06	0.05	0.04
$E_{Q_1}\varphi$	0.56	0.87	0.99	0.44	0.76	0.96	0.40	0.73	0.95	0.42	0.77	0.94
$E_{N_1}\varphi$	0.57	0.90	0.99	0.45	0.78	0.97	0.44	0.79	0.97	0.46	0.78	0.95
$E_{M_1}\varphi$	0.59	0.88	0.99	0.44	0.78	0.96	0.42	0.74	0.95	0.46	0.77	0.95

$\delta=0.01$	5.3			6			6.3			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.07	0.05	0.06	0.05	0.05	0.04	0.06	0.06	0.05	0.05	0.05	0.05
$E_{N_0}\varphi$	0.05	0.03	0.02	0.04	0.04	0.02	0.05	0.03	0.03	0.04	0.04	0.03
$E_{M_0}\varphi$	0.04	0.03	0.03	0.04	0.04	0.03	0.05	0.04	0.04	0.05	0.04	0.03
$E_{Q_1}\varphi$	0.50	0.78	0.97	0.39	0.66	0.91	0.40	0.73	0.95	0.37	0.65	0.90
$E_{N_1}\varphi$	0.56	0.87	0.99	0.43	0.75	0.94	0.40	0.64	0.88	0.43	0.74	0.95
$E_{M_1}\varphi$	0.53	0.87	0.99	0.43	0.75	0.94	0.40	0.70	0.93	0.42	0.73	0.93

$\delta=0.05$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.05	0.05	0.04	0.05	0.03	0.05	0.05	0.05	0.05	0.07	0.04	0.05
$E_{N_0}\varphi$	0.01	0.01	0.00	0.02	0.01	0.00	0.02	0.01	0.00	0.02	0.01	0.00
$E_{M_0}\varphi$	0.02	0.01	0.00	0.03	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.00
$E_{Q_1}\varphi$	0.17	0.29	0.46	0.14	0.19	0.26	0.10	0.17	0.22	0.10	0.16	0.22
$E_{N_1}\varphi$	0.32	0.59	0.84	0.22	0.46	0.69	0.21	0.41	0.61	0.21	0.43	0.65
$E_{M_1}\varphi$	0.31	0.59	0.80	0.22	0.37	0.63	0.23	0.39	0.62	0.23	0.40	0.63

Table 2. Level and power of test in Section 3 when σ is unknown
(a) $p_0=0.01$, $p_1=0.05$, $LSL=0$

	USL											
$\delta=0.005$	5.3						6					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.01	0.02	0.04	0.05	0.05	0.01	0.01	0.01	0.04	0.06	0.05
$E_{N_0}\varphi$	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.03	0.02	0.02
$E_{M_0}\varphi$	0.05	0.06	0.06	0.04	0.05	0.05	0.05	0.05	0.04	0.06	0.05	0.05
$E_{Q_1}\varphi$	0.44	0.80	0.98	0.44	0.82	0.98	0.37	0.72	0.95	0.38	0.76	0.97
$E_{N_1}\varphi$	0.45	0.80	0.98	0.44	0.82	0.98	0.38	0.72	0.95	0.39	0.76	0.97
$E_{M_1}\varphi$	0.61	0.93	0.99	0.60	0.93	0.99	0.56	0.89	0.99	0.55	0.91	0.99

$\delta=0.005$	6.5						7.0					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.01	0.01	0.05	0.05	0.05	0.01	0.01	0.01	0.05	0.05	0.05
$E_{N_0}\varphi$	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.03	0.02	0.02
$E_{M_0}\varphi$	0.05	0.04	0.05	0.04	0.04	0.03	0.04	0.05	0.05	0.06	0.05	0.05
$E_{Q_1}\varphi$	0.36	0.71	0.94	0.37	0.75	0.96	0.37	0.71	0.94	0.37	0.75	0.96
$E_{N_1}\varphi$	0.37	0.71	0.95	0.38	0.75	0.97	0.38	0.71	0.95	0.38	0.75	0.96
$E_{M_1}\varphi$	0.55	0.89	0.99	0.54	0.91	0.99	0.56	0.88	0.99	0.55	0.90	0.99

$\delta=0.01$	5.3						6					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.02	0.02	0.05	0.05	0.05	0.01	0.01	0.02	0.05	0.05	0.05
$E_{N_0}\varphi$	0.03	0.02	0.01	0.02	0.02	0.01	0.03	0.02	0.01	0.02	0.02	0.01
$E_{M_0}\varphi$	0.06	0.05	0.04	0.05	0.06	0.04	0.05	0.06	0.05	0.05	0.04	0.04
$E_{Q_1}\varphi$	0.45	0.79	0.98	0.42	0.79	0.98	0.38	0.72	0.95	0.36	0.72	0.95
$E_{N_1}\varphi$	0.47	0.80	0.98	0.43	0.79	0.98	0.40	0.74	0.95	0.37	0.74	0.95
$E_{M_1}\varphi$	0.63	0.93	0.99	0.60	0.93	0.99	0.57	0.90	0.99	0.54	0.90	0.99

Table 2. Level and power of test in Section 3 when σ is unknown (Continued)

(a) $p_0=0.01$, $p_1=0.05$, $LSL=0$

	UST											
$\delta=0.01$	6.5						7.0					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.01	0.02	0.05	0.05	0.05	0.01	0.01	0.02	0.05	0.05	0.05
$E_{N_0}\varphi$	0.02	0.02	0.01	0.02	0.02	0.01	0.03	0.02	0.01	0.02	0.02	0.01
$E_{M_0}\varphi$	0.05	0.04	0.03	0.05	0.06	0.04	0.06	0.04	0.04	0.04	0.05	0.05
$E_{Q_1}\varphi$	0.38	0.72	0.94	0.36	0.71	0.94	0.37	0.72	0.94	0.35	0.72	0.95
$E_{N_1}\varphi$	0.39	0.73	0.95	0.37	0.73	0.95	0.40	0.73	0.95	0.37	0.73	0.95
$E_{M_1}\varphi$	0.58	0.89	0.99	0.55	0.90	0.99	0.56	0.90	0.99	0.53	0.90	0.99

$\delta=0.05$	5.3						6					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.03	0.04	0.05	0.05	0.05	0.01	0.02	0.03	0.06	0.05	0.05
$E_{N_0}\varphi$	0.02	0.01	0.00	0.01	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.00
$E_{M_0}\varphi$	0.06	0.06	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.05	0.05
$E_{Q_1}\varphi$	0.33	0.57	0.84	0.25	0.51	0.81	0.27	0.48	0.74	0.20	0.42	0.70
$E_{N_1}\varphi$	0.38	0.66	0.90	0.29	0.60	0.87	0.33	0.59	0.84	0.25	0.53	0.81
$E_{M_1}\varphi$	0.56	0.86	0.98	0.49	0.83	0.98	0.52	0.83	0.97	0.45	0.80	0.97

$\delta=0.05$	6.5						7.0					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.02	0.03	0.06	0.05	0.05	0.01	0.02	0.03	0.05	0.05	0.05
$E_{N_0}\varphi$	0.02	0.01	0.00	0.01	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.00
$E_{M_0}\varphi$	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.05	0.04	0.04
$E_{Q_1}\varphi$	0.27	0.48	0.72	0.20	0.42	0.69	0.27	0.46	0.73	0.20	0.41	0.69
$E_{N_1}\varphi$	0.32	0.57	0.83	0.25	0.51	0.80	0.33	0.57	0.83	0.26	0.51	0.80
$E_{M_1}\varphi$	0.51	0.81	0.97	0.45	0.79	0.97	0.51	0.82	0.97	0.46	0.79	0.97

Table 2. Level and power of test in Section 3 when σ is unknown (Continued)

(b) $p_0=0.01$, $p_1=0.025$, $LSL=0$

	USL											
$\delta=0.005$	5.3						6					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.01	0.01	0.05	0.05	0.05	0.01	0.01	0.01	0.04	0.06	0.05
$E_{N_0}\varphi$	0.02	0.01	0.01	0.03	0.02	0.02	0.02	0.01	0.01	0.03	0.02	0.02
$E_{M_0}\varphi$	0.05	0.07	0.05	0.06	0.06	0.04	0.05	0.03	0.04	0.05	0.05	0.05
$E_{Q_1}\varphi$	0.15	0.30	0.56	0.16	0.36	0.64	0.11	0.23	0.42	0.14	0.28	0.50
$E_{N_1}\varphi$	0.15	0.31	0.56	0.17	0.38	0.64	0.12	0.24	0.45	0.14	0.30	0.54
$E_{M_1}\varphi$	0.25	0.50	0.79	0.26	0.56	0.84	0.21	0.42	0.71	0.23	0.48	0.77
$\delta=0.005$	6.5						7.0					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.01	0.01	0.05	0.05	0.05	0.01	0.01	0.01	0.05	0.05	0.05
$E_{N_0}\varphi$	0.02	0.02	0.01	0.03	0.03	0.02	0.02	0.01	0.01	0.02	0.03	0.03
$E_{M_0}\varphi$	0.05	0.07	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.04
$E_{Q_1}\varphi$	0.11	0.21	0.40	0.13	0.27	0.48	0.11	0.21	0.40	0.13	0.27	0.49
$E_{N_1}\varphi$	0.12	0.23	0.43	0.13	0.29	0.51	0.11	0.23	0.44	0.14	0.29	0.53
$E_{M_1}\varphi$	0.19	0.42	0.69	0.22	0.48	0.75	0.20	0.42	0.69	0.22	0.48	0.75
$\delta=0.01$	5.3						6					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.01	0.02	0.05	0.05	0.05	0.01	0.01	0.02	0.05	0.05	0.05
$E_{N_0}\varphi$	0.03	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02
$E_{M_0}\varphi$	0.03	0.04	0.05	0.04	0.03	0.05	0.07	0.05	0.05	0.04	0.05	0.05
$E_{Q_1}\varphi$	0.16	0.30	0.54	0.15	0.32	0.58	0.12	0.22	0.41	0.12	0.24	0.45
$E_{N_1}\varphi$	0.18	0.33	0.57	0.17	0.35	0.60	0.14	0.25	0.44	0.14	0.27	0.49
$E_{M_1}\varphi$	0.27	0.52	0.79	0.26	0.54	0.81	0.23	0.44	0.72	0.22	0.46	0.74

Table 2. Level and power of test in Section 3 when σ is unknown (Continued)

(b) $p_0=0.01$, $p_1=0.025$, $LSL=0$

	USL											
$\delta=0.01$	6.5						7.0					
	Influ fn method			Jackknife emthod			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.00	0.01	0.02	0.05	0.05	0.05	0.01	0.01	0.02	0.05	0.05	0.05
$E_{N_0}\varphi$	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02
$E_{M_0}\varphi$	0.04	0.05	0.06	0.03	0.04	0.05	0.05	0.04	0.05	0.06	0.09	0.10
$E_{Q_1}\varphi$	0.12	0.22	0.41	0.12	0.23	0.42	0.13	0.21	0.39	0.12	0.23	0.43
$E_{N_1}\varphi$	0.14	0.24	0.43	0.13	0.26	0.47	0.15	0.25	0.44	0.14	0.27	0.48
$E_{M_1}\varphi$	0.23	0.44	0.69	0.22	0.46	0.72	0.23	0.44	0.70	0.22	0.45	0.73
$\delta=0.05$	5.3						6					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.02	0.03	0.06	0.05	0.05	0.00	0.02	0.03	0.06	0.06	0.05
$E_{N_0}\varphi$	0.03	0.01	0.00	0.02	0.01	0.00	0.03	0.01	0.01	0.02	0.01	0.00
$E_{M_0}\varphi$	0.04	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.03	0.03
$E_{Q_1}\varphi$	0.11	0.13	0.22	0.08	0.11	0.20	0.09	0.10	0.13	0.06	0.09	0.13
$E_{N_1}\varphi$	0.15	0.22	0.38	0.16	0.20	0.36	0.13	0.18	0.27	0.10	0.16	0.26
$E_{M_1}\varphi$	0.24	0.41	0.64	0.20	0.38	0.62	0.21	0.34	0.54	0.17	0.32	0.53
$\delta=0.05$	6.5						7.0					
	Influ fn method			Jackknife method			Infl fn appr			Jackkni appr		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E_{Q_0}\varphi$	0.01	0.02	0.03	0.06	0.05	0.05	0.00	0.02	0.03	0.05	0.05	0.05
$E_{N_0}\varphi$	0.02	0.01	0.01	0.02	0.01	0.01	0.03	0.01	0.00	0.02	0.01	0.00
$E_{M_0}\varphi$	0.05	0.05	0.04	0.04	0.05	0.04	0.06	0.05	0.05	0.05	0.05	0.06
$E_{Q_1}\varphi$	0.09	0.09	0.12	0.06	0.08	0.11	0.08	0.10	0.13	0.06	0.08	0.12
$E_{N_1}\varphi$	0.12	0.17	0.26	0.09	0.15	0.25	0.12	0.17	0.26	0.10	0.15	0.25
$E_{M_1}\varphi$	0.21	0.34	0.53	0.18	0.32	0.51	0.20	0.35	0.54	0.17	0.33	0.53

Table 3. Level and power of Huber's robust maximin test when σ is known-asymptotic version, obtained from Eq. (4)

(a) $p_0=0.01$, $p_1=0.05$, $LSL=0$

	USL											
$\delta=0.005$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.03
$E^A_{M_0}\varphi$	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.03
$E^A_{Q_1}\varphi$	0.94	0.99	0.99	0.89	0.99	0.99	0.88	0.99	1.0	0.89	0.99	0.99
$E^A_{N_1}\varphi$	0.95	0.99	0.99	0.91	0.99	0.99	0.90	0.99	1.0	0.90	0.99	0.99
$E^A_{M_1}\varphi$	0.95	0.99	0.99	0.91	0.99	0.99	0.90	0.99	1.0	0.90	0.99	0.99
$\delta=0.01$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.02	0.03	0.03	0.02
$E^A_{M_0}\varphi$	0.04	0.03	0.02	0.04	0.03	0.02	0.04	0.03	0.02	0.04	0.03	0.02
$E^A_{Q_1}\varphi$	0.92	0.99	0.99	0.86	0.99	0.99	0.85	0.99	0.99	0.85	0.99	0.99
$E^A_{N_1}\varphi$	0.94	0.99	0.99	0.89	0.99	0.99	0.88	0.99	0.99	0.88	0.99	0.99
$E^A_{M_1}\varphi$	0.94	0.99	0.99	0.89	0.99	0.99	0.88	0.99	0.99	0.88	0.99	0.99
$\delta=0.05$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00
$E^A_{M_0}\varphi$	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
$E^V_{Q_1}\varphi$	0.62	0.92	0.99	0.51	0.84	0.98	0.50	0.83	0.98	0.50	0.83	0.98
$E^A_{N_1}\varphi$	0.81	0.99	0.99	0.72	0.97	0.99	0.71	0.99	0.99	0.71	0.97	0.99
$E^A_{M_1}\varphi$	0.80	0.99	0.99	0.70	0.97	0.99	0.69	0.96	0.99	0.69	0.96	0.99

Table 3. Level and power of Huber's robust maximin test when σ is known-asymptotic version, obtained from Eq. (4) (Continued)

(b) $p_0=0.01$, $p_1=0.025$, $LSL=0$

	USL											
$\delta=0.005$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.04	0.03
$E^A_{M_0}\varphi$	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
$E^A_{Q_1}\varphi$	0.55	0.87	0.99	0.44	0.76	0.95	0.42	0.73	0.94	0.42	0.74	0.95
$E^A_{N_1}\varphi$	0.58	0.90	0.99	0.47	0.79	0.97	0.45	0.77	0.96	0.45	0.78	0.96
$E^A_{M_1}\varphi$	0.58	0.90	0.99	0.47	0.79	0.97	0.45	0.77	0.96	0.45	0.78	0.96
$\delta=0.01$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.04	0.03	0.02	0.04	0.03	0.03	0.04	0.03	0.03	0.04	0.03	0.03
$E^A_{M_0}\varphi$	0.04	0.03	0.03	0.04	0.03	0.03	0.04	0.03	0.03	0.04	0.03	0.03
$E^A_{Q_1}\varphi$	0.49	0.82	0.97	0.38	0.68	0.91	0.36	0.65	0.89	0.37	0.66	0.90
$E^A_{N_1}\varphi$	0.54	0.87	0.99	0.38	0.68	0.91	0.36	0.65	0.89	0.37	0.66	0.90
$E^A_{M_1}\varphi$	0.54	0.87	0.99	0.43	0.75	0.95	0.41	0.73	0.94	0.42	0.74	0.94
$\delta=0.05$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.01	0.01	0.00	0.02	0.01	0.00	0.02	0.01	0.00	0.02	0.01	0.00
$E^A_{M_0}\varphi$	0.01	0.01	0.00	0.02	0.01	0.00	0.02	0.01	0.00	0.02	0.01	0.00
$E^A_{Q_1}\varphi$	0.17	0.28	0.45	0.11	0.17	0.26	0.11	0.15	0.23	0.11	0.16	0.24
$E^A_{N_1}\varphi$	0.32	0.59	0.84	0.23	0.43	0.67	0.22	0.40	0.63	0.23	0.41	0.65
$E^A_{M_1}\varphi$	0.31	0.59	0.83	0.23	0.42	0.65	0.22	0.39	0.61	0.22	0.40	0.63

Table 4. Level and power of test when σ is unkown-obtained from Eq. (6)

(a) $p_0=0.01$, $p_1=0.05$, $LSL=0$

	USL											
$\delta=0.005$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01
$E^A_{M_0}\varphi$	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.03	0.03	0.04	0.03	0.03
$E^A_{Q_1}\varphi$	0.24	0.60	0.90	0.21	0.52	0.85	0.21	0.51	0.84	0.21	0.51	0.84
$E^A_{N_1}\varphi$	0.29	0.72	0.97	0.26	0.64	0.93	0.25	0.63	0.93	0.25	0.63	0.93
$E^A_{M_1}\varphi$	0.34	0.74	0.97	0.31	0.68	0.94	0.31	0.67	0.03	0.31	0.67	0.93
$\delta=0.01$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
$E^A_{M_0}\varphi$	0.05	0.04	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.04	0.04
$E^A_{Q_1}\varphi$	0.22	0.53	0.85	0.19	0.45	0.77	0.14	0.44	0.76	0.19	0.44	0.76
$E^A_{N_1}\varphi$	0.27	0.67	0.95	0.24	0.60	0.90	0.24	0.58	0.90	0.23	0.58	0.90
$E^A_{M_1}\varphi$	0.37	0.73	0.96	0.33	0.67	0.92	0.33	0.67	0.92	0.33	0.67	0.92
$\delta=0.05$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
$E^A_{M_0}\varphi$	0.05	0.06	0.04	0.06	0.05	0.04	0.05	0.05	0.04	0.06	0.05	0.05
$E^A_{Q_1}\varphi$	0.27	0.53	0.80	0.23	0.44	0.71	0.22	0.43	0.70	0.22	0.44	0.70
$E^A_{N_1}\varphi$	0.29	0.62	0.90	0.25	0.54	0.84	0.25	0.53	0.83	0.25	0.53	0.83
$E^A_{M_1}\varphi$	0.08	0.87	0.99	0.55	0.84	0.98	0.54	0.83	0.97	0.54	0.84	0.97

Table 4. Level and power of test when σ is unknown-obtained from Eq. (6) (Continued)

(b) $p_0=0.01$, $p_1=0.025$, $LSL=0$

	USL											
$\delta=0.005$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.02	0.02	0.01	0.03	0.02	0.01	0.03	0.02	0.01	0.03	0.02	0.01
$E^A_{M_0}\varphi$	0.05	0.04	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.05	0.05	0.04
$E^A_{Q_1}\varphi$	0.10	0.19	0.35	0.08	0.15	0.26	0.08	0.14	0.24	0.08	0.14	0.25
$E^A_{N_1}\varphi$	0.12	0.27	0.49	0.11	0.21	0.38	0.10	0.20	0.37	0.11	0.21	0.37
$E^A_{M_1}\varphi$	0.18	0.34	0.57	0.16	0.29	0.48	0.15	0.28	0.46	0.15	0.28	0.47

$\delta=0.01$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01
$E^A_{M_0}\varphi$	0.07	0.06	0.06	0.07	0.06	0.06	0.07	0.06	0.06	0.07	0.06	0.06
$E^A_{Q_1}\varphi$	0.09	0.16	0.27	0.07	0.12	0.19	0.70	0.11	0.18	0.07	0.11	0.18
$E^A_{N_1}\varphi$	0.11	0.24	0.43	0.10	0.19	0.33	0.10	0.18	0.32	0.10	0.18	0.32
$E^A_{M_1}\varphi$	0.21	0.37	0.59	0.19	0.32	0.50	0.18	0.31	0.49	0.20	0.32	0.50

$\delta=0.05$	5.3			6			6.5			7		
n	20	50	100	20	50	100	20	50	100	20	50	100
$E^A_{Q_0}\varphi$	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$E^A_{N_0}\varphi$	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.01
$E^A_{M_0}\varphi$	0.06	0.05	0.05	0.07	0.06	0.05	0.05	0.05	0.05	0.06	0.05	0.05
$E^A_{Q_1}\varphi$	0.10	0.15	0.22	0.08	0.11	0.14	0.08	0.10	0.13	0.08	0.10	0.13
$E^A_{N_1}\varphi$	0.12	0.21	0.36	0.10	0.17	0.27	0.10	0.16	0.26	0.10	0.17	0.26
$E^A_{M_1}\varphi$	0.42	0.65	0.86	0.39	0.61	0.81	0.39	0.60	0.80	0.40	0.60	0.81

for the measurement to lie in that region is about the same, that is way the value leaves similar result when the specification limits changes from (0, 5.3] to (0, 7].

From above four tables, a strong evidence shows that no matter which value of *USL* we choose, the behavior of the level and power are not changed significantly.

(1) **Known scale**

When the scale parameter σ is given, the distributions Q_0, Q_1 exhibit the least favorable property as predicted by theory for all specified limits (*LSL*, *USL*). The significance levels are close to the nominal value of 0.05 under Q_0, and are considerably less than 0.05 under normality and mixture of normal when $\delta=0.05$ for both $p_1=0.025$ and 0.05. But almost all of them satisfy the restriction that the significance levels are dominated by the nominal value 0.05. The power under normality and mixture of normal are much higher than the power under Q_1 when $\delta=0.05$. As δ increases, the power decreases for each sample size and alternative. Moreover, the difference between the power under normality and under Q_1 increases as δ increases. The power decreases when the test changes from 0.05 to 0.025 for all choes of the specification limits.

The explanation for these findings is that as δ increases, the normal and least favorable distribution become farther apart, so that differences in power are larger. Moreover, as δ increases, Q_0 and Q_1 are closer together, and there is heavier truncation, and hence more loss of information. Therefore, the power decreases as δ increases. The difference reaches the maximum between the power under Q_0 and the other two distributions when δ reaches 0.05.

If the scale parameter σ is thought to be known and the size of the neighborhood δ can be assumed small, that is, there are only very small departures from normality, then the power of Huber's test against Q_1 gives useful lower bounds on power against other alternatives in the neighborhood, particularly against the normal alternative. We can say that when δ is small, the power function is robust.

(2) Estimated scale

When the scale parameter σ is unknown and either the jackknife method or the influence function method is used to estimate the variance of the test statistic T_n, then in all cases appear to have the smallest power. In almost all the cases, the significance level under varies conditions are all close to the nominal value 0.05. The performance under normality is almost always better than the performance under Q_0 or Q_1.

In Table 2, the significance level in all cases are close to the nominal value 0.05. Q_0, Q_1 show the least favorable properrty. The power are about the same as $\delta=0.005$ and 0.01. But as $\delta=0.05$, the power decreased dramatically. For the more strict case, i.e., as $p_1=0.025$, the power becomes much smaller compare to the power when $p_1=0.05$. It looks like when we fixed *LSL*, as *USL* changed from 5.3 to 7, the power doesn't chhange too much for fixed p_1 and δ.

When we compare the power of the test under normality and under Q_1, we see that the power under Q_1 is smaller than under normality, but the differences between them generally are smaller than 0.1, except for the case when the alternative $p_1=0.05$ and the size of the neighborhood δ is 0.05. The other thing we can see from the simulation is that when the size of the neighborhood increases, the power generally decreases.

Hence, either version of the statistic with the adjusted standard deviation estimator is recommended. Both of them control the consumer's risk and producer's risk resonablly.

(3) Approximating the OC functions of the robust tests

For any acceptance sampling plan, we have to choose the critical value and the sample size (and γ) in order to guarantee that the OC curve will pass through the points $(p_0, 1-\alpha)$ and (p_1, β). We first consider approximating the OC function or equivalently the power of Huber's test from the normal approximation to the distribution of $\bar{\psi}$

Table 3 shows the asymptotic power under normal distribution, mixed normal, and the least favorable distributions when σ is given.

This table is based on Eq. (4) of Section 2. Comparing these values with Table 1 shows that the asymptotic approximation is quite accurate. Hence, the asymptotic power formula can be used to design a robust plan which controls both the consumer's and the producer's risks.

In Section 3, an approximation to the power function of the T_n test presented in Eq. (6). This expression is tabulated in Table 4 for the cases studied in this article. Notice that when the test changes from a loss one to a strict one, i. e., $p_1=0.05$ to 0.025, the power changes dramatically in all cases. Comparison of Table 2 with Table 4 indicates that for $\delta=0.005$ and 0.01, when then the sample is large enough, the asymptotic power formula agrees quite well with the simulated power of the T_n test, using either the influence function method or the jackknife method. But for $\delta=0.05$, asymptotic power is close to the simulated power for both small and large sample sizes. Hence, a robust scheme with unknown scale parameter can be designed to hold both producer's and consumer's risks close to desired values.

6. ACKNOWLEDGEMENTS

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計量值允收計劃之研究

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摘 要

一般在常態分配的假設下一個計量值允收計劃是根據非中心 T (non-central T) 統計量做檢定。由文獻可知此種計量值允收計劃在非常態分配時並不具有穩健性，爲了克服此問題本論文延伸胡伯 (Huber) 的最大最小 (Maximn) 檢定建立了一個近似穩健檢定。由統計模擬得知本近似穩健檢定在眞正的分佈離常態分配不遠時頗值得推薦。

魚體內多氯聯苯檢測方法之研究

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摘　　要

多氯聯苯在 1970 年代以前因其特有之化學惰性與熱安定性質，曾被大量生產且長期使用於各種工業用途；然而由於人們對其毒性一無所知，且疏於防治其汚染，多氯聯苯已成爲目前環境中最嚴重的汚染物之一。再者由於多氯聯苯分子之不易被生物分解，長年累積，造成食物鏈的中、高階層生物體中含量極高的事實。爲檢測生物基質中多氯聯苯的含量，本研究以眞實魚體做材料基質，並添加已知量之標準品，以探討在複雜生物基質中有效之萃取及淨化步驟，供氣相層析／電子捕捉偵測器檢測。

關鍵詞：多氯聯苯、生物累積、皂化、淨化、氣相層析。

一、引　　言

多氯聯苯 (polychlorinated biphenyls，PCBs) 早期被大量使用於和人類生活息息相關的設備和材料上。然而，由於人爲的疏失與多氯聯苯持有之化學及物理穩定性質，PCBs 已造成生態系統中存量最多的汚染物[7]，我國於民國六十八年亦發生了全世界第二次人類 PCBs 中毒事件，震驚了社會各階層，明顯暴露出人們的無知與多氯聯苯對人們健康的威脅。多氯聯苯之長期危害，更因生物界食物鏈的關係由遭受汚染的基層生物而逐漸累積於較高層之魚貝類等生物體中[8]，若人們誤食此等含高濃度多氯聯苯之魚貝類，其傷害實不可言喻。因此魚貝類中 PCBs 含量之檢測已成爲環境中重要之汚染指標[10]。由於生物基質複雜及生化代謝作用之介入，PCBs 分析往往面對許多的困擾與挑戰[1]。目前國內環保署雖有檢測方法，但尚未公告，因此，本篇研究乃參酌多篇國內外相關研究文獻，再配合一般實驗室的基本配備，發展出生物體中 PCBs 的驗證方法，使其合理、適用並合乎經濟與環保。

二、材料與方法

1. 儀器設備

包括烘箱；旋轉揮發儀 (Eyela，型號 N-INW)；微量天平；氣相層析儀

(HP-5890，型號 series II)；層析分離管柱 (J&W，靜相 DB-5，30 m×0.25 mm i.d.)；分液漏斗；迴流皂化裝置。

2. 試劑

(1) 蒸餾水：去離子蒸餾水，由 Millipore 公司 Ultra-Pure R/Q Water System 所製備。
(2) 皂化酒精溶液：1M NaOH 配製於 95%工業酒精 (公賣局) 中。
(3) 矽膠：購自 Sigma 公司，粒子孔隙直徑 (pore diameter) 為 60Å。
(4) 多氯聯苯標準品：購自 Ultra Scientific 公司，濃度各為 100 ppm 之 hexane 溶液，包括 Aroclor 1221、1232、1242、1248、1254、1260、1262 及 1268，供定量查核之用。
(5) 多氯聯苯參考標準品 (Standard Reference Material，SRM)：MA-B-/OC sample No. 103，Lyophilized Fish Tissue 購自國際原子能總署 (International Atomic Energy Agency，IAEA)。
(6) 無水硫酸鈉：純度 99%購自 Merck。

3. 魚體之處理

魚體經採集回到實驗室後，摒除頭、鱗鰓、內臟等雜物並以清水洗淨，再以小刀沿背脊切割上下兩片魚肉。去骨後的魚肉以紙巾吸乾表面水份，並以研缽將魚肉均勻攪碎，置於容器密封後加貼標籤並隨即冷藏於 0°C 之冷凍庫中待用。

4. 魚肉之皂化

魚肉所含脂肪成份甚高，且 PCBs 具脂溶性質，因此皂化處理在釋出 PCBs 以提高其萃取效率[8]。均質之魚肉待解凍後，秤取 5 公克加入等量之無水硫酸鈉拌勻，置於皂化試管中，加入 15 mL 1 M 之氫氧化鈉酒精溶液，以乾浴器加熱至 90°C，使其連續迴流至少 2 小時，當魚肉完全分解時即可停止加熱，待皂化液冷卻後即可進行有機溶劑萃取。

5. 皂化液之溶劑萃取

將上述冷卻之皂化液倒入 100 mL 之分液漏斗中，皂化試管再分別以 10 mL 之正己烷、酒精、蒸餾水依次洗滌以脫附可能殘餘在玻璃壁上之 PCBs，所有洗滌液全數倒入前述之分液漏斗中，靜置待其分層後即進行液—液分離，上層之正己烷有機層及下層之水層分別收集，後者再以 15 mL 正己烷萃取二次，合併三次收集之有機層於 100 mL 之單頸圓底瓶中。

6. 萃取液之濃縮

收集於圓底瓶中之有機萃取液，則以減壓濃縮裝置減小體積，當溶液蒸發至剛要乾爲止時卽停止，再以多次少量（每次約 500 μL）之正己烷溶洗瓶中殘餘物，置於 4 mL 之玻璃瓶中，並以氮氣緩緩吹乾至 2 mL 待用。

7. 萃取液之淨化

於上述萃取及濃縮過程中，與 PCBs 化學性質近似之干擾物質亦將無可避免的被萃取且濃縮成極高的濃度，造成層析時背景值提高或干擾物質波峰與特徵波峰重疊，檢測效率因而降低[2]。此外電子捕捉偵測器（Electron Capture Detector）靈敏度極高，該偵測器除了極易遭到干擾物質之污染（contamination）以外，亦可能遭受因注射濃渡過高而超載（overload）等破壞。ECD 屬於選擇性極高的偵測器，適用於含鹵素族化合物之檢測，但是對於親電性（electrophilic）物質亦有反應，諸如脂肪、鄰苯二甲酸酯與硫元素等皆爲可能的干擾[6]。因此注射前萃取液的淨化處理，目的在有選擇的將待測物與干擾物分開。基質複雜如魚體的萃取液若不經淨化處理，情況嚴重時，將造成層析無法繼續進行的後果，但是對一般輕微情況而言，未經處理之樣品其解析度（resolution）及靈敏度（sensitivity）比淨化處理後之樣品效率降低。

(1) 矽膠管柱之製備

利用丟棄式玻璃吸管當作矽膠塡充管柱，塡充前先將玻璃棉推擠於吸管前端當作塞子，再乾式塡入約 3 公分活化後的矽膠，因爲矽膠屬極性靜相，若空氣中之水分子與矽膠鍵結，將改變矽膠之層析性質，所以矽膠管柱製備後應馬上使用[5]。

(2) 淨化程序

將上述步驟 6 所得之濃縮萃取液，由管柱頂端加入，並控制管柱中溶液流速，當濃縮液液面下降至與矽膠塡充物頂端齊平時，卽以 10 mL 正己烷緩緩沖提並收集沖提液至玻璃瓶中，過多之溶劑則以氮氣吹乾，並溶入 2 mL 之正己烷中供氣相層析定性定量使用。

8. 標準品檢量線之製備

本研究總共取得八種由美國孟山多（Monsanto）公司專利之 PCBs，經分別精稱重量後製備成四種以正己烷爲溶劑之儲存標準混合液（Stock Standard Mixture Solution），第一種混合液中含 Aroclor 1221、1254；第二種含

Aroclor 1242、1260；第三種含 Aroclor 1232、1262；第四種含 Aroclor 1248、1268。四種儲存標準混合液再依次稀釋成五點檢量濃度，其中當做起點之最低濃度，應稍高於 Aroclor 之方法偵測極限，中間濃度應等於最低濃度之四倍，最高濃度應接近但不大於線性定量範圍上限[3]。實際執行時，檢量線之最高濃度爲 2.5 ppm 依次遞減爲 2.0、1.0、0.8 與 0.4 ppm。

9. 感應因子之計算

每一種 PCBs 爲多波峰混合物，感應因子 (calibration factor，CF) 之計算乃由各種 Aroclor 層析圖中選取多個具有特徵的波峰，以波峰面積之和與該 Aroclor 之濃度，依公式 (1) 計算之[3]。

$$CF = \frac{\text{特徵波峰面積之和}}{\text{標準品注射量 (ng)}} \qquad (1)$$

10. 樣品之定性與定量

樣品層析圖獲得後，多氯聯苯之定性方法是辨識並挑選層析圖中與標準品層析圖中類型、滯留時間相同的特徵滯留峰；定量時則將上述所有選出與標準品相同之多個特徵波峰，以其波峰面積之和依公式 (2) 計算多氯聯苯之濃度[3]。

$$\text{濃度 } (\mu g/kg) = \frac{\text{樣品波峰面積之和}}{\text{CF 之平均值}} \times \frac{\text{濃縮萃取液體積 } (\mu L)}{\text{魚肉重 (g)}} \qquad (2)$$

若濃縮萃取液需經稀釋後才適用於檢量線之線性範圍，則眞實樣品之原來濃度應再乘以稀釋倍數。

11. 氣相層析操作條件

本研究所使用之氣相層析儀係採惠普 (Hewlett Packard) 公司所生產之 Series II，並配備電子捕捉偵測器 (ECD)，層析時操作條件設定如後：

純度爲 99.999%之氦氣爲本研究之動相，層析管中之流速爲 5 mL/min；輔助氣體亦爲氦氣。進樣口之溫度設定爲 250°C；樣品注射體積爲 1uL。升溫程式 (temperature programming) 之起始溫度爲 200°C；並於此起始溫度保持恆溫 2 min ；其後即開始第一階段升溫至最終溫度爲 260°C ；所採用之溫度梯度爲 2°C/min ；第二階段升溫之最終溫度爲 280°C ；並採用溫度梯度爲 5°C/min；最後再以升溫程式之最終溫度保持恆溫 5 min；以再生 (regenerate) 管柱。本研究所採用之層析管柱爲 DB-5 由 J&W 公司所製造。

12. 分析方法之品質管制措施

(1) 方法空白 (Method Blank)

不含 PCBs 之魚肉，經過與樣品相同之前處理步驟，亦卽皂化、萃取、濃縮、淨化，且以相同條件做氣相層析。方法空白樣品之執行應間斷性實施，本研究採總樣品數之 10%，在所有空白樣品中，多氯聯苯檢出量不應超過報告偵測極限[5]。

(2) 方法偵測極限

多氯聯苯在某基質中以特定檢測方法所能測得之最低濃度值稱爲方法偵測極限。實際執行時的方法是添加檢量線最低濃度值 3 倍之標準品於魚肉基質中，經所有前處理程序並以 GC/ECD 量測，如此之操作、定量程序分別重覆七次，以七次分析數據計算標準偏差值，其乘以 3 卽爲待測物之方法偵測極限[9]。

(3) 基質添加 (matrix spike recovery，MSR) 與重覆實驗 (matrix spike recovery duplicate，MSRD)

基質添加回收率之計算如公式 (3)[3]：

$$\text{MSR/MSRD}\ (\%)=\frac{\text{添加樣品濃度}-\text{樣品原濃度}}{\text{添加濃度}}\times 100 \qquad (3)$$

三、結果與討論

做爲標準品添加的魚肉由新莊地區超市購買，均爲體長約 20 公分，體重約 360 公克的吳郭魚，因考慮多氯聯苯累積量與魚的體型大小成正比，故不宜挑選太大的魚，每一條魚於使用前爲了解 PCBs 污染之程度，先以薄板層析進行 PCBs 含量粗估[4]，凡未顯示螢光之陰性反應者，視爲適當基質。本實驗以濕重之魚肉開始進行皂化、萃取、淨化等前處理操作，因顧慮乾重需經冷凍、乾燥、均質等複雜手續，極可能引入其他污染，且分析者對於樣品來源不易分辨，故採取較單純的魚肉濕重直接做前處理。

爲了測定魚肉含水份，於每批次實驗進行之同時，另稱取已知濕重之魚肉置烘箱中 (150°C) 乾燥 3～5 日。待重量不變時卽得乾重，濃度以乾重爲主的換算公式如下[5]：

$$\text{乾重濃度}=\text{濕重濃度}\times\frac{100}{100-\text{含水百分比}} \qquad (4)$$

由本實驗同時檢測魚肉中水份含量之結果顯示，含水百分比各批次相近，其平均值爲 74%；若將此值代入 (4) 式極易換算成乾重之濃度。此外，研缽攪碎之魚肉並不影響皂化，顯示此種操作程序之可行性。

含脂肪量高之基質，皂化法爲先行將大分子之脂肪加以分解，以方便下一步驟之溶劑萃取，於是皂化成了整個分析方法的必要且速率限制步驟，爲了加速皂化效率，皂化前基質均質化之程度，皂化液之新舊，皂化時之溫度均爲影響皂化時間長短之因素。

完成皂化後的樣品，則以傳統之液液萃取法，以正己烷有機溶劑自皂化液中連續萃取 PCBs 三次以提高回收率。結果大量的脂肪酸等干擾物質與 PCBs 亦一同被萃取出來，造成後續層析之干擾，因此萃取液之淨化其重要性可想而知。本實驗所採用之淨化管柱，爲傳統式的矽膠填充管柱，雖然在填充矽膠管柱時變因很多，但較之商品化的固相萃取管柱 (solid phase extraction，SPE) 經濟且便宜，若能夠注意矽膠的預先活化、填充以及沖提等過程，以其容量 (capacity) 大之優點，傳統管柱仍爲淨化複雜基質時的好工具。

本次研究計劃共執行了 60 個樣品的分析，其中包括八種不同的 Aroclor (兩種配成一組），五個不同濃度的標準品檢量線共得 20 個標準品樣品。在魚肉基質標準品添加部份，因爲考慮基質的複雜性，故每一基質異於檢量線，只做一種 PCBs 的添加，四次重覆總共分析了 32 個添加樣品。至於品保品管所要求的儀器與方法空白等品管樣品（共八個)，皆依美國環保署合約實驗室 (contract laboratory program，CLP) 分析程序夾於所有樣品中執行分析[5]。因此，共有兩個儀器空白，四個方法空白。因爲參考標準品昂貴且有量的限制，故僅重覆了兩次。

Aroclor 混合物中氯原子的重量比與 ECD 之感應具線性關係，亦即氯原子數愈多者，ECD 感應也愈大[10]，此種關係可由方法偵測極限證實，多氯聯苯之最低檢測值由 Aroclor 1221之 0.2 mg/kg（乾重）逐漸隨 Aroclor 中氯原子重量百分比之增加而降低；而含氯原子重量百分比高達 68% 之 Aroclor 1268 其偵測極限值等於 0.04 mg/kg（乾重）爲八種 PCBs 中之最低者。

1. PCBs 之定性

純的 PCB 標準品注入氣相層析儀附電子捕捉偵測器即可得到如圖 1 的層析圖，數目極多的波峰來自標準品 Aroclor 1232 與 1260 的混合液，層析圖前半部的波峰來自 Aroclor 1232，而後半部則來自 Aroclor 1260。至於 Aroclor 類別之定性乃自各標準品圖譜中挑選特徵波峰鑑定之，亦即每一種 Aroclor 挑選代表性的波峰共十個，表一與表二即顯示 Aroclor 1232 與 1260 用來定性之特徵波峰的滯留時間及滯留時間視窗之計算。

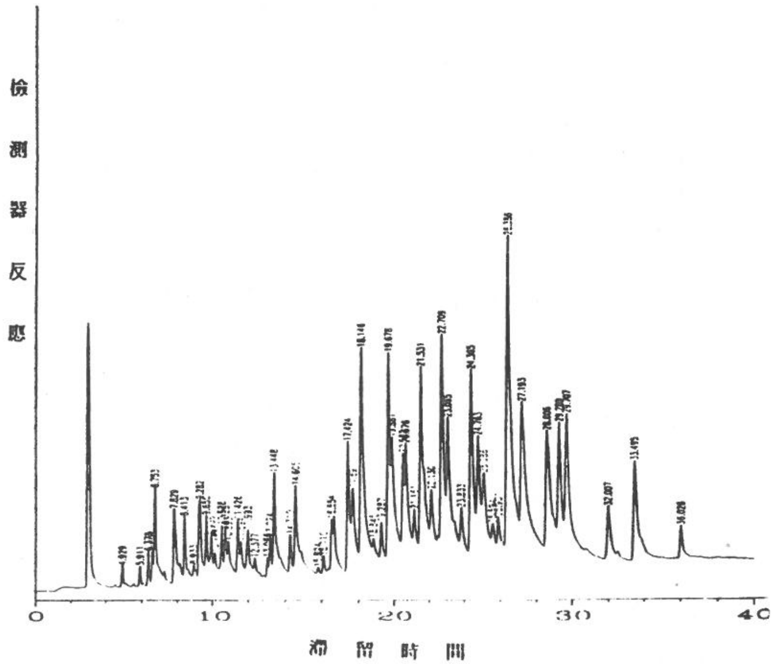

圖 1　Aroclor 1232、1260 混合標準品氣相層析圖。

表一　Aroclor 1232 標準品校正分析

波峰	滯留時間 (min)					平均	RT window	
	1	2	3	4	5	滯留時間	From	To
1	10.513	10.519	10.516	10.528	10.538	10.523	10.550	10.495
2	10.748	10.717	10.711	10.725	10.773	10.735	10.803	10.666
3	10.872	10.800	10.800	10.890	10.897	10.852	10.981	10.723
4	11.408	11.423	11.417	11.426	11.437	11.422	11.451	11.393
5	11.680	11.600	11.585	11.594	11.599	11.612	11.715	11.508
6	11.973	11.979	11.984	11.993	12.003	11.986	12.018	11.955
7	13.200	13.217	13.219	13.224	13.233	13.219	13.251	13.186
8	13.425	13.439	13.441	13.448	13.458	13.442	13.475	13.410
9	14.284	14.300	14.307	14.310	14.319	14.304	14.339	14.269
10	14.582	14.597	14.600	14.605	14.616	14.600	14.633	14.567

RT window = RT mean ±3 standard deviation or ±0.1 whichever is greater.

表二 Aroclor 1260 標準品校正分析

波　峰	滯	留	時	間 (min)		平　均	RT window	
	1	2	3	4	5	滯留時間	From	To
1	17.392	17.411	17.420	17.424	17.43ς	17.416	17.516	17.316
2	18.114	18.134	18.145	18.146	18.157	18.139	18.239	18.039
3	19.640	19.662	19.673	19.678	19.686	19.668	19.768	19.568
4	21.486	21.512	21.527	21.531	21.537	21.519	21.619	21.419
5	22.662	22.689	22.707	22.709	22.715	22.696	22.796	22.596
6	23.018	23.044	23.060	23.065	23.071	23.052	23.152	22.952
7	24.316	24.344	24.366	24.365	24.371	24.352	24.452	24.252
8	26.332	26.362	26.383	26.386	26.389	26.370	26.470	26.270
9	28.541	28.577	28.611	28.606	28.610	28.590	28.690	28.490
10	29.222	29.251	29.276	29.280	29.283	29.262	29.362	29.162
11	29.645	29.671	29.697	29.707	29.703	29.685	29.785	29.585

RT window=RT mean ±3 standard deviation or ±0.1 whichever is greater.

2. PCBs 之定量

樣品經前處理且濃縮後即注入氣相層析儀，圖 2 即是魚肉添加多氯聯苯 1260 所得之層析圖，根據表二 Aroclor 1260 特徵滯留時間視窗 (RT window) 選定十個波峰後，將該等波峰面積總加起來經由公式 (2) 計算樣品中 Aroclor 1260 的濃度。

3. 回收率

每一種 PCBs 之四次添加樣品，經皂化、萃取、淨化等操作後，計算其濃度並與已知添加量相比較以公式 (3) 計算回收率，32 個添加樣品之回收率列於表三，顯示了四次回收率實驗之數值，亦包括標準品添加量、測得量等數據。除了 Aroclor 1221 回收率顯著偏低外，由其他各種 Aroclor 所得回收率皆在 100% 左右顯示，本研究方法之可用性及操作人員技能之一致性，事實上，Aroclor 1221 具有頗高的蒸氣壓，其揮發速率與 Aroclor 1260 比較，幾乎大了 200 倍[7]，因此，Aroclor 1221 可能在前處理過程中揮發散失。

4. 參考標準品之測試

為了達成研究數據合乎品質要求，本實驗除了進行單一實驗室內魚肉標準品添加之重覆測試外，且取得外購自國際原子能總署之均質冷凍乾燥魚肉參考標準

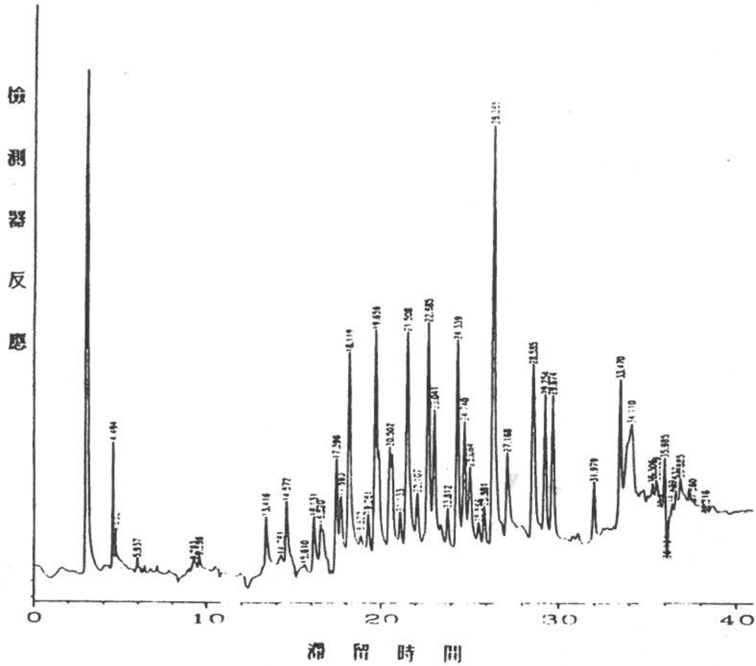

圖 2 魚肉基質添加 Aroclor 1260 氣相層析圖。

樣品，經由與上述樣品相同之皂化、萃取、淨化等前處理與氣相層析程序後，其氣相層析圖依特徵波峰法逐一與標準品圖譜之滯留時間視窗詳細比對，結果定性為多氯聯苯 1254，兩個重覆樣品所含之 Aroclor 1254 經由檢量線計算後各為 0.62 與 0.76 ppm 。此二數值與原子能總署之建議值相近，證明本研究方法之可信性。

四、謝 誌

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表三 PCBs 標準品添加魚肉基質重覆實驗 ($n=4$)

添加標準品		添加量 (μg)	測得量 (μg)	回收率 (%)
1221	一	2	1.06	53
	二		0.66	33
	三		0.56	28
	四		0.60	30
1232	一	2	1.30	65
	二		1.28	64
	三		1.50	75
	四		1.46	73
1242	一	2	2.20	110
	二		2.23	116
	三		1.76	88
	四		1.62	81
1248	一	2	1.38	69
	二		1.60	80
	三		1.54	77
	四		1.48	74
1254	一	2	1.78	89
	二		1.88	94
	三		2.26	113
	四		1.96	98
1260	一	2	2.28	114
	二		2.34	117
	三		1.66	83
	四		2.20	110
1262	一	2	2.32	116
	二		2.48	124
	三		2.08	104
	四		2.88	144
1268	一	2	1.30	65
	二		1.24	67
	三		1.42	71
	四		1.58	79

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The Method of Study Polychlorinated Biphenyls in Fish Tissues

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ABSTRACT

Before 1970's, polychlorinated biphenyls (PCBs) characterized by their chemical inertness and heat stability were one of the most manufactured and utilized compounds in many industrial applications. Due to the unawareness and ignorance of their toxicity to human health, PCBs were errorneously handled and disposed for a very long period of time, and therefore, they are one of the major known contaminants on earth. Moreover, because of their bio-stable and undegradable nature, PCBs have found accumulated to warning concentrations in higher levels of food chain. In order to detect their presence in complex matrices, we spiked eight available PCB standards into real fish tissue, followed by saponification, hexane extraction, florisil cleanning up and then analyzed the extract by GC/ECD.

ONE POT SYNTHESIS OF 3-METHYL-4′-SUBSTITUTED-4-STYRYLPYRIDINE METHIODIDE

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ABSTRACT

3-Methyl-4′-substituted-4-styrylpyridine methiodide derivatives are readily synthesized in excellent yields by sequentially mixing lutidine with methyl iodide under methanol reflux and adding various aryl aldehydes and using piperidine as catalyst.

1. INTRODUCTION

Recently, it has received much attention in the synthesis of noncentrosymmetric organic compounds for non-linear optics(1). We wish to report here a facile one pot synthesis of a series of 3-methyl-4′-substituted-4-styrylpyridine methiodides which might crystallize noncentrosymmetrically. Synthesis of such compounds could possibly be done in two ways. First, 3-methyl-4′-substituted-4-styrylpyridine may be prepared by reacting various aryl aldehydes with lutidine at 200°C using $ZnCl_2$ as catalyst(2) (or in refluxing acetic anhydride(3) for non-acid-sensitive compounds), then reacting with methyl iodide to form its quaternary salts. However, this method is not appealing to us because many functionalities can not be introduced under such vigorous reaction conditions and poor yields are usually obtained. Second, perparation of 3-methyl-4′-substituted-4-styrylpyridine methiodide could be done by condensation reactions(4) between various aryl aldehydes with lutidine methiodide using piperidine as the catalyst in which lutidine methiodide can be prepared by reacting lutidine with methyl iodide under methanol reflux. This type of reactions usually proceeds under mild conditions and reactants can preserve various functionalities.

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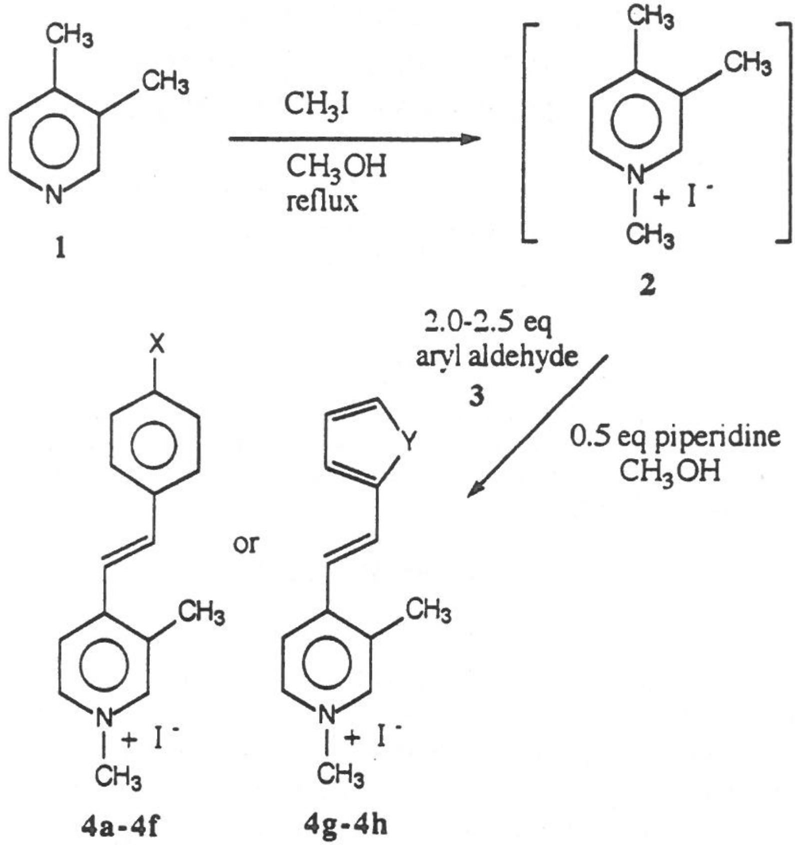

Scheme: Synthesis of 3-methyl-4′-substituted-4-styrylpyridine methiodide

In our experiment, lutidine **1** was used to react with methyl iodide under methanol reflux to form lutidine methiodide **2** (Scheme). Since lutidine methiodide was hygroscopic, weighing was a serious problem for the second step of condensation reaction. Also because of the same solvent (methanol) was to be used for reactions between lutidine methiodide and aryl aldehydes **3**, it would be better not to isolate intermediate **2** and subsequently add 2.0-2.5 equivalents of various functionized aryl aldehydes **3** and use about 0.5 equivalents of piperidine as catalyst. Yields of these reactions were found good to excellent (70-98%, see Table 1). Trans isomers were found to be the only products in all of our reactions which could be easily identified by

Table 1. Physical properties of 3-methyl-4′-substituted-4-styrylpyridine methiodide

Comp.	XorY	Yield (%)	mp. (±1°C)	Mass[b] (m/e, %)	¹H NMR (δ)	λ_{max} (nm)
4a	None	90	251	195(100) 142(33)	2.54 (*s*, 3H), 4.22 (*s*, 3H), 7.49 (*m*, 4H), 7.82 (*dd*, 2H, *J*=7.5, 1.6 Hz), 7.92 (*d*, 1H, *J*=16.2 Hz), 8.38 (*d*, 1H, *J*=6.6 Hz), 8.75 (*d*, 1H, *J*=6.6 Hz), 8.81 (*s*, 1H)	346
4b	OCH_3	94	241	225(100) 142(29)	2.52 (*s*, 3H), 3.82 (*s*, 3H), 4.19 (*s*, 3H), 7.04 (*d*, 2H, *J*=8.7 Hz), 7.31 (*d*, 1H, *J*=16.2 Hz), 7.79 (*d*, 2H, *J*=8.7 Hz), 7.90 (*d*, 1H, *J*=16.2 Hz), 8.33 (*d*, 1H, *J*=6.6 Hz), 8.69 (*d*, 1H, *J*=6.6 Hz), 8.76 (*s*, 1H)	380
4c	$N(CH_3)_2$	90	262	238(100) 142(50)	2.47 (*s*, 3H), 3.00 (*s*, 6H), 4.14 (*s*, 3H), 6.76 (*d*, 2H, *J*=8.8 Hz), 7.11 (*d*, 1H, *J*=15.9 Hz), 7.65 (*d*, 2H, *J*=8.8 Hz), 7.86 (*d*, 1H, *J*=15.9 Hz), 8.25 (*d*, 1H, *J*=6.7 Hz), 8.58 (*d*, 1H, *J*=6.7 Hz), 8.65 (*s*, 1H)	475
4d	$N(C_2H_5)_2$	80	232	266(66) 142(15)	1.03 (*t*, 6H, *J*=7.0 Hz), 2.46 (*s*, 3H), 3.41 (*q*, 4H, *J*=7.0 Hz), 4.13 (*s*, 3H), 6.72 (*d*, 2H, *J*=8.8 Hz), 7.06 (*d*, 1H, *J*=15.9 Hz), 7.63 (*d*, 2H, *J*=8.8 Hz), 7.85 (*d*, 1H, *J*=15.9 Hz), 8.24 (*d*, 1H, *J*=6.7 Hz), 8.56 (*d*, 1H, *J*=6.7 Hz), 8.63 (*s*, 1H)	489
4e	OH	70	309	211(83) 142(100)	2.48 (*s*, 3H), 4.18 (*s*, 3H), 6.63 (*d*, 2H, *J*=8.6 Hz), 7.19 (*d*, 1H, *J*=16.1 Hz), 7.67 (*d*, 2H, *J*=8.6 Hz), 7.85 (*d*, 1H, *J*=16.1 Hz), 8.31 (*d*, 1H, *J*=6.7 Hz), 8.65 (*d*, 1H, *J*=6.7 Hz), 8.74 (*s*, 1H), 10.08 (*s*, 1H)	394
4f	F	75	254	213(100) 142(40)	2.54 (*s*, 3H), 4.23 (*s*, 3H), 7.32 (*t*, 2H, *J*=8.8 Hz), 7.44 (*d*, 1H, *J*=16.2 Hz), 7.91 (*m*, 3H), 8.37 (*d*, 1H, *J*=6.6 Hz), 8.75 (*d*, 1H, 6.6 Hz), 8.83 (*s*, 1H)	345

Table 1. Physical properties of 3-methyl-4′-substituted-4-styrylpyridine methiodide (Continued)

Comp.	XorY	Yield (%)	mp. (±1°C)	Mass[b] (m/e,%)	¹H NMR (δ)	λ_{max} (nm)
4g	O[a]	94	222	185(100) 142(61)	2.48 (*s*, 3H), 4.19 (*s*, 3H), 6.70 (*dd*, 1H, *J*=3.4, 2.9 Hz), 6.98 (*d*, 1H, *J*=3.4 Hz), 7.12 (*d*, 1H, *J*=16.0 Hz), 7.81 (*d*, 1H, *J*=16.0 Hz), 7.93 (*d*, 1H, *J*=1.5), 8.31 (*d*, 1H, *J*=6.6 Hz), 8.70 (*d*, 1H, *J*=6.6 Hz), 8.78 (*s*, 1H)	379
4h	S[a]	98	237	201(100) 142(45)	2.48 (*s*, 3H), 4.19 (*s*, 3H), 7.12 (*d*, 1H, *J*=16.0 Hz), 7.20 (*dd*, 1H, *J*=4.9, 4.4 Hz), 7.59 (*d*, 1H, *J*=3.6 Hz), 7.79 (*d*, 1H, *J*=4.9 Hz), 8.14 (*d*, 1H, *J*=16.0 Hz), 8.32 (*d*, 1H, *J*=6.7 Hz), 8.71 (*d*, 1H, *J*=6.7 Hz), 8.77 (*s*, 1H)	379

[a] The aryl aldehyde was Furfural, 2-thiophenaldehyde.
[b] EI mode.

¹H NMR spectra. Yields of **4g** and **4h** (Table 1) were found even superior to those obtained by Philips' method[4] in which picoline methiodide was isolated.

Previously, it was arqued[5] that 3-picoline could also react with arylaldehydes under the same conditions used for 2-or 4-picoline. However, from ¹H NMR and X-ray diffraction analysis. ue do not find any isomers such as 4-methyl-4′-substituted-3-styrylpyridine methiodides from all of our reactions.

2. EXPERIMENTAL

Substituted aryl aldehydes (Aldrich) were used as received. Lutidine was distilled and stored over potassium hydroxide. Methanol was used without purification. Melting points were measured by a Du Pont 910 & 9900 DSC with heating reat at 10°C/min (calibrated by Indinium). The ¹H NMR spectra were recorded on a Bruker AM-300 spectrometer. The MS spectra were obtained by using a Jeol Jms Sx/Sx 102A system at 70 eV. UV-VIS absorption spectra were recorded by a Shimadsu UV-160A spectrometer. Infrared spectra were recorded by Beckman instrument.

3. GENERAL PROCEDURE

A typical procedure is as follows. To a round bottom flask were added 3,4-lutidine (0.5 ml, 4.48 mmol) and methyl iodide (0.5 ml, 8.03 mmol). The mixture was stirred under 2 ml of methanol reflux for one hour. After cooling to room temperature, another 5 ml of methanol was added, followed by the aryl aldehyde (2.0-2.5 eq) and about 0.3 ml of piperidine (0.5 eq). The resulting solution was heated to reflux with stirring for another three hours. After the solution was cooled to 0°C, 20-30 ml of ethyl ether was then added to precipitate the products. After filtration under reduced pressure, the crude products of 3-methyl-4′-substituted-4-styrylpyridine methiodide were isolated. Yields of crude products were about 70-98%. Recrystallization was done in CH_3OH/CH_2Cl_2 (1:3).

4. ACKNOWLEDGEMENT

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3-甲基-4′-取代-4-苯乙烯基吡啶甲基碘的合成

賈文隆 陳俊男

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摘 要

以 3,4- 二甲基吡啶和甲基碘反應形成四級鹽類接著就在 piperidine 的催化下與一系列芳香醛類反應，合成一系列 3- 甲基 -4- 對位取代苯乙烯基啶吡甲基碘化合物此反應條件溫和，有良好的產率。

GENERAL REALIZATION FOR THE z AND y PARAMETERS OF MULTITERMINAL NETWORKS USING CCII

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ABSTRACT

This paper proposes systematic methods to synthesise the z and y parameters of linear, time-invariant and relaxed multiterminal networks. The z and y parameters can be nonreciprocal and independent of one antoher. The number of minus-type of current conveyor (CCII-) is very few.

1. INTRODUCTION

Second generation current conveyors have been found useful in many applications. In recent years, they are applied to the realization of floating and grounded immittances and z and y parameters of multiports with all poles and zeros being in the open left half plane (Hou and Wu et al., 1993; Hou and Chen et al., 1993)[1,2]. One of the most important subclasses of multiports is the multiterminal network, i.e., the "grounded" multiport. This paper deals with the z and y parameters of this type of network. On the other hand, few CCII- are needed to achieve the realized object.

2. CIRCUIT CONFIGURATIONS

Nullors[3~5] are used to provide a common framework for considering current-conveyor and operational-amplifier circuits. A nullor shown in Fig. 1 is the two-port network that has the null transmission matrix; that is, it is characterized by the terminal equations.

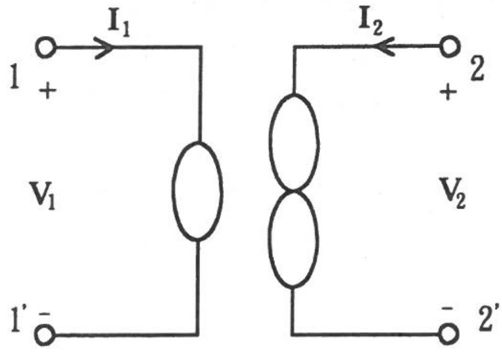


Fig. 1. Symbol of nullor.

$$\begin{bmatrix} V_1(s) \\ I_1(s) \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} V_2(s) \\ -I_2(s) \end{bmatrix}$$

To assist in further use of nullor theory, it is convenient to separate the input terminals 1-1′ and to think of the resultant one-port as an element with the property that it maintains zero voltage between its terminals and maintains zero current flow between its terminals; this element is called a nullator. A nullator shown in Fig. 2 is a one-port network defined by the terminal constraints.

$$V_1(s) = I_1(s) = 0$$

or

$$v_1(t) = i_1(t) = 0$$

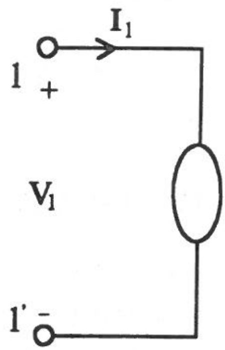


Fig. 2. Symbol of nullator.

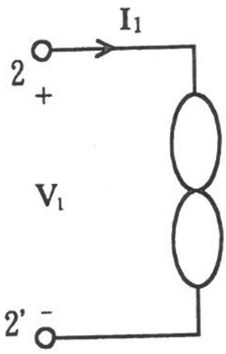


Fig. 3. Symbol of norator.

It is also convenient to separate the output terminals 2-2′ from the nullor and define a separate one-port, known as norator. A norator shown in Fig. 3 is a one-port network for which the terminal voltage $v_1(t)$ and the terminal current $i_1(t)$ are unconstrained; that is,

$$V_1(s)\equiv\text{arbitrary} \qquad I_1(s)\equiv\text{arbitrary}$$

or

$$v_1(t)\equiv\text{arbitrary} \qquad i_1(t)\equiv\text{arbitrary}^{(4)}$$

Assuming CCII- be ideal ($i_y=0$, $v_x=v_y$, $i_z=-i_x$), a CCII- may be represented by a nullator-norator pair, as shown in Fig. 4.

The equations of z parameters of the n-terminal network is given below:

$$\begin{pmatrix} V_1 \\ V_2 \\ \vdots \\ V_n \end{pmatrix} = \begin{pmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{nn} \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ \vdots \\ I_n \end{pmatrix} \tag{1}$$

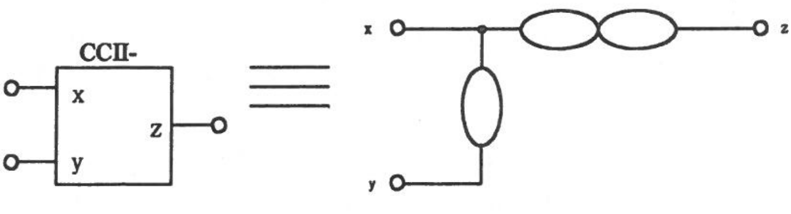


Fig. 4. Nullator-norator model of minus-type CCII.

The steps of the realization of z parameters are listed as follows:

(i) In Eq. (1), the same current I_1 flows through $z_{11}, z_{12}, \cdots, z_{1n}$. The impedance z_{11} is connected in series with the V_1 input terminal. A norator can be added between z_{i1} and $z_{(i+1)1}$ ($i=1, 2, \cdots, n$). The impedance z_{n1} is grounded. The same methods are applied to the othe groups. The results are shown in Fig. 5(a).

(ii) Nullators are added to the pairs of node (B, E), (A, J) $\cdots$ et al.. The nullator-norator representation of Eq. (1) is shown in Fig. 5(b).

(iii) By replacing nullator-norator pair with CCII-, the network in Fig. 5(b) can be converted to the n-terminal realization circuit in Fig. 5(c).

The equations of y parameters of the n-terminal network is given below:

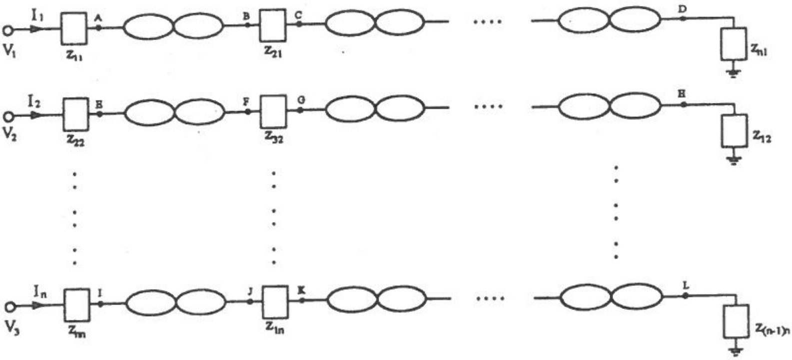
$$\begin{pmatrix} I_1 \\ I_2 \\ \vdots \\ I_n \end{pmatrix} = \begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & & \vdots \\ y_{n1} & y_{n2} & \cdots & y_{nn} \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \\ \vdots \\ V_n \end{pmatrix} \tag{2}$$

The steps of the realization of y parameters are listed below:

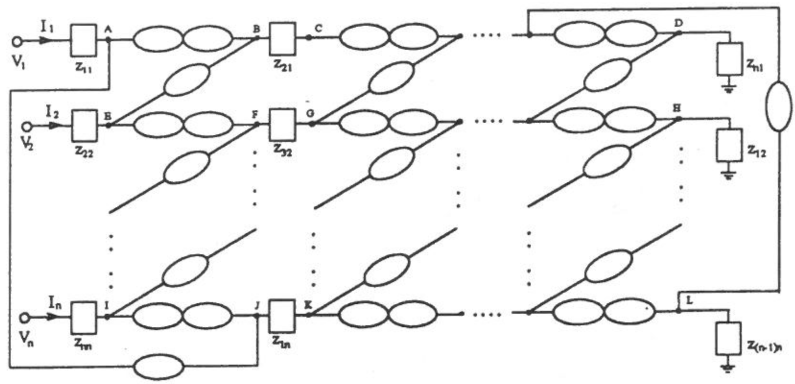
(i) In Eq. (2), the same voltage V_1 is across each grounded admittance $y_{11}, y_{21}, \cdots, y_{n1}$. A nullator can be added between the non-grounded terminals of y_{11} and y_{21}. The same methods are applied to groups of $y_{i2}, y_{(i+1)2}, \cdots, y_{in}$ and $y_{(i+1)n}$ ($i=1, 2, \cdots, n$). This result is shown in Fig. 6(a).

(ii) Norators are added to the pairs of node (A', B'), (D', E'), (G', H') $\cdots$ et al. in order to satisfy the nullator-norator representation of Eq. (2) show in Fig. 6(b).

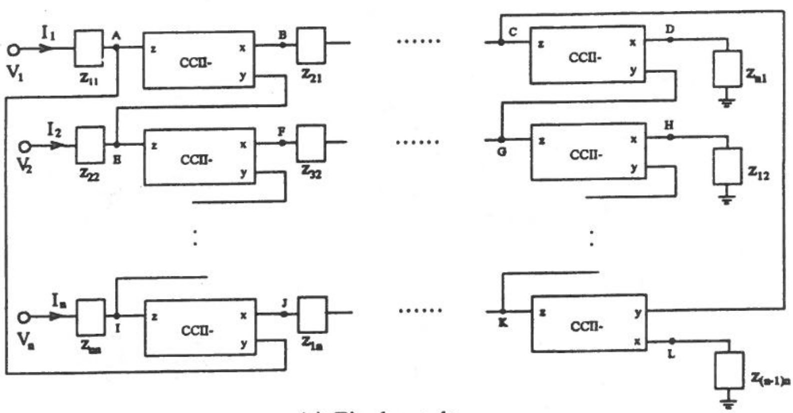
(iii) By replacing nullator-norator pair with CCII-, the network in Fig. 6(b) can be constructed to the n-terminal realization circuit in Fig. 6(c).



(a) First step

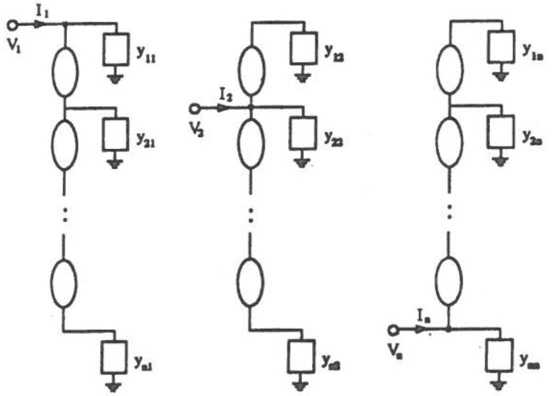


(b) Second step

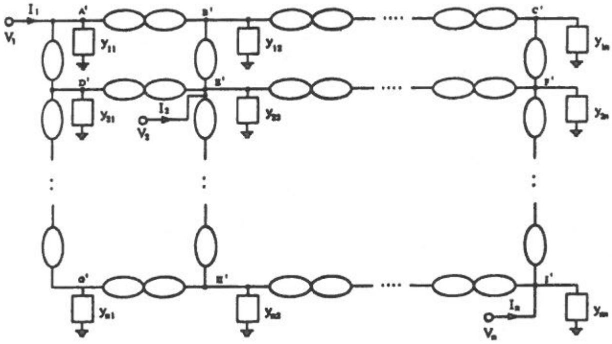


(c) Final result

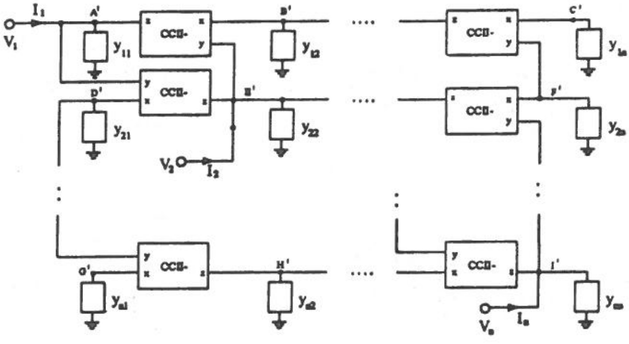
Fig. 5. Realization of *N*-terminal network of Eq. (1).



(a) First step



(b) Second step



(c) Final result

Fig. 6. Realization of N-terminal network of Eq. (2).

For simplicity and without losing generalization, a 4-terminal network is considered.

(1) The equations of z parameters are given below:

$$\left.\begin{aligned} v_1 &= z_{11}I_1 + z_{12}I_2 + z_{13}I_3 \\ v_2 &= z_{21}I_1 + z_{22}I_2 + z_{23}I_3 \\ v_3 &= z_{31}I_1 + z_{32}I_2 + z_{33}I_3 \end{aligned}\right\} \qquad (3)$$

The steps of the realization of z parameters are listed as follows:

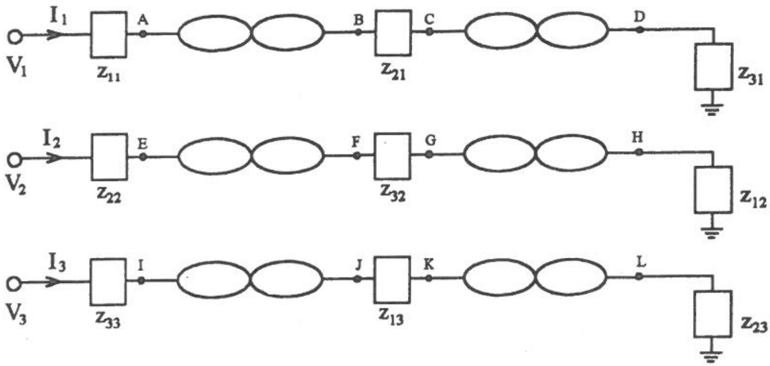
(i) In Eq. (3), the same current I_1 flows through z_{11}, z_{21} and z_{31}. The impedance z_{11} is connected in series with the V_1 input terminal. A norator can be added between z_{11} and z_{21}. Another norator is added between z_{21} and z_{31}. The impedance z_{31} is grounded (z_{jk} is grounded, if $j \neq k$ is the only grounded impedance with current I_k flowing through and is the only grounded impedance in the jth equation of Eq. (3). The same methods are applied to the other two groups of z_{22}, z_{32}, z_{12} and z_{33}, z_{13}, z_{23}. The result is shown in Fig. 7(a).

(ii) Nullators are added to the pairs of nodes (A, J) and (K, H) in order to satisfy the first equation of Eq. (3). Similarly, nullators are added to node pairs (E, B), (C, L) as well as node pairs (I, F), (G, D) to satisfy the second and the third equations of Eq. (3). The nullator-norator representation of Eq. (3) is shown in Fig. 7(b).

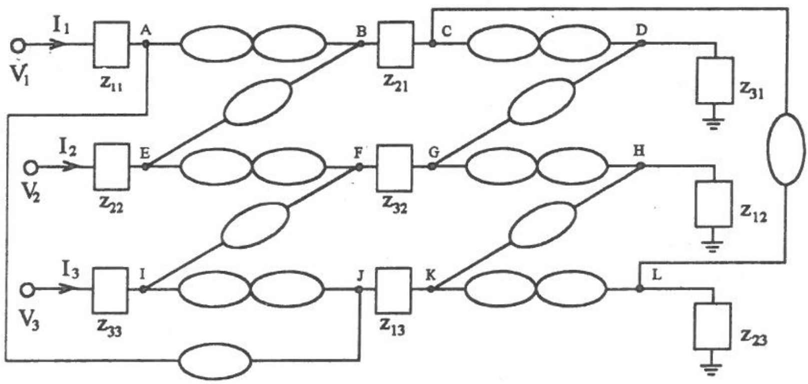
(iii) If all the z parameters with the total poles and zeros being in the open left half plane, the impedance of the z parameters can be synthesised (Hou and Wu et al., 1993; Hou and Chen et al., 1993). The same procedure can be applied to 3-termined and multiterminal networks.

(iv) By replacing nullator-norator pair (A, B, E), (E, F, I), (I, J, A), (C, D, G), (G, H, K), (K, L, C) with CCII-, the network in Fig. 7(b) can be converted to the 3-terminal realization circuit in Fig. 7(c).

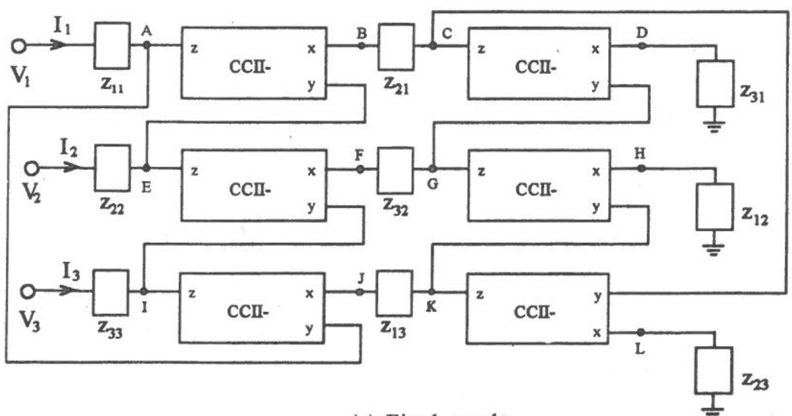
(2) The equations of y parameters of a multiterminal networks is given as follows:



(a) First step



(b) Second step



(c) Final result

Fig. 7. Realization of 3-terminal network of Eq. (3).

$$\left.\begin{aligned} I_1&=y_{11}v_1+y_{12}v_2+y_{13}v_3 \\ I_2&=y_{21}v_1+y_{22}v_2+y_{23}v_3 \\ I_3&=y_{31}v_1+y_{32}v_2+y_{33}v_3 \end{aligned}\right\} \tag{4}$$

The steps of the realization of y parameters are listed below:

(i) In Eq. (4), the same voltage drop V_1 is across each grounded admittance y_{11}, y_{21}, y_{31}. A nullator can be added between the non-grounded terminals of y_{11} and y_{21}. Another nullator is added between the non-grounded terminals of y_{21} and y_{31}. The same methods are applied to the groups of y_{12}, y_{22}, y_{32} and y_{13}, y_{23}, y_{33}. This result is shown in Fig. 8(a).

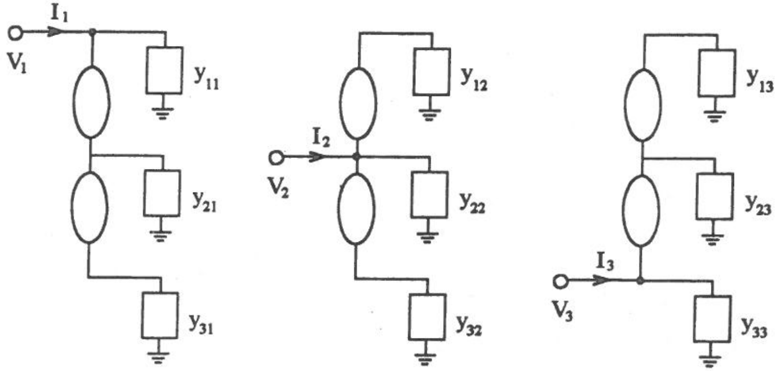
(ii) Norators are added to the pairs of nodes (A', B') and (B', C') in order to satisfy the first equation of Eq. (4). Similarly, norators are added to node pairs (D', F'), (E', F') as well as node pairs (G', H'), (H', I') to satisfy the second and the third equations of Eq. (4). The nullator-norator representation of Eq. (4) is shown in Fig. 8(b).

(iii) If all the y parameters with the whole poles and zeros being in the open left half plane, the admittances of the y parameters can be synthesised (Hou and Wu et al., 1993; Hou and Chen et al., 1993). The same procedure can be applied to 3-terminal and multiterminal networks.

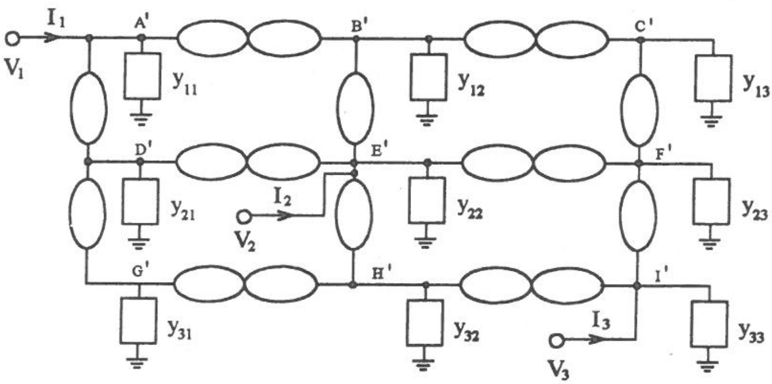
(iv) By replacing nullator-norator pair (A', B', E'), (A', D', E'), (D', G', H'), (B', C', F'), (E', F', I'), (E', H', I') with CCII-, the network in Fig. 8(b) can be constructed to the 3-terminal realization circuit in Fig. 8(c).

3. EXPERIMENTAL RESULTS

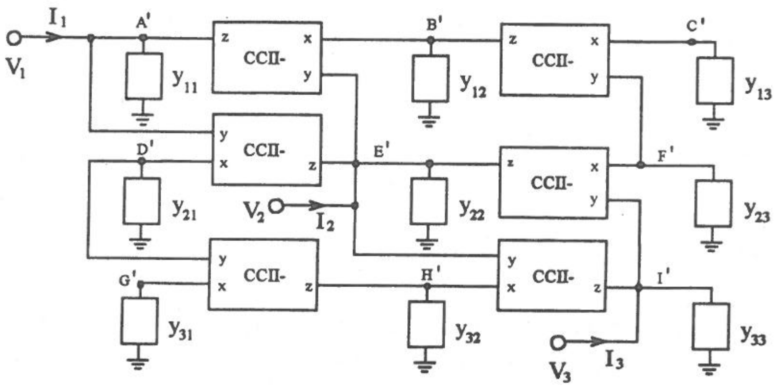
In order to verify the theoretical prediction of the proposed z and y parameters of multiterminal networks, two experiments are demonstrated. The operational amplifier (AD 844) is chosen as the CCII. In Fig. 7(c), let $z_{11}=1\ \text{K}\Omega$, $z_{12}=9\ \text{K}\Omega$, $z_{13}=5\ \text{K}\Omega$, $z_{21}=3\ \text{K}\Omega$, $z_{22}=8\ \text{K}\Omega$, $z_{23}=2\ \text{K}\Omega$, $z_{31}=4\ \text{K}\Omega$, $z_{32}=6\ \text{K}\Omega$, $z_{33}=7\ \text{K}\Omega$ and $V_1=V_2=V_3=5\ \text{V}$. The $I_1=0.387$ mA, $I_2=0.445$ mA and $I_3=0.105$ mA were got. In Fig. 8(c), let $y_{11}=1$ milli-siemens,



(a) First step



(b) Second step



(c) Final result

Fig. 8. Realization of 3-terminal network of Eq. (4).

y_{21}=9 milli-siemens, y_{13}=5 milli-siemens, y_{21}=3 milli-siemens, y_{22}= 8 milli-siemens, y_{23}=2 milli-siemens, y_{31}=4 milli-siemens, y_{32}=6 milli-siemens, y_{33}=7 milli-siemens and $I_1=I_2=I_3=100\ \mu A$. The $V_1=7.69$ mV, $V_2=9.09$ mV and $V_3=2.09$ mV were found. They agree with the theoretical analysis well.

4. CONCLUSION

The systematic methods to realize the z and y parameters of linear, time-invariant and relaxed multiterminal networks are given. It is necessary that all the poles and zeros of the z and y parameters are in the open left half plane. The z and y parameters can be nonreciprocal. They may or may not have a relation with any others. For z or y parameters of an $(n+1)$ terminal network, $n(n-1)$ CCII- are required. The number of CCII- is very few.

5. ACKNOWLEDGMENT

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使用第二代電流傳輸器實體化多端點網路的 z 及 y 參數

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摘　　要

本文對合成線性不隨時變無起始值的多端點網路的 z 及 y 參數提出一個有系統之方法。這些 z 參數及 y 參數可不爲互易且彼此無關。同時使用了少數量的第二代電流傳輸器。

ANALYSIS OF A MULTIPLE WINDING INDUCTION MACHINE WITH SATURATION AND HYSTERESIS OF MAGNETIZING BRANCH

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ABSTRACT

A dynamic model of multiple winding induction machines that includes saturation and hysteresis of the magnetizing branch is presented. A novel describing function is used to represent the nonlinearity of the magnetization curve of a magnetic core. Steady state and transient analysis are presented to show the significant influence of the magnetizing core nonlinearity on induction motor dynamics. Simulation results and harmonic analysis demonstrate that not only can the torque pulsation amplitude be reduced, but the system performance is also improved through a multiple inverter feeding to a multiple winding induction machine with proper winding displacement angle.

1. INTRODUCTION

A multiphase machine has much benefit in the industry applications, such as to improve reliability, to reduce the torque pulsations and rotor harmonic power loss for inverter feeding motors(1), and to extend a relatively low upper limit on voltage and current(2,3). The modeling and analysis of a multiple winding induction machine based on constant parameters is proposed by Nelson and Krause(3). Saturation phenomenon in induction machines has called much author's attention(4~6). An improved saturation model that considers the saturation in both rotor and stator cores is introduced in(4). Moreira et al. have presented a model of saturated induction machine which includes the flux space harmonic components traveling in the air gap location(5). Kerkman proposed a polynomial function approached induction motor model in arbitrary reference frame that includes saturation of the magnetizing branch[6]. In practice, the dynamic performance of induction machines, such as the torque pulsating characteristic, is significantly influenced by the nonlinearity and hysteresis of the magnetizing core. However, none of the above methods has considered the hysteresis effects of the magnetizing path in a machine.

In this paper, a multiple winding induction machine model that incorporates saturation and hysteresis characteristic of the magnetizing branch is proposed. The derived model can be used to predict the dynamic behavior and harmonic performance of the transient and steady state. Digital computer simulation and spectrum analysis are introduced to show the validity of our model. Simulation results demonstrate that the nonlinearity of saturation and hystersis, and the displacement angle between multiple stator winding sets have played a significant role in the dynamic behavior of induction machines.

2. MACHINE EQUATIONS INCLUDING SATURATION AND HYSTERESIS EFFECTS

The dynamic equations of a multiple winding induction machine with N sets of identical three phase stator winding and M sets of rotor winding are presented in Appendix. In order to simplify the process of modeling an induction machine saturation effects, it is achieved by properly selecting the magnetizing flux linkage and rotor current as the state variables. The magnetizing flux linkage is separated from the leakage flux linkage in the derivation. Although this is not rigorous precision, such selection is convenient for transient analysis approach[6]. Because an ungrounded source system and a symmetrical winding machine are the most often employed, therefore, the zero sequence component will be neglected in the following sessions. The multiple winding machine equations then can be expressed in matrix form as

$$\begin{bmatrix} V_{qds} \\ V'_{qds} \end{bmatrix} = \begin{bmatrix} \bar{R}_s & \bar{0} \\ \bar{0} & \bar{R}'_r \end{bmatrix} \begin{bmatrix} i_{qds} \\ i'_{qdr} \end{bmatrix} + \frac{1}{\omega_b} \begin{bmatrix} \bar{X}_{1s} & \bar{0} \\ \bar{0} & \bar{X}'_{1r} \end{bmatrix} \frac{d}{dt} \begin{bmatrix} i_{qds} \\ i'_{qdr} \end{bmatrix}$$
$$+ \frac{1}{\omega_b} \begin{bmatrix} \overline{\omega X} & \bar{0} \\ \bar{0} & \overline{(\omega-\omega_r) X} \end{bmatrix} \begin{bmatrix} i_{qds} \\ i'_{qdr} \end{bmatrix} + \begin{bmatrix} \bar{p} + \overline{\omega D} \\ \bar{p} + \overline{(\omega-\omega_r) D} \end{bmatrix} [\lambda_{mpd}] \qquad (1)$$

where all vectors and matrices are same with the Eq. (A-1) except for neglect of the zero sequence components. The electromanetic torque and swing equation of the induction machine are

$$T_e=\frac{3}{2}\times\frac{\text{pole}}{2}\times\left\{\lambda_{md}\left[f_1(\lambda_{mq},\ \lambda_{md})-\sum_{j=1}^{M}i'_{qrj}\right]\right.$$
$$\left.-\lambda_{mq}\left[f_2(\lambda_{mq},\ \lambda_{md})-\sum_{j=1}^{M}i'_{drj}\right]\right\} \quad (2)$$

$$J\frac{d\omega_r}{dt}+T_L=T_e \quad (3)$$

Note that in Eq. (2) the algebraic relationship between the magnetizing flux linkage and magnetizing current has not been formulated. The magnetizing current versus the magnetizing flux linkage of the magnetizing branch is sketched in Fig. 1. A novel describing function is first proposed to express the saturation and hysteresis of the magnetizing branch, that is,

$$i_m=f(\lambda_m)=k_1\lambda_m+k_3\lambda_m^3+k_5\lambda_m^5+k_7\lambda_m^7+I_{hs}\sin(\omega_e t+\alpha) \quad (4)$$

The nature of the describing function is an inverse function of the normal magnetization curve. In the above equation, the first four odd power polynomial terms, λ_m's, express the saturation characteristic of the magnetizing branch, and the last sinusoidal term represents the hysteresis characteristic of the core, where I_{hs} is the coercive force current component of the magnetizing branch. The parameters of the Eq. (4), are determined by numerical approximation algorithm according to the corresponding magnetization curve. In the linear case, $f(\lambda_m)$ becomes

$$i_m=k_1\lambda_m \quad (5)$$

For a three phase machine system, the three phase describing function, Eq. (4), can be transformed into q and d components by Park's transformation principle[3]. The q and d stator current equations, related to the magnetizing flux linkage and rotor current, can be written as

$$i_{qs}=\sum_{j=1}^{N}i_{qsj}=k_1\lambda_{mq}+\lambda_{mq}(k_3\lambda_{md}^2+k_5\lambda_{md}^4+k_7\lambda_{md}^6)$$
$$+\sqrt{2}I_{hs}\sin(\omega_e t+\alpha)-\sum_{j=1}^{M}i'_{qrj} \quad (6)$$

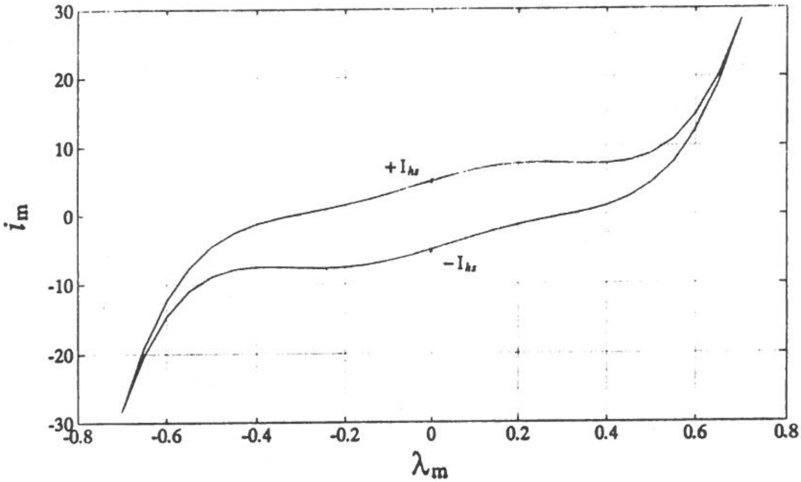


Fig. 1. Saturation data and describing function approximation current versus flux.

$$i_{ds}=\sum_{j=1}^{N} i_{dsj}=k_1\lambda_{md}+\lambda_{md}(k_3\lambda_{mq}^2+k_5\lambda_{mq}^4+k_7\lambda_{mq}^6)$$
$$+\sqrt{2}\,I_{hs}\cos(\omega_e t+\alpha)-\sum_{j=1}^{M} i'_{drj} \tag{7}$$

For an identical N sets of stator winding of a conventional induction machine, combing the q- and d-axis voltage of N sets stator winding, the stator voltage vectors of the multiple winding induction machine can be formed as

$$\Sigma V_{qds}=\begin{bmatrix}\Sigma V_{qs}\\ \Sigma V_{ds}\end{bmatrix}=\begin{bmatrix}\sum_{j=1}^{N} V_{qsj}\\ \sum_{j=1}^{N} V_{dsj}\end{bmatrix}=\begin{bmatrix}R_{s1} & 0\\ 0 & R_{s1}\end{bmatrix}\begin{bmatrix}\sum_{j=1}^{N} i_{qsj}\\ \sum_{j=1}^{N} i_{dsj}\end{bmatrix}$$
$$+\frac{1}{\omega_b}\begin{bmatrix}0 & \omega X_{1s1}\\ \omega X_{1s1} & 0\end{bmatrix}\begin{bmatrix}\sum_{j=1}^{N} i_{qsj}\\ \sum_{j=1}^{N} i_{dsj}\end{bmatrix}$$
$$+\frac{1}{\omega_b}\begin{bmatrix}X_{1s1} & 0\\ 0 & X_{1s1}\end{bmatrix}\frac{d}{dt}\begin{bmatrix}\sum_{j=1}^{N} i_{qsj}\\ \sum_{j=1}^{N} i_{dsj}\end{bmatrix}$$
$$+\begin{bmatrix}N & 0\\ 0 & N\end{bmatrix}\frac{d}{dt}\begin{bmatrix}\lambda_{mq}\\ \lambda_{md}\end{bmatrix}+\begin{bmatrix}0 & N\omega\\ N\omega & 0\end{bmatrix}\begin{bmatrix}\lambda_{mq}\\ \lambda_{md}\end{bmatrix} \tag{8}$$

Substituting Eqs. (6) and (7) into Eq. (8). And combing with the rotor voltage vectors V'_{qdr} of Eq. (1), the complete induction machine model for indentical N sets of stator winding and M sets of rotor winding are resulted as

$$\begin{bmatrix} \Sigma V_{qds} \\ V'_{qdr} \end{bmatrix} = \begin{bmatrix} k_1\overline{R_{s1}} & -\overline{R_{s1}}^T \\ \bar{0} & \overline{R'_{r1}} \end{bmatrix} \begin{bmatrix} \lambda_{mqd} \\ i'_{qdr} \end{bmatrix} + \frac{1}{\omega_b} \begin{bmatrix} k_1\overline{X_{1s1}} & -\overline{X_{1s1}}^T \\ \bar{0} & \overline{X'_{1r1}} \end{bmatrix} \frac{d}{dt} \begin{bmatrix} \lambda_{mqd} \\ i'_{qdr} \end{bmatrix}$$
$$+\frac{1}{\omega_b} \begin{bmatrix} k_1\overline{\omega D_1}X_{1s1} & -\overline{\omega X}^T \\ \bar{0} & \overline{(\omega-\omega_r)X} \end{bmatrix} \begin{bmatrix} \lambda_{mqd} \\ i'_{qdr} \end{bmatrix}$$
$$+\begin{bmatrix} N(\bar{p}+\overline{\omega D}) \\ \bar{p}+\overline{(\omega-\omega_r)D} \end{bmatrix} [\lambda_{mqd}]$$
$$+\begin{bmatrix} \overline{R_{s1}}+\frac{1}{\omega_b}\overline{\omega D_j}X_{1s1}+\frac{1}{\omega_b}\overline{X_{1s1}}p \\ \bar{0} \end{bmatrix} [\lambda_{mqd}][k]^T \|\lambda_{mqd}\|^2$$
$$+\begin{bmatrix} \overline{R_{s1}}+\overline{\omega_e X} \\ \bar{0} \end{bmatrix} \begin{bmatrix} \sqrt{2}I_{hs}\sin(\omega_e t+\alpha) \\ \sqrt{2}I_{hs}\cos(\omega_e t+\alpha) \end{bmatrix} \tag{9}$$

where

$$\Sigma V_{qds} = \left[\sum_{j=1}^{N} V_{qsj},\ \sum_{j=1}^{N} V_{dsj} \right]^T$$

$$\overline{R_{s1}}^T = [\overline{R_{s1}},\ \overline{R_{s1}},\ \cdots,\ \overline{R_{s1}}]$$

$$\overline{X_{1s1}}^T = [\overline{X_{1s1}},\ \overline{X_{1s1}},\ \cdots,\ \overline{X_{1s1}}]$$

$$\overline{R_{s1}} = \text{Diag}[R_{s1},\ R_{s1}]$$

$$\overline{X_{1s1}} = \text{Diag}[X_{1s1},\ X_{1s1}]$$

$$\overline{\omega_e X} = \frac{1}{\omega_b} \begin{bmatrix} 0 & (\omega+\omega_e) \\ -(\omega+\omega_e) & 0 \end{bmatrix} X_{1s1}$$

$$\lambda_{mqd} = [\lambda_{mq},\ \lambda_{md}]^T$$

$$[k]^T = [k_3,\ k_5,\ k_7]$$

$$\|\lambda_{mqd}\|^2 = [\|\lambda_{mqd}\|^2,\ \|\lambda_{mqd}\|^4,\ \|\lambda_{mqd}\|^6]^T$$

and the dynamic revolving equation of the indiction machine is

$$J\frac{d\omega_r}{dt}+T_L=T_e \tag{10}$$

where

$$T_e=\frac{3}{2}\times\frac{\text{pole}}{2}\times\left[\lambda_{mq}\sum_{j=1}^{M}i'_{drj}-\lambda_{md}\sum_{j=1}^{M}i'_{qrj}\right]$$

Equations (9) and (10) consist of the model basis for the computer simulation of a multiple winding induction machine that incorporates the saturation and hysteresis of the core in magnetizing branch. An equivalent circuit for the multiple winding induction machine operating with saturation and hysteresis is developed from the above model equations. This circuit is shown in Fig. 2 for both q- and d-axis

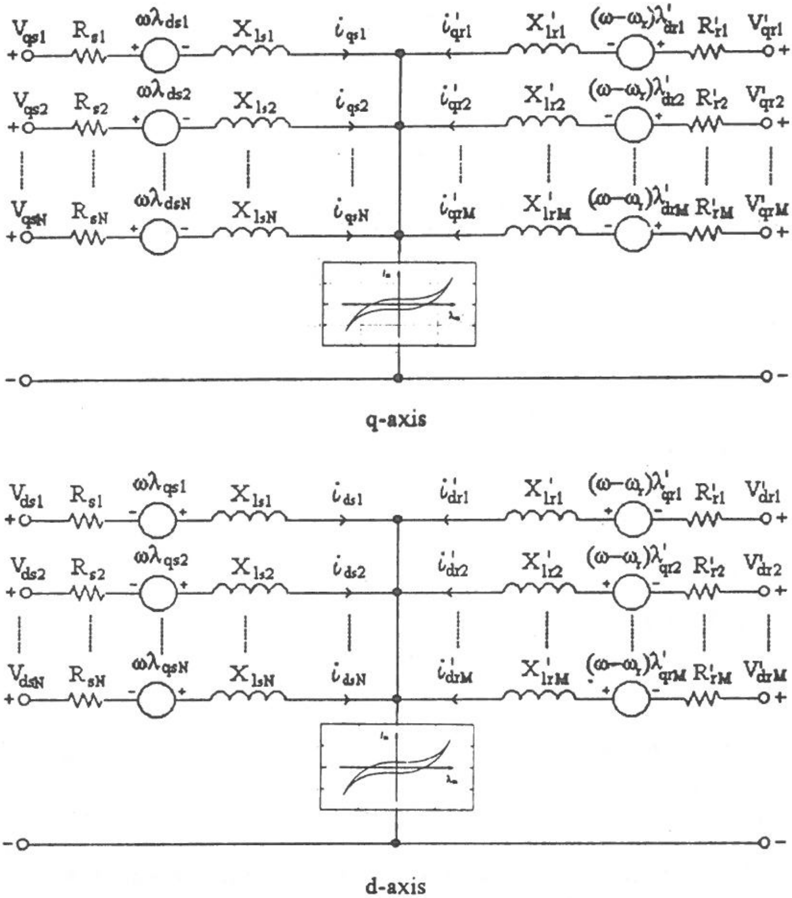


Fig. 2. The q and d equivalent circuits of a multiple winding induction machine for arbitrary reference frame.

equivalent model. It incorporates N-set stator and M-set rotor circuits for the q and d variables, respectively. The nonlinear magnetizing branch denotes the saturation and hysteresis effects of the induction machine cores. The parameters of the equivalent circuits are given in terms of the machine designed parameters and the field test.

Based on induction machine theory, for the convenience of mathematical manipulation, the above mentioned machine equations are derived in the form of q- and d-axis components[6]. The transformation between a-b-c and q-d-o components is readily determined by

$$\bar{F}_{abc}=\Gamma(\beta)\bar{F}_{qdo} \tag{11}$$

where

$$\bar{F}_{abc}=[F_a,\ F_b,\ F_c]^T$$
$$\bar{F}_{qdo}=[F_q,\ F_d,\ F_o]^T$$
$$\Gamma(\beta)=\begin{pmatrix} \cos\beta & \sin\beta & 1 \\ \cos\left(\beta-\frac{2}{3}\pi\right) & \sin\left(\beta-\frac{2}{3}\pi\right) & 1 \\ \cos\left(\beta+\frac{2}{3}\pi\right) & \sin\left(\beta+\frac{2}{3}\pi\right) & 1 \end{pmatrix}$$
$$\beta=\delta-\delta_{ckt}$$
$$\delta=\int_0^t \omega dt+\delta(0)$$
$$\delta_{ckt}=\int_0^t \omega_{ckt} dt+\delta_{ckt}(0)$$

As choosing the reference frame fixed in the stator, then the arbitrary angular velocity, $\omega=0$, and the angular velocity of the circuit, $\omega_{ckt}=0$. Applying transformation to the stator circuit of a multiple winding induction machine, result in

$$[F_{abcs}]=\text{Diag}\,[\Gamma(\beta_{s1}),\ \Gamma(\beta_{s2}),\ \cdots,\ \Gamma(\beta_{sN})][F_{qdos}] \tag{12}$$

where

$$F_{abcs}=[\bar{F}_{abcs1},\ \bar{F}_{abcs2},\ \cdots,\ \bar{F}_{abcssN}]^T$$
$$\bar{F}_{abcsj}=[F_{asj},\ F_{bsj},\ F_{csj}]^T$$
$$F_{qdos}=[\bar{F}_{qdos1},\ \bar{F}_{qdos2},\ \cdots,\ \bar{F}_{qdosN}]^T$$
$$\bar{F}_{qdosj}=[F_{qsj},\ F_{dsj},\ F_{osj}]^T$$

$$\Gamma(\beta_{sj})=\begin{pmatrix} \cos\beta_{sj} & \sin\beta_{sj} & 1 \\ \cos\left(\beta_{sj}-\frac{2}{3}\pi\right) & \sin\left(\beta_{sj}-\frac{2}{3}\pi\right) & 1 \\ \cos\left(\beta_{sj}+\frac{2}{3}\pi\right) & \sin\left(\beta_{sj}+\frac{2}{3}\pi\right) & 1 \end{pmatrix}$$

Note that $\beta_{sj}=\delta(0)-\delta_{cktsj}(0)$, where δ_{cktsj} is the angle between a reference axis and the magnetic axis of phase a of the jth stator set. For a two set stator winding machine i.e., with $N=2$, it yield $\delta_{ckts1}(0)=0°$ and $\delta_{ckts2}=\theta_d$, where θ_d is the displacement angle between the two set stator winding. Similarly, the transformation for the rotor circuits of the multiple winding machine, gives

$$[F_{abcr}]=\text{Diag}\,[\Gamma(\beta_{r1}),\ \Gamma(\beta_{r2}),\ \cdots,\ \Gamma(\beta_{rM})][F_{qdor}] \tag{13}$$

where

$$F_{abcr}=[\bar{F}_{abcr1},\ \bar{F}_{abcr2},\ \cdots,\ \bar{F}_{abcrM}]^T$$
$$\bar{F}_{abcrj}=[F_{arj},\ F_{brj},\ F_{crj}]^T$$
$$F_{qdor}=[\bar{F}_{qdor1},\ \bar{F}_{qdor2},\ \cdots,\ \bar{F}_{qdorM}]^T$$
$$\bar{F}_{qdorj}=[F_{qrj},\ F_{drj},\ F_{orj}]^T$$

$$\Gamma(\beta_{rj})=\begin{pmatrix} \cos\beta_{rj} & \sin\beta_{rj} & 1 \\ \cos\left(\beta_{rj}-\frac{2}{3}\pi\right) & \sin\left(\beta_{rj}-\frac{2}{3}\pi\right) & 1 \\ \cos\left(\beta_{rj}+\frac{2}{3}\pi\right) & \sin\left(\beta_{rj}+\frac{2}{3}\pi\right) & 1 \end{pmatrix}$$

Be aware of that $\beta_{rj}=\delta(0)-\delta_{cktrj}(0)$, where $\delta_{cktrj}(0)$ is the initial angle between the magnetic axis of phase a of the jth rotor circuit set and a reference axis, which is arbitrary choice. The transformation algorithm will be used in the next section to analyze the dynamic performance of a multiple winding induction machine.

3. SIMULATION RESULTS AND HARMONIC ANALYSES

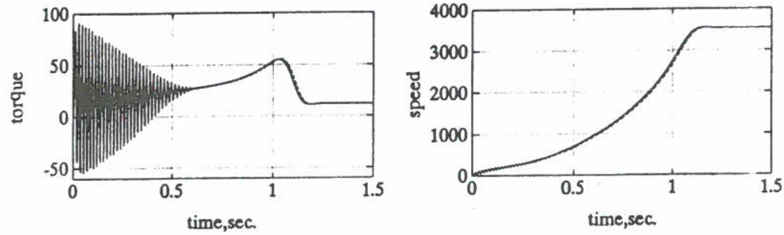
In order to verify the validity of the mathematical model and to evaluate the performance of the multiple winding induction machine, computer simulation is carried out. In addition, the proposed machine model is compared with the linear circuit models. The free acceleration and steady state feature of the machine are simulated under different excitation sources and various displacement angle between two stator winding sets. The freqency spectral analysis is utilized to illustrate the harmonic performance of the line current and the electromagnetic torque of the tested machine under different simulating conditions. The induction machine under consideration has two identical three phase stator winding sets and a singler rotor winding shown in Fig. 2 with $N=2$ and $M=1$.

The computer simulation was under taken with stationary reference frame, $\omega=0$. The squirrel cage rotor induction machine parameters are:

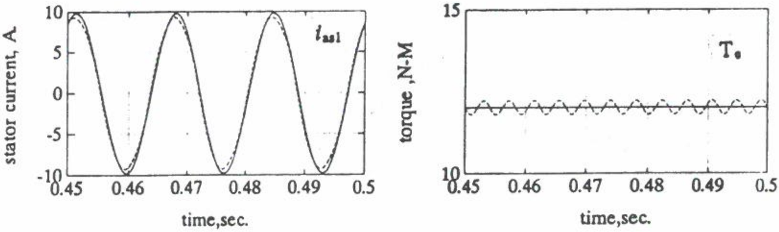
220 V	7.5 HP	60 Hz	2 pole
$R_{s1}=R_{s2}=0.21\ \Omega$		$R'_{r1}=0.16\ \Omega$	
$X_{1s1}=X_{1s2}=0.686\ \Omega$		$X'_{1r1}=0.604\ \Omega$	
$J=0.052$ kg-M^2		$I_{hs}=0.5$ A	
$k_1=17.22$		$k_3=-89.48$	
$k_5=372.22$		$k_7=-242.63$	

The Runge-Kutta fourth order integration routines are used to solve the nonlinear differential Eqs. (9) and (10). The obtained numerical solution gives the performance of the multiple winding induction machine with saturation and hysteresis characteristics. The performance was investigated for various displacement angles, such as 0°, 30°, and 60° between two set stator windings.

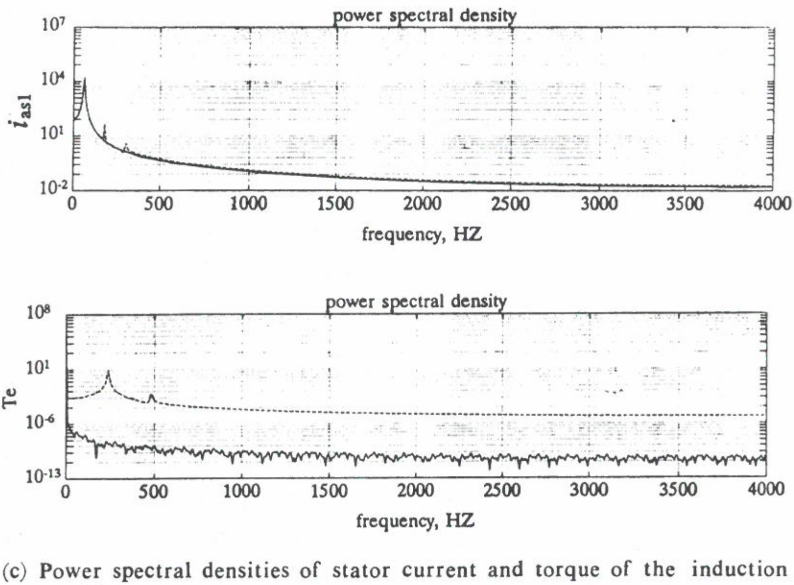
Figure 3 shows the comparisons of the dynamic response of the induction machine under the rated sinusoidal excitation for both the linear and proposed nonlinear models. Figure 3(a) shows the free acceleration of the torque and speed characteristics. Figure 3(b) shows the steady state phase current of stator winding and the electromagnetic torque. For the nonlinear model including saturation and hysteresis, the 3rd and 5th harmonics induced obvious waveform distortion of the stator current, and the 4th and 8th harmonics generated pulsations of the steady state torque. A stepped voltage source was used to simulate the switching performance of the inverter feeding induction motor. The dynamic responses of the induction machine are depicted in Fig. 4. Figure 4(a) and 4(b) show the transient and steady state responses of the stator current and torque under pulse width modulation (PWM) six-step



(a) Transient responses

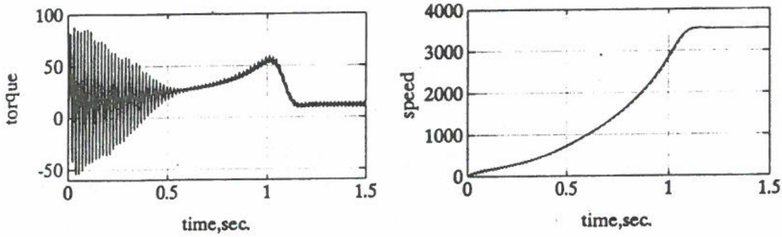


(b) Steady state responses

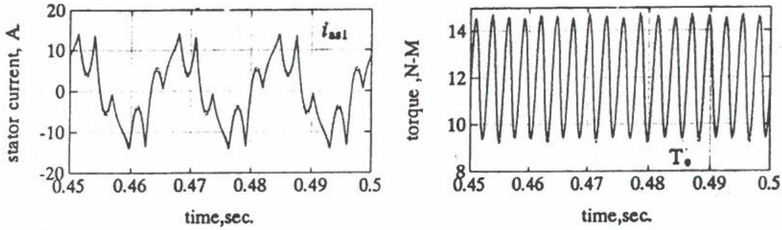


(c) Power spectral densities of stator current and torque of the induction machine

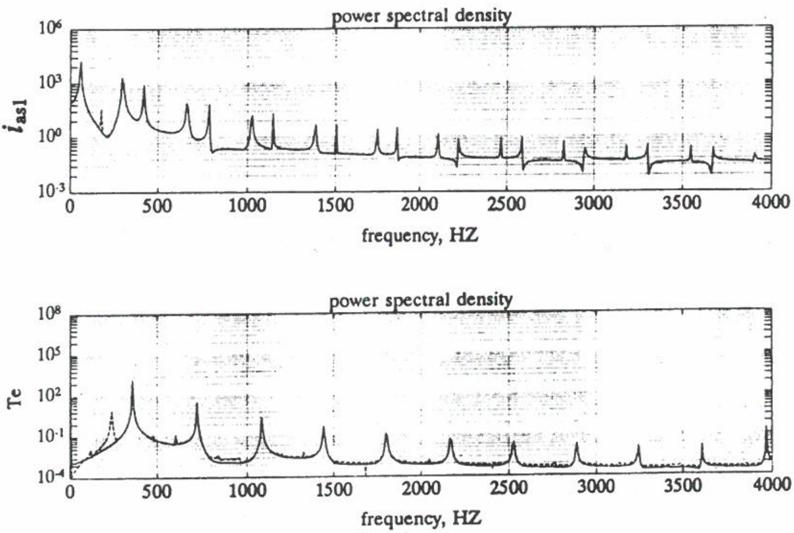
Fig. 3. Dycamic performance of the induction machine under the rated sinusoidal excitation.
—— Linear model ------ Proposed nonlinear model



(a) Transient responses



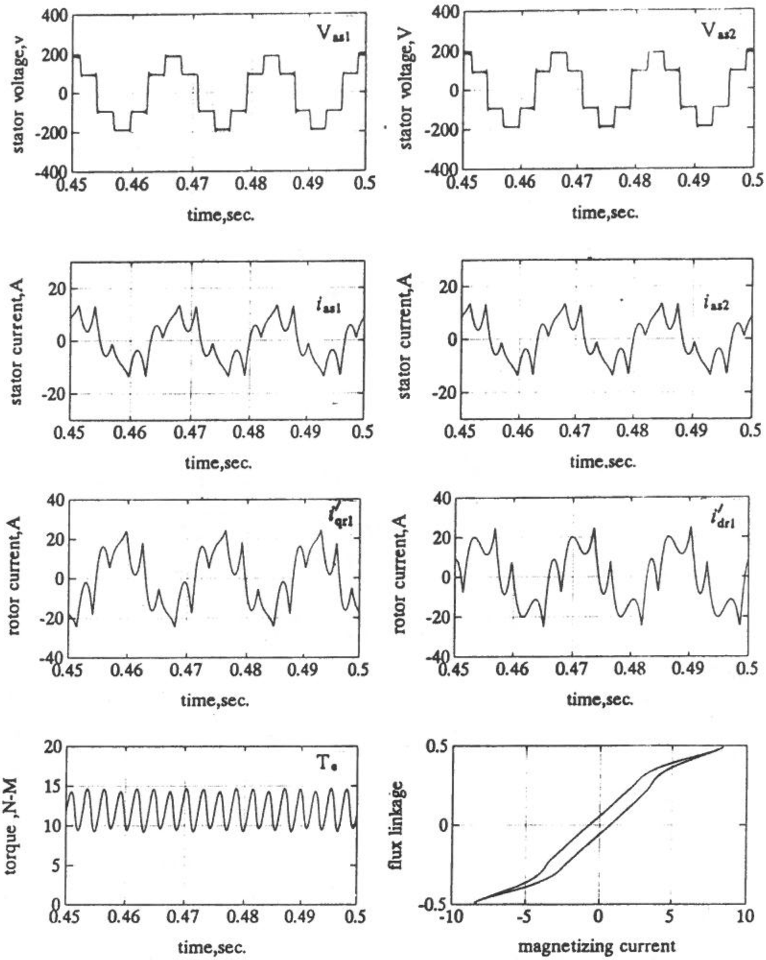
(b) Steady state responses



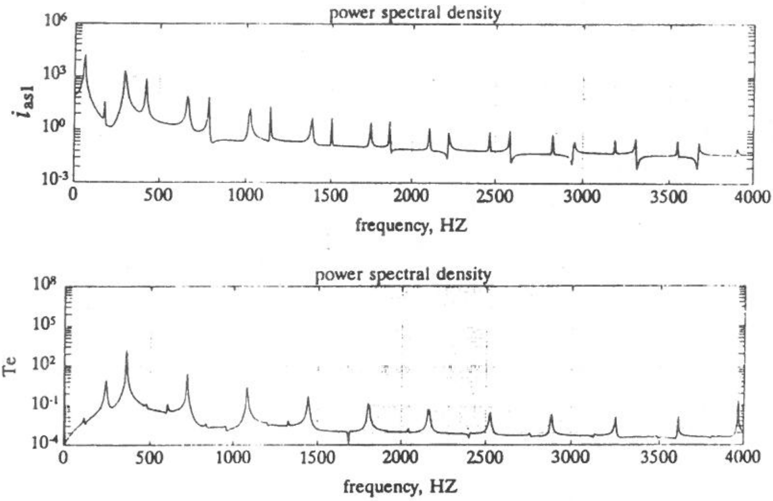
(c) Powere spectral densities of stator current and torque of the induction machine

Fig. 4. Dynamic performance of the induction machine under the stepped voltage excitation.

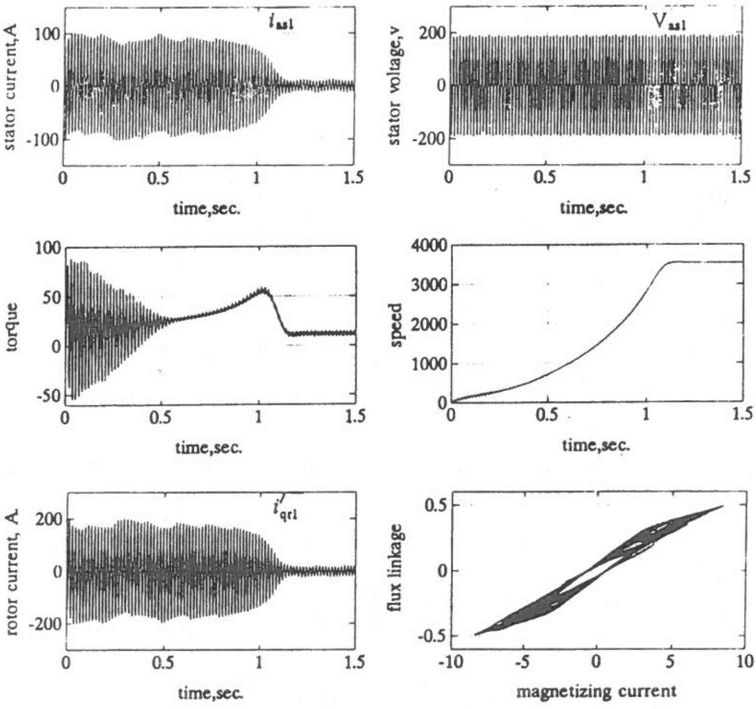
—— Linear model ------ Proposed nonlinear model source excitations. The torque pulsating amplitude is higher than that in the sinusoidal excitations. From the power spectral density in the Fig. 4(c), it is obviously observed, that the torque and speed characteristics for the nolinear model have induced an additional 3rd harmonic component. Figures 5-7 illustrate the performance of the induction machine for different displacements between multiple stator winding sets under the proposed nonlinear model. Both the steady state and transient



(a) Steady state responses for 3.67 V/Hz, 60 Hz



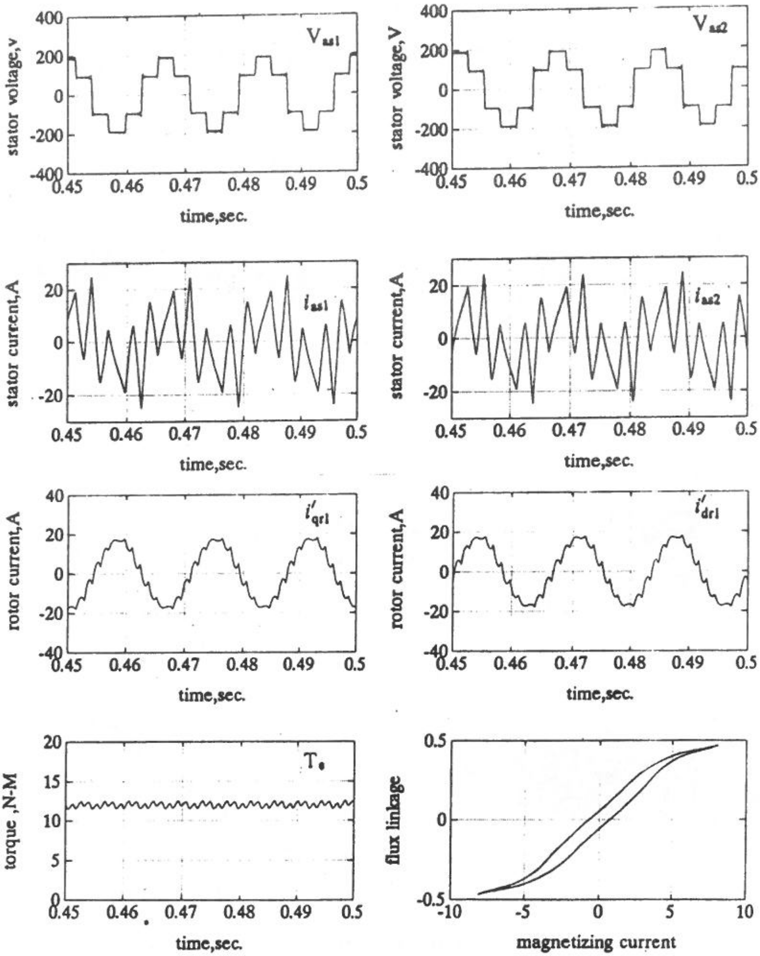
(b) Power spectral densities of stator current and torque of the induction machine



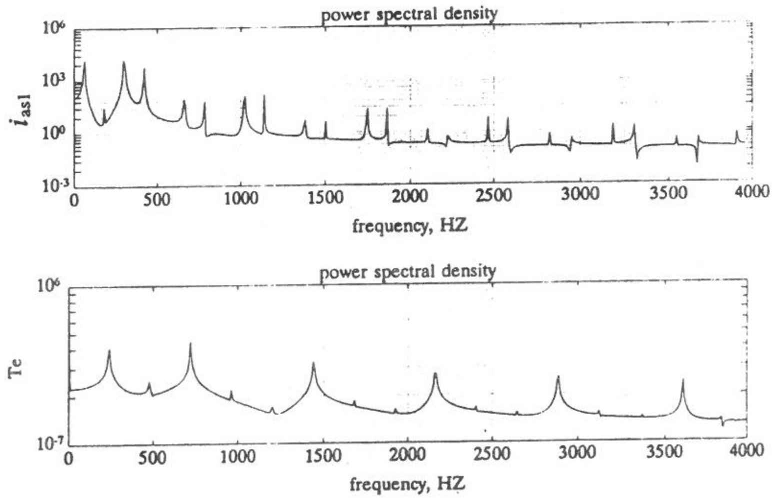
(c) Transient responses for 3.67 V/Hz, 60 Hz

Fig. 5. Multiple winding induction machine performance with 0° displacement angle between stator winding sets under stepped voltage excitation.

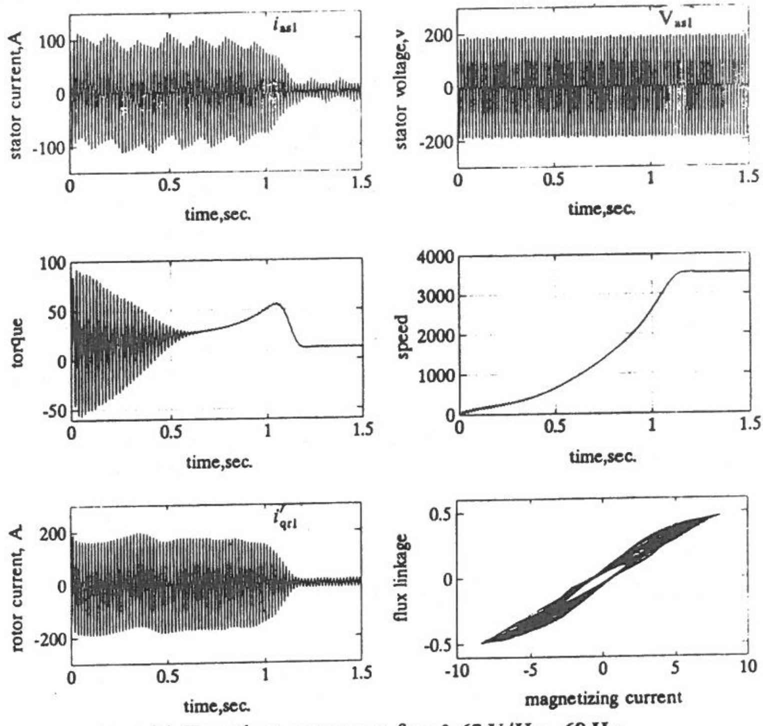
results are included in Figs. 5-7. Figures 5(a)-7(a) show the applied stepped stator voltage and the corresponding stator and rotor currents with different displacement angles between two stator windings. The steady state toque pulsation and the magnetiation curve are also shown in the last two figures. The steady state magnetization curve is very close to the normal magnetizing curve, as shown in Fig. 1. The harmonic content of the stator current and electromagnetic torque



(a) Steady state responses for3 .67 V/Hz, 60 Hz



(b) Power spectral densities of stator current and torque of the induction machine

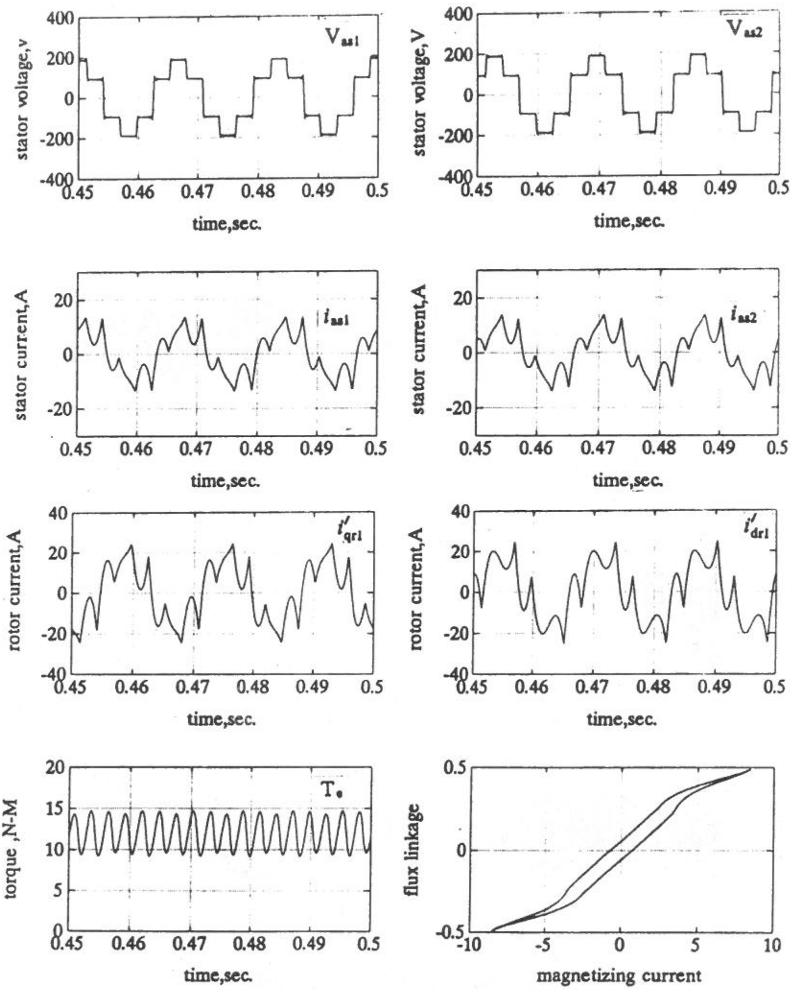


(c) Transient responses for 3.67 V/Hz, 60 Hz

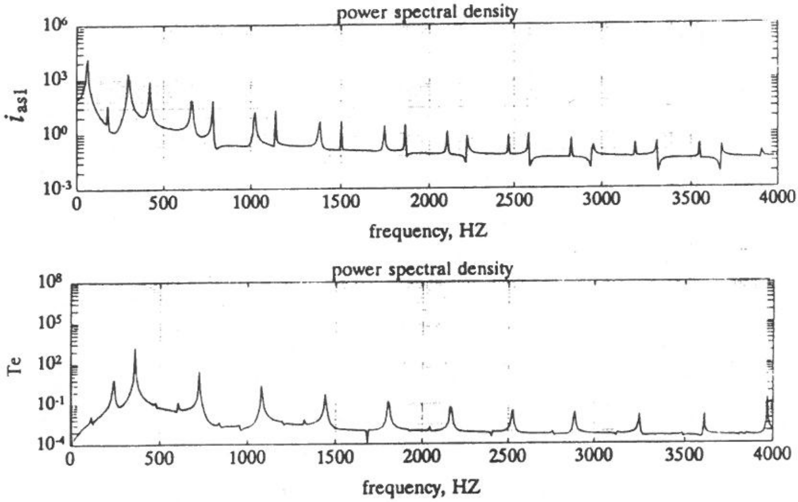
Fig. 6. Multiple winding induction machine performance with 30° displacement angle between stator winding sets under stepped voltage excitation.

are presented as power spectral density in Figs. 5(b)-7(b). The acceleration performance of the induction machine under various displacement angles is shown in Figs. 5(c)-7(c). Several features can be observed from the simulation results.

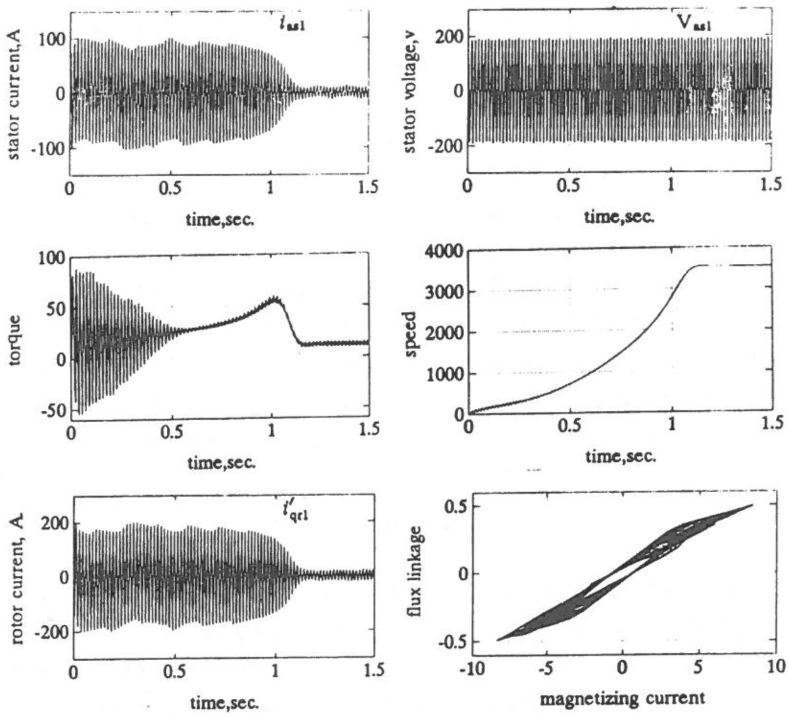
(a) The steady state behaviors for the displacement angle of 0° and 60° posses negligible difference. The dominant frequency of the pulsating torque components is six times of the applied source



(a) Steady state responses for 3.67 V/Hz, 60 Hz



(b) Power spectral densitise of stator current and torque of the induction machine



(c) Transient responses for 3.67 V/Hz, 60 Hz

Fig. 7. Multiple winding induction machine performance with 60° displacement angle between stator winding sets under stepped voltage excitation.

frequency, f_0. The peak amplitude of the pulsating component of torque is 46 percent of the applied load torque. The harmonic set of the steady state torque is given by [$4f_0$, $6f_0$, $12f_0$, $18f_0$, ⋯], which is exactly sketched in Figs. 5(b) and 7(b).

(b) The torque pulsating feature is evidently improved for the choice of 30° displacement between the stator winding sets. The peak amplitude of pulsating torque has been reduced from 46 percent down to only 8 percent of the load torque corresponding to 0° and 60° displacements, and 30° displacements, respectively. The harmonic set of the steady state torque is only [$4f_0$, $12f_0$, $24f_0$, ⋯], where the dominant frequency is located at twelve times of the source frequency.

(c) The steady state waveshape of q- and d-axis rotor currents for the 30° displacements is more sinusoidally approximated than for other two cases. This is the reason why the pulsating torque components are significantly reduced. The waveshape of stator current is severely distorted, and the amplitude of the harmonics is largely increased. From Fig. 6(b), it can be seen that amplitudes of 5th and 7th harmonic components are higher than those of the other two cases.

(d) Due to the consideration of saturation and hysteresis effects contained by the nonlinear model, the additional torsional oscillation will be substantially increased in both steady state electromagnetic torque and speed characteristics.

(e) The saturation and hysteresis effects of the magnetizing core play as a more important role in the steady states than that in the transient performance of an induction machine.

4. CONCLUSION

A new saturation model of a multiple winding induction machine, which includes the hysteresis effect of the magnetization core, has been developed in this paper. The model's validity and nonlinearity effects were demonstrated by steady state and transient analyses through computer simulations. A spectrum analysis is frequently utilized to investigate the harmonic influence under different models and excitations.

To analyze and/or to improve torque pulsation characteristic of a machine from the proposed model, it is achieved by using two stepped PWM inverters. These inverters generate arbitrary displacement angles between stator winding sets to drive the multiple winding induction machine. The proposed model also provides an effective approach to compute the hysteresis losses of induction machines. This loss component plays as a significant role in the optimal design of high efficiency machines and high technique inverters.

The comparative study and experimental verification for the saturation model of induction machine and the proposed approach in this paper can be suggested for later study.

5. ACKNOWLEDGEMENT

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APPENDIX

The mutiple winding induction machine model with core magnetizing flux linkage and machine current as state variables can be written as a compact form:

$$\begin{bmatrix} V_{qdos} \\ V'_{qdor} \end{bmatrix} = \begin{bmatrix} \overline{R_s} & \bar{0} \\ \bar{0} & \overline{R'_r} \end{bmatrix} \begin{bmatrix} i_{qdos} \\ i'_{qdor} \end{bmatrix} + \frac{1}{\omega_b} \begin{bmatrix} \overline{X_{1s}} & \bar{0} \\ \bar{0} & \overline{X'_{1r}} \end{bmatrix} \frac{d}{dt} \begin{bmatrix} i_{qdos} \\ i'_{qdor} \end{bmatrix}$$

$$+ \frac{1}{\omega_b} \begin{bmatrix} \overline{\omega X} & \bar{0} \\ \bar{0} & \overline{(\omega-\omega_r)X} \end{bmatrix} \begin{bmatrix} i_{qdos} \\ i'_{qdor} \end{bmatrix}$$

$$+ \begin{bmatrix} \bar{p}+\overline{\omega D} \\ \bar{p}+\overline{(\omega-\omega_r)D} \end{bmatrix} [\lambda_{mqdo}] \tag{A-1}$$

where

$$\overline{\omega X} = \text{Diag}\,[\,\overline{\omega D_1} X_{1s1},\ \overline{\omega D_2} X_{1s2},\ \cdots,\ \overline{\omega D_N} X_{1sN}\,]$$

$$\overline{\omega D} = [\,\overline{\omega D_1},\ \overline{\omega D_2},\ \cdots,\ \overline{\omega D_N}\,]^T$$

$$\overline{\omega D_j} = \begin{bmatrix} 0 & \omega \\ -\omega & 0 \end{bmatrix}$$

$$\overline{(\omega-\omega_r)X} = \text{Diag}\,[\,\overline{(\omega-\omega_r)D_1} X'_{1r1},\ \overline{(\omega-\omega_r)D_2} X'_{1r2},\ \cdots,\ \overline{(\omega-\omega_r)D_M} X'_{1rM}\,]$$

$$\overline{(\omega-\omega_r)D} = [\,\overline{(\omega-\omega_r)D_1},\ \overline{(\omega-\omega_r)D_2},\ \cdots,\ \overline{(\omega-\omega_r)D_M}\,]^T$$

$$\overline{(\omega-\omega_r)D_j} = \begin{bmatrix} 0 & (\omega-\omega_r) \\ -(\omega-\omega_r) & 0 \end{bmatrix}$$

all the vectors, V, V', i, i', and λ_m are of the form

$$F_{qdos} = [\,\bar{F}_{qdos1},\ \bar{F}_{qdos2},\ \cdots,\ \bar{F}_{qdosN}\,]^T$$
$$\bar{F}_{qdosj} = [\,F_{qsj},\ F_{dsj},\ F_{osj}\,]^T$$
$$F'_{qdor} = [\,\bar{F}'_{qdor1},\ \bar{F}'_{qdor2},\ \cdots,\ \bar{F}'_{qdorM}\,]^T$$
$$\bar{F}_{qdorj} = [\,F'_{qrj},\ F'_{drj},\ F'_{orj}\,]^T$$

and

$$J\frac{d\omega_r}{dt} + T_L = T_e \tag{A-2}$$

where

$$T_e=\frac{3}{2}\times\frac{\text{pole}}{2}\times[\lambda_{md}i_{qs}-\lambda_{mq}i_{ds}]$$

$$i_{qs}=\sum_{j=1}^{N}i_{qsj}=f_1(\lambda_{mq},\ \lambda_{md})-\sum_{j=1}^{M}i'_{qrj}$$

$$i_{ds}=\sum_{j=1}^{N}i_{dsj}=f_2(\lambda_{mq},\ \lambda_{md})-\sum_{j=1}^{M}i'_{drj}$$

and p denotes the differential operator d/dt. ω_b and ω_r are the base angular frequency and the angular velocity of the rotor shaft of the induction machine, respectively. The diagnal matrices $\overline{R_s}$ and $\overline{X_{1s}}$ contain the elements of N set stator winding resistance and leakage impedance, respectively. In similar, $\overline{R'_r}$ and $\overline{X'_{1r}}$ represent the M set rotor winding resistance and leakage impedance, respectively.

具磁路飽和與磁滯之多重繞組感應電動機特性分析

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摘　要

本文提出具有磁路飽和與磁滯之多重繞組感應電動機的動態特性模型。文中採用一種新的描述函數來表示磁性鐵心磁化曲線的非線性特性。穩態和暫態分析證明磁性鐵心的非線性特性對感應電動機的動態特性有非常重要的影響。計算機模擬和諧波分析顯示複式變流器驅動具有適當位移角的多重繞組感應電動機，不但可以減少轉矩震動的振幅，還可以改系統的動態特性。

科技教育資訊展示方法研究

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摘 要

許多編導軟體在顯示內容時提供了各種不同展示方式。例如：淡入淡出(fade)、捲動 (scroll)、掃描 (wipe)、翻頁 (turn page)。一般電腦輔助教學軟體發展者，在選擇內容展示方法時，大多任意選擇其中一種方法。在展示方式選擇方面，目前並無相關文獻可供參考。至於在內容展示方式的一致性方面參考文獻也從缺。以致有些軟體自始至終均用同一種展示方法。也有些軟體在設計時，每一個單元使用不同的展示方法。其設計理念是基於以下假設：以不同展示方式展示內容，將能吸學習者注意力，進而增加使用者的學習興趣。但到底那種展示方式較適合人類學習及閱讀的習慣？那種展示方式有助於人類學習的進展？那種展示方式對學習者的學習成效較有助益？是本文所要探討的課題。

關鍵詞：電腦科技、多媒體、展示方法。

一、前 言

隨著科技日益進步，將高科技納入教學課程內是必須的。而如何善用高科技，尤其是電腦科技在教學環境中更是一個廣被討論的課題。科技教育 (Educational Technology) 的主要課題在於探討各種不同科技對學習成效、教學投資報酬率、個人化教學、教學管理、學習態度等方面的影響。其中電腦輔助教學軟體因具有個人化教學、易於普及、鼓勵參與及互動等特性，功效日益受到教育界重視。

電腦輔助教學軟體的研發，雖然在有關單位及業界的大力推廣下，數年來不論在產品的品質及數量上，或者是應用的普及方面均仍有待加強。究其原因可能有二：(1) 現有電腦輔助教學軟體在內容設計及展示方式上不够生動，不足以引起學習者興趣。(2) 其次是製作電腦輔助教學軟體的編導軟體功能不够強大，及中文化程度不够。但隨著電腦教育及訓練科技的日益更新。同時國內多媒體科技也日漸成熟。利用多媒體科技，來增進電腦輔助教學軟體的內容及展示效果，將可大爲提升學習者興趣。而在中文視窗環境下，許多編導軟體不但功能已十分強大而且中文掛入也不成問題。今後電腦輔助教學軟體的研發將更爲普遍與容易。從事如何增進電腦輔助教學軟體品質提升的研究是必須的。

二、文獻回顧

在談及資訊展示時，有的僅提及如何把各種不同格式的資訊：動畫、聲音、圖型、文字適當的整合在一起 (Slaughter，1992)。至於各種展示方法：淡入淡出 (fade)、捲動 (scroll)、掃描 (wipe)、翻頁 (turn page) 則在不同應用領域內有不同的意義。

在微軟的視窗環境下，如果要展示的文件資訊其體積 (size) 太大。微軟建議利用捲動視窗來展示 (Burger，1993)。而在設計及製作二度空間動畫時，曾提及展示方法翻頁 (page flipping)。它強調的是如何以動畫的方式製作此種翻頁效果 (Burger，1993)。淡入淡出及掃描在攝影界多指在聯接及轉換兩段影片時的特殊效果 (Burger，1993；Rabb，1993)。各種應用領域內的展示方法如今能應用到電腦輔助教學軟體內容設計及展示上，值得欣喜。但如何善用這些方式的文獻則從缺。

三、計劃目地

許多編導軟體在展示內容時也提供了各種不同方式。例如：淡入淡出 (fade)、捲動 (scroll)、掃描 (wipe)、翻頁 (turn page)。一般電腦輔助教學軟體發展者，在選擇展示方法時均隨意行之。有些軟體自始至終均用同一種展示方法。也有些軟體在設計時，每一個單元使用不同的展示方法。其假設是因差異性的增加，將能增加使用者的學習興趣。但那種展示方式較適合人類學習及閱讀的習慣？那種展示方式較適合人類學習的進展？那種展示方式對學習成效較有助益？均爲本研究探討的重點及目地所在。

四、名詞定義

對本文中提及的各種展示方法，就其在本研究中的含義加以定義如下：

1. 淡入淡出 (fade)

一個影像畫面逐漸換到黑色畫面或由黑色畫面逐漸換到一個影像畫面。

2. 捲動 (scroll)

所要展示的文件體積 (size) 大於展示視窗 (window)。利用在視窗旁邊加設水平及垂直捲動棒 (scroll bar)，以滑鼠操作檢視文件整個部份。

3. 掃描 (wipe)

將原來展示的畫面以某種方式轉換成另一面。掃描方式常見的有：水平、垂直等。

4. 翻頁 (turn page)

模擬人類翻書頁的動作，由書的一角慢慢將全頁翻轉。

5. 綜合方式 (mixed)

課程軟體內部的各個單元，利用上述四種展示方法，分別展示。

五、研究方法

1. 研究變數

Independent variable：淡入淡出 (fade)、捲動 (scroll)、掃描 (wipe)、翻頁 (turn page)、綜合方式 (mixed)。(每個單元採用不同的展示方法所成的版本) Dependent variable：學習成效，學習時間。

2. 研究假設 (hypothesis)

(1)不同資訊展示方法對學習成效的影響沒有顯著差異。
(2)不同資訊展示方法對學習時間的影響沒有顯著差異。

3. 取樣對像

(a) 取樣對象特徵

具有使用滑鼠能力。熟悉圖型使用者界面操作環境 (GUI: Graphic User Interface，MS Windows)。曾修習過電腦概論或電腦軟體應用等相關課程。

(b) 取樣限制

(1) 取樣對象限制：取樣對象必須具備以上描述之特徵。
(2) 地點限制：因軟硬體的取得及智慧財產權的限制，取樣對象必需在研究主持人研究室內參與此項研究工作。
(3) 時間限制：取樣對象必須用一小時研習電腦科技電腦輔助教學軟體、隨後接受二十題選擇題之學後測驗、最後要求填寫使用者接受性調查表。費時很長。由於以上對象、地點、時間等限制。使取樣對象的範圍及可獲得性大為縮小。

(c) 取樣方式

由輔仁大學資訊工程、圖書資訊、及生物等系中隨機的選取六十位同學。這些樣本可作爲太學中資訊科系與非資訊科系，理工科與文科學生的代表。總計樣本中有 31 位男性 (52%)、29位女性 (48%)。30 位來自資訊工程系、20 位來自圖書資訊系、及 10 位來自生物系。對五種不同展示方法 (Fade、Wipe、Turn page、Scroll、Mixed) 的電腦科技電腦輔助教學軟體參與測試。將參測同學隨機的分成五組，每組十二人。每組接受一種版本展示方法的測試。

4. 進行步驟

(a) 發展研究工具

製作電腦科技電腦輔助教學軟體。在選定題材方面是就現在流行的多媒體系統中，挑選了九種現在或未來將普遍被接受的系統。其中有五種軟體系統：專家系統 (ES: Expert System)，智慧型電腦輔助教學軟體 (ITS: Intelligent Tutoring System)，電腦模擬 (Computer Simulation)，電腦輔助教學 (CAI: Computer-Assisted Instruction)，電腦遊戲 (Computer Game)。四種硬體設備：數位化互動影像 (DVI: Digital Video Interactive)，數位化互動光碟 (CD-I: Compact-Disc Interactive)，光碟機 (CD-ROM: Compact-Disc Read Only memory)，交談式影碟 (IVD: Interactive Video Disc)。

選擇這九種電腦科技的原因可以歸納爲以下幾點：(1) 這些電腦科技所使用的資料皆爲數位化格式，它具有特點爲：可編輯性，不失眞，可壓縮以減少資料量，可用網路傳送。是未來資訊儲存的主要格式。(2) 這些電腦科技皆適合個人化的教學 (Individualized Instruction)，可以根據每個學習者的個人差異性來作適當的調整。可以說是末來教學發展的趨勢。(3) 這些電腦科技均可以使用多媒體的方式來展示。多媒體是這幾年來最具發展潛力的一個領域。因爲資訊的多樣性可以引起學習者很大的興越。(4) 這些科技均可以在電腦上展示。而今天個人電腦已十分普及而且是一種很好的教學工具。

除了這九種電腦科技構成電腦輔助教學軟體的九大單元外，每一單元的內容分成五個項目來說明：說明、系統、運用、特色、限制。以這種方式來介紹每一種電腦科技，不但更有條理。同時使用者可以隨自己的需要，選擇自己想看的單元 (Self-Selection)，自己控制所要接受資訊的次序 (Self-Control)。

在軟體內容方面，主要可分爲文字鍵入、圖形掃描。最後利用編導軟體：Toolbook 將脚本上的文字圖形整合成電腦科技電腦輔助教學軟體。

(b) 製作不同版本電腦科技電腦輔助教學軟體

相同的內容但因展示方法的不同而有五種不同版本。(1) 完全以淡入淡出

(fade) 展示主要內容。(2) 完全以捲動 (scroll) 展示主要內容。(3) 完全以掃描 (wipe) 由左至右，展示主要內容。(4) 完全以翻頁 (turn page) 展示主要內容。(5) 完全以綜合方式 (mixed) 展示主要內容。

(c) 預試 (Pilot Test)

使用五種不同版本的電腦科技電腦輔助教學軟體。供五位同學（輔仁大學資訊工程系二位、圖書資訊系二位、及生物系一位）試用。依據預試結果對電腦科技電腦輔助教學軟體的內容及使用者介面加以改進。

(d) 測試方法

由二位研究助理全程陪同參測同學接受測試。其過程如下：

(1) 對每位參測同學解釋測試目的、過程、電腦科技電腦輔助教學軟體使用方法。

(2) 參測同學利用電腦科技電腦輔助教學軟體學習其中各種電腦科技。研究助理則利用基本資料表記錄時間（開始時間，完成時間，中斷時間）、完成率（是否每一種電腦科技單元內容均完成研習）、及解答參測同學所遇問題（使用上問題，內容方面問題，這些問題所費時間將計入中斷時間）。

(3) 參測同學隨後接受二十題選擇題之學後測驗。每題一分，總分二十分。為使學後測驗執行時間縮短，僅對五種電腦科技進行測驗，每種科技均有相同數目的選擇題（四題）。針對受測者對軟體內容的認知，規則運用，手續性知識等加以測驗。

(4) 參測同學最後要求填寫使用者接受性調查表。問卷的設計，以前期測試中最常被提起的問題的基礎，再加以系統化的分類，組織而成。主要分成幾大類：參測同學對軟體內容的意見，參測同學對軟體使用者介面的意見。以及開放性問題：參測同學對軟體內容及使用者介面的建議。必需廣泛而有系統的蒐集參測同學對軟體內容及使用者介面的意見。否則便不能對這個軟體的內容及使介面的品質加以衡量。

六、測試結果

1. 學後測驗結果

參測同學學後測驗結果如下表：

	平均成績	平均時間
淡入淡出展示	17.00	14.50
掃描展示	16.50	15.17
翻頁展示	13.67	14.00
捲動展示	12.67	14.17
綜合展示	17.50	15.83

由參測同學學後測驗結束得知 Mixed 版本平均成績最高：15 83 分。Turn page 版本平均成績最低：14 分。Mixed 版本平均費時最長：17.5 分鐘。而 Scroll 版本平均費時最短：12.67 分鐘。進一步用 PC SAS 軟體分析學後測驗結果。其中關於不同版本與時間關係，以及不同版本與分數關係採用 ONE WAY ANOVA (analysis of variance) 分析。在信心係數 (Confidence factor) 為 0.05 時，Pr>F 分別為 0.2972 及 0.3983。顯示出版本對時間以及版本對分數並沒有造成顯著差異。再就時間對分數相關性加以分析，使用 correlation analysis。所得結果顯示時間與分數並沒有很強的相關性。

2. 使用者接受性調查結果

以下是問卷中使用者對軟體接受性「選擇題」部份進行的統計分析。所有參測者均回答了此部份全部問題所以樣本人數是 60 人。

使用者接受性問題	非常同意及同意	無意見	不同意及非常不同意
軟體使用非常容易	84.38	9.38	6.25
使用說明部分有助學習使用	78.23	18.75	3.13
軟體包含了各主要電腦科技	50.00	37.50	12.5
軟體對各科技應用及限制的描述是合適的	53.13	43.75	3.13
軟體對各科技說明是足够的	28.13	50.00	21.88
軟體對各科技系統介紹是詳盡的	28.13	40.63	31.25
軟體對各電腦科技的介紹有助益	87.50	9.38	3.13
學後測驗很合適	62.51	21.88	15.63

3. 使用者建議

(1) 內容方面：電腦網路的介紹，專有名詞的解釋，內容字體加大，內容更深入一點，內容增加動畫、音效及圖片說明。

(2) 使用者介面方面：增加鍵盤輸入方式，按鈕的設計不够生動。

七、討　論

1. 學後測驗結果

Mixed 版本平均成績最高。其原因之一可能是 Mixed 版本具有多樣性的展示方式，較能引起使用者興趣及注意。Turn page 版本平均成績最低。此種展示方式雖然與人類傳統閱讀習慣相符，但可能造成學習者對軟體內容僅加以流覽，反而造成測驗成績較差。

經過統計分析後發現，版本對時間以及版本對分數並沒有造成顯著差異。但因爲受測人數太少（每組僅有十二人），如果測試人數能有一佰伍拾人（即每組三十人），則對測試結果將能够更爲肯定。目前造成沒有顯著差異的其他原因可能有：(1) 受測者本身背景知識、電腦技能之差異對時間及成績的影響比展示方式更爲重大。(2) 每頁展示轉換時間非常短，約在 0.6 秒以內，使用者可能本身無法明確感覺展示方式的差異，所以成績與時間也沒有太大關聯。

不過由學後測驗結果顯示 Mixed 版本。使用者花費的學習時間最長，而平均成績也最高。多樣性的展示方法似乎較能吸引學習者注意力，同時引起學習興趣。今後在設計及製作電腦輔助教學軟體時，不妨考慮採用綜合展示方式。

2. 使用者接受性調查結果

約有 80% 的參測者認爲此軟體容易學習及容易使用。參測者在學習此軟體時可把大部份的心力用在內容學習及內容展示方法上。而不需花費額外心力在學習使用軟體及使用者介面上。而超過 85% 的參測者認爲此軟體對電腦科技是有助益的。由此可假設參測者對學習軟體有相當興越，並願意花相當心力去學習。有 70% 的參測者認爲學後測驗很合適。因此雖然本研究的樣本數不足，但學後測驗成績的統計分析結果，仍具有相當參考價值。

參測者對各種科技的說明及各種科技系統的介紹有 70% 以上覺得不够詳盡。這與本軟體原來設計目標相符。本電腦科技電腦輔助教學軟體主要目標是用來作爲展示方式測試工具。而非眞正的電腦科技教學軟體。否則過度詳細的內容將增加研習軟體的時間。使參測時間加長而樣本的取得將更爲困難。

3. 未來研究方向

本研究如能在未來進一步探討展示方法與教學內容的關係。即在各種內容中找出最適合的展示方法。以及展示方法與個人習性的關係。探討不同個人閱讀習性對展示方法的影響。

八、誌　　謝

非常感謝輔仁大學聖言會，對本研究贊助部份經費，使研究得以順利完成。聖言會所贊助經費部份，更由理工學院周院長善行私人提供，更令人感佩。

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An Investigation of Information Display Methods in Educational Computing

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ABSTRACT

Currently, a lots of authoring tools providing different display methods for user to present their courseware content. Display method, such as: fade-in or fade-out, wipe, scroll bar, turn-page are most frequently used. But, display method selection decisions are frequently made by instructional designers based upon personal preference. Many Computer Assisted Instruction courseware have been developed during the last ten years. They can be placed into two categories according to their displaying method: courseware that use one display method throughout the whole program, and courseware that use more than one display method in the program. A review of the literature didn't provided much of the theoretical basis for the selection of display method. The objective of this study is to develop and evaluate an computer technology CAI with different display method embedded in it which may or may not affect the progress and performance of learners.

Key Words: Computer technology, Multimedia, Presentation method.

A DATA STRUCTURE FOR THE GENERATION OF UNSTRUCTURED MESHES

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ABSTRACT

With the rapid advancement in computer technology, analyzing a flow in a complex geometry using computational fluid dynamics (CFD) is becoming more and more practical. In the early days of CFD development, many efficient schemes have been established. In order to prove the technology, these schemes are tested with simple geometries, such as airfoils and channels. Rectangular (Structure) meshes can easily be generated for these types of geometry. Codes using rectangular meshes are usually very efficient computationally, especially on a vector and/or parallel machine. However, it is sometimes impossible to generate satisfactory grids for complex geometries using the traditional rectangular grids generators. In recent years, unstructured meshes are gaining popularity in the CFD community. Due to the irregular data structure of an unstructured grid, codes using such a mesh is usually less efficient on a parallel/vector machine. There should still be room for improvement in the coding of an unstructure-grid flow solver.

The purpose of this research is to establish an efficient data structure for generating unstructured meshes in C programming language. The data structure contains three substructures, 'nodes', 'edges', and 'levels'. Its usefulness stems from two important facts. First, it provides an indirect addressing system to connect the locations of the substructures. This is an appropriate way for unstructured meshes, since in principle the meshes are ordered randomly. Second, it is a dynamic data structure that can change in size while the program is running. Details of these three substructures are described in this paper and the whole data structure is applied in the diverging channel problem and the converging-diverging channel problem.

Key Words: Compressible Flow, CFD, Unstructured Mesh, Finite Volume, Steady/Unsteady Flows.

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* Engineer

1. INTRODUCTION

In recent years a wide variety of researches on the generation of unstructured meshes around bodies of complex geometrical shapes have been worked. However, unstructured mesh solvers suffer from inherent efficiency limitations. One can at best hope to minimize these limitations by the use of efficient algorithms, coding, and computer architecture.

In this paper it is attempted to develop a data structure which effectively generates unstructured meshes. As the data structure can be implemented in some programming language, it must be designed to take advantage of the features of that language. Therefore, it is concerned not only to design an effective data structure, but also to emphasize how the data structure can be implemented in some specific program language appropriately.

There are at least two major ideas to design the data structure. One is to devise the data structure such that the use of unstructured meshes requiring the storage of connectivity information along with the use of an indirect addressing system. The other is to construct the data structure for performing the operations such as insertions and deletions as efficiently as possible. The first idea is because that the unstructured meshes are in random order usually, and the second idea is to provide a data structure with effective operations count for searching, insertions and deletions. Therefore, a dynamic data structure involving the use of an indirect addressing system is required.

The attention is shifted in coding after the data structure has been designed. Coding is a very exact skill. The choice of a programming language is one especially important consideration in coding. For many years the programming language FORTRAN has been widely used in scientific applications(1). FORTRAN was originally designed for scientists, engineers, and mathematicians. The language is noted for its ability to express mathematical expressions and equations easily. However, FORTRAN has several disadvantages when used to implement a data structure. It has limited file processing capabilities, limited ability to define and effectively process complicated data, and limited ability to control memory allocation. For these reasons FORTRAN is not an appropriate choice as the programming language to implement the data structure. Today the C programming language has become pervasive in many different domains. C is a powerful, elegant, general-purposed programming language. C offers programmers a good deal of control over their resources, and memory is a critical resource. For the significant advantages of C, it is determined to implement the data structure by using the C programming language.

In the following, the data structure for the generation of unstructured meshes is introduced. It consists of three substructures: 'nodes', 'edges', and 'levels', which are described sequentially, one at a time. Finally, some examples and their results are given.

2. DOUBLY LIKED LISTS FOR NODES

A singly linked list[2,3] is a data structure for storing the items of a list in which the ordering is given explicity. It consists of a collection of elements, and each of them stores two parts of information: (1) a data item of the list and (2) a link or pointer that indicates explicitly the location of the element containing the successor of this list. Items can be inserted or deleted simply by chaining the values of the pointers linking the list. To implememnt linked lists, it is considered to construct them by using pointers and structures in C. The reliable implementation of a linked list is a useful structure for processing dynamic lists whose maximum sizes are not known in advance and whose sizes change significantly because of repeated insertions and deletions.

A doubly linked list is a bidirectional list. It is constructed by using data items that contains, in addition to the data, two links: a forward link pointing to the successor of the data item and a backward link pointing to its predecessor. In the cases of one dimensional space one could locate the predecessor or the successor of a node for unstructured meshes, hence a doubly linked list is needed. Each node contains its own information and two links to its successor and predecessor. The doubly linked list for nodes can be implemented by the following declaration:

```
typedef struct  VOL_NODE_LIST   * NODE_POINTER;
typedef struct  NODE_DATA       * NODE_DATA_POINTER;
typedef struct  VOLUME_DATA     * VOLUME_DATA_POINTER;

struct VOL_NODE_LIST

  {
   NODE_DATA_POINTER     node_data;
   VOLUME_DATA_POINTER vol_data;
   NODE_POINTER             next_vol_node, previous_vol_node;
  }

struct NODE_DATA

{
/* Containing the general node information such as the order number of
   the node, the pressure of the node, ···, etc. */
......
}

struct VOLUME_DATA

{
/* Containing the node information related with the volume */
}
```

The data structure for the 'node' (VOL_NODE_LIST) includes:

(1) A pointer (node_data) that points to a structure that contains all the information involving the node,

(2) A pointer (vol_data) that points to a structure that contains all the volume data, and

(3) Two pointers, one (next_vol_node) links to the successor of the node and the other (previous_vol_node) links to the predecessor of it.

A typical 'node' is illustrated in Fig. 1.

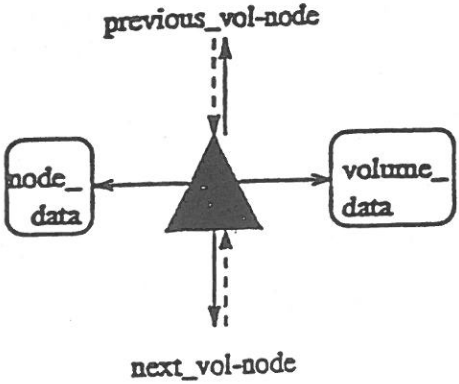


Fig. 1. Substructure: node.

3. A COMBINATION OF BINARY TREES AND DOUBLY LINKED LISTS FOR EDGES

Binary trees are well-known data structures in computer sciences[2,3]. A binary tree may be empty, or it consists of a specially designated element called the root together with two binary trees, namely, the left and the right subtree of the root. Binary trees are specially useful in modeling processes with two possible outcomes performed repeatedly. The idea, to use binary trees as a part of the structure for edges, is that an edge on a level of coarse grids may be split into two edges on the next level of fine grids, if necessary. In the case of the generation of unstructured meshes in one dimensional space, one also needs to know the locations of the predcessor and the successor of each edge on the same level. Therefore, a combination of binary trees and doubly linked lists is constructed as a data structure for edges. The declarations of the data structure is now given below:

```
typedef struct  EDGE_TREE   * TREE_POINTER;
typedef struct  EDGE_DATA   * EDGE_DATA_POINTER;
```

```
struct EDGE_TREE
  {
    NODE_POINTER        vol_node1, vol_node2;
    EDGE_POINTER        parent, kid1, kid2, next_edge,
                        previous_edge;
    EDGE_DATA_POINTER data;
  }

struct EDGE_DATA
{
/* Containing all the edge information */
......
}
```

The data structure for the 'edge' includes:

(1) Two pointers of the NODE_POINTER data type. One (vol_node1) points to the closest node of the edge in the left, while the other (vol_node2) in the right.

(2) Five pointers of the EDGE_POINTER data type. Two pointers (previous_edge and next_edge) form the part of the doubly linked list and the rest of three pointers (parent, kid1, and kid2) form the other part of the binary tree.

(3) A pointer (data) that points to a structure containing all the edge data.

Figure 2 displays a typical 'edge' cell.

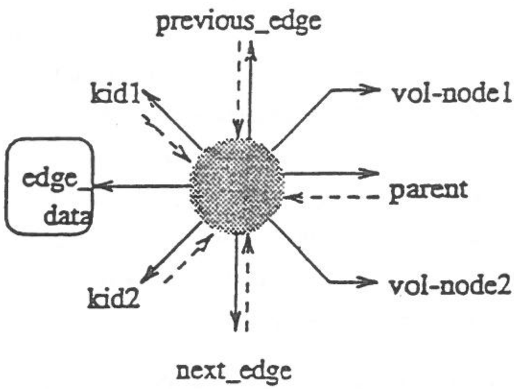


Fig. 2. Substructure: edge.

It is noted that the 'edge' substructure is the most complicated one among the three substructures developed in this data structure. In the case of the generation of unstructured meshes in one dimensional space all the edges in the same level construct a doubly linked list. Also, each edge in some level may be split into two edges in the next fine level, kid1 and kid2 are the pointers to these two edges. Note that kid2 may be dummy with the value NULL if the splitting is not necessary. The pointer parent points to the parent of the edge in the previous coarse level. One can see that three pointers (parent, kid1 and kid2) link edges in the different levels and form the part of the binary tree of the substructure.

4. SINGLY LINKED LISTS FOR LEVELS

The multigrid method is used to accelerate the convergence of the algorithm on unstructured meshes[4]. It operates on a sequence of grid levels of coarse and fine unstructured meshes. A singly linked list is accomplished by the order of levels from coarse to fine. As in the doubly linked list, the singly linked list can be implemented by usimy pointers and structures in C. Thus, it is led to declarations like the following:

```
          type struct  LEVEL_LIST  * LEVEL_POINTER;

struct LEVEL_LIST
  {
   NODE_POINTER  first_vol_node;
   EDGE_POINTER  first_edge;
   LEVEL_POINTER next_level;
  }
```

The data structure for a 'level' includes:

(1) A pointer (first_vol_node) points to the first node in this level.

(2) A pointer (first_edge) points to the first edge in this level, and

(3) A pointer (next_level) points to the next fine level.

Figure 3 presents a typical cell of 'level', and Fig. 4 illustrates the whole data structure.

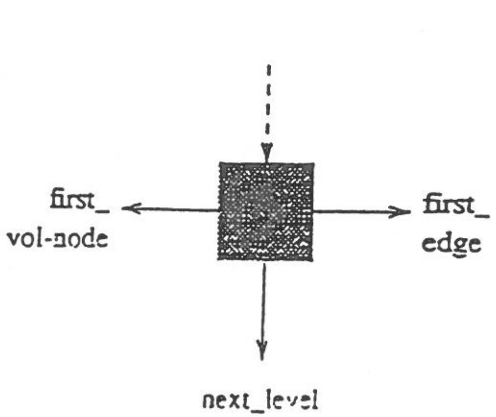


Fig. 3. Substructure: level.

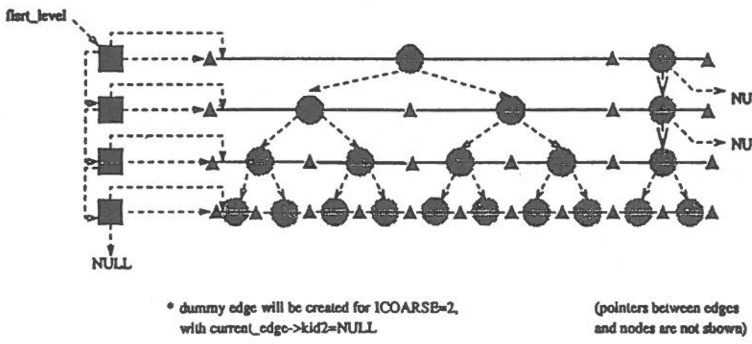


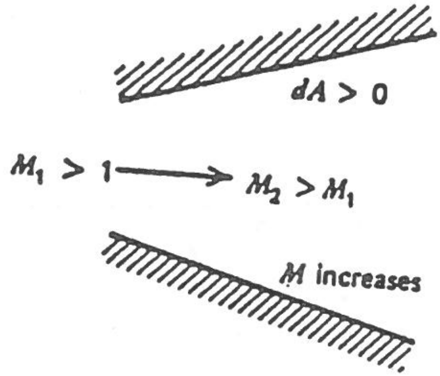
Fig. 4. Schematic data structure.

5. NUMERICAL RESULTS

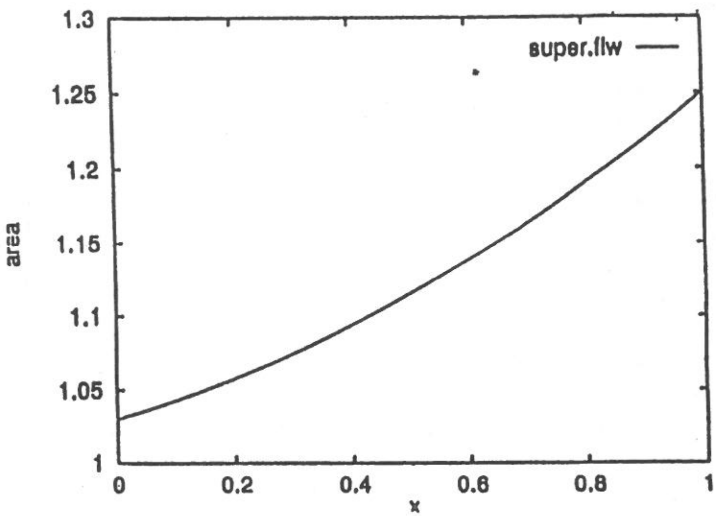
In order to asses the performance of the data structure presented in this paper for actual channel flow caluclations, several test cases were computed. The data structure discussed above was implemented in a Runge-Kutta scheme of Jameson type with options of three, four, or five stage time stepping scheme[5,6]. Three examples and their results are shown.

diverging channel (supersonic flow)

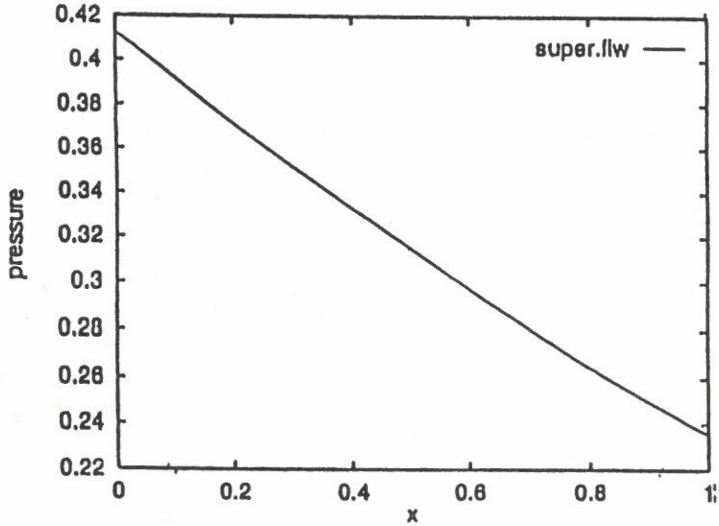
Consider the diverging flow[7~9] passage illustrated in Fig. 5(a). The channel area A varies with distance x, as shown in Fig. 5(b). As the inlet Mach number is supersonic ($M_1>1$), and an increase in area ($dA>0$) results in a decrease in pressure and an increase in Mach number. The results are illustrated in Figs. 5(c) and 5(d), respectively. Figure 6 shows the average error versus the number of iterations for this case.



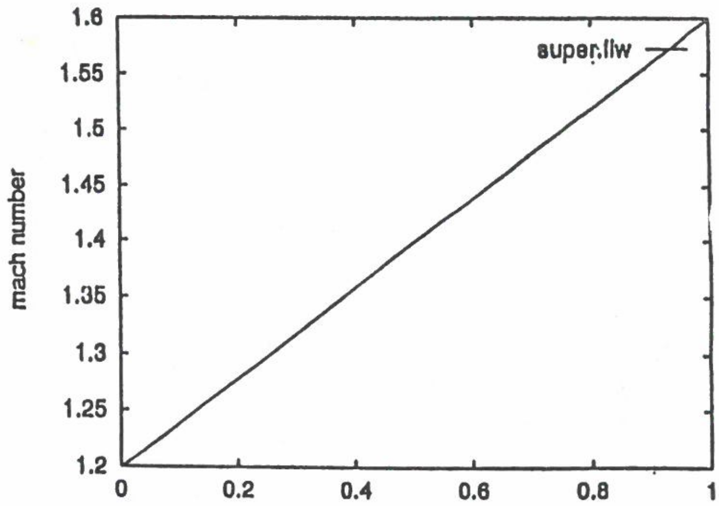
(a)



(b)



(c)



(d)

Fig. 5. Diverging channel (supersonic flow).

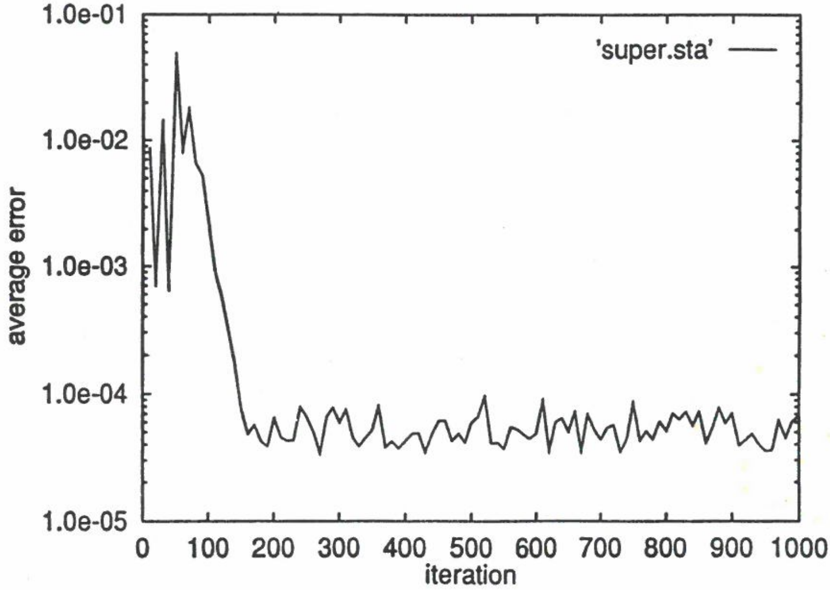
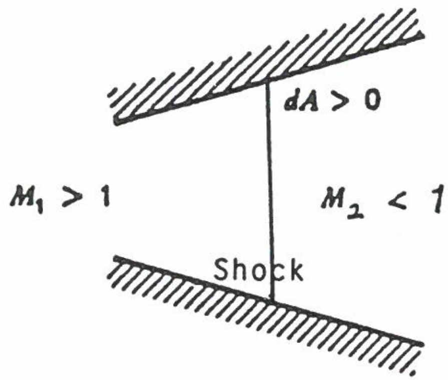


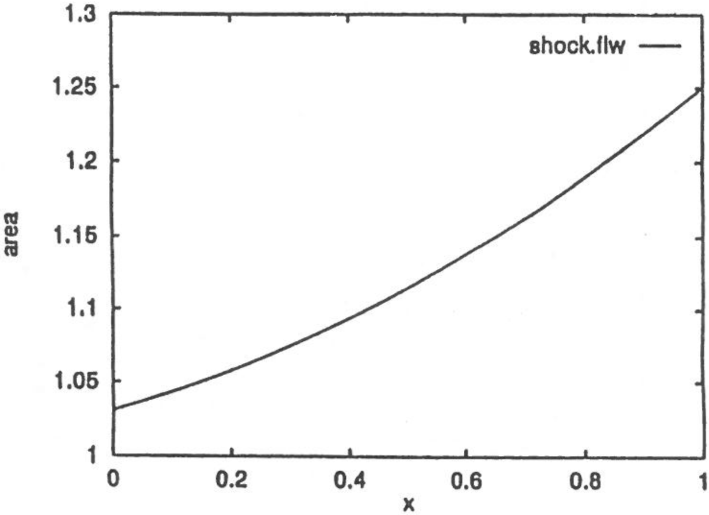
Fig. 6. Convergence rate for the diverging channel (supersonic flow).

diverging channel (shock)

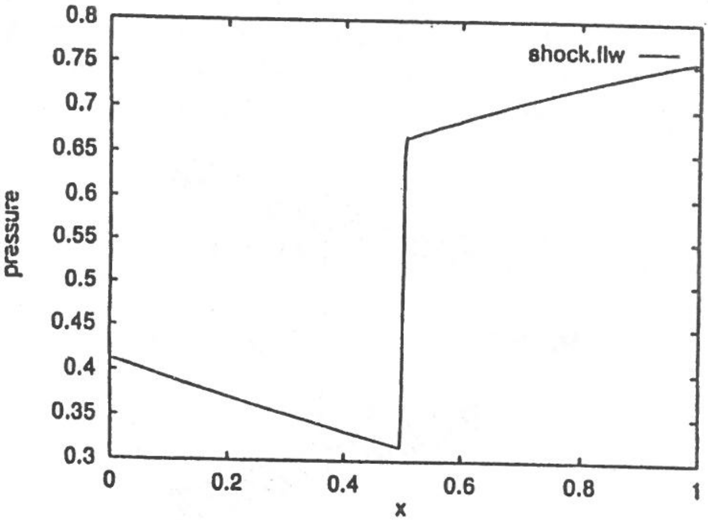
Now, consider the diverging channel[7~9] in the previous case with the same inlet conditions (see Figs. 7(c) and 7(d) at $x=0$) except having different back pressure P_b. Changes in back pressure P_b can be transmitted back to the fluid in the cannel. For example, when an increase in back pressure occurs, a shock is produced in the channel



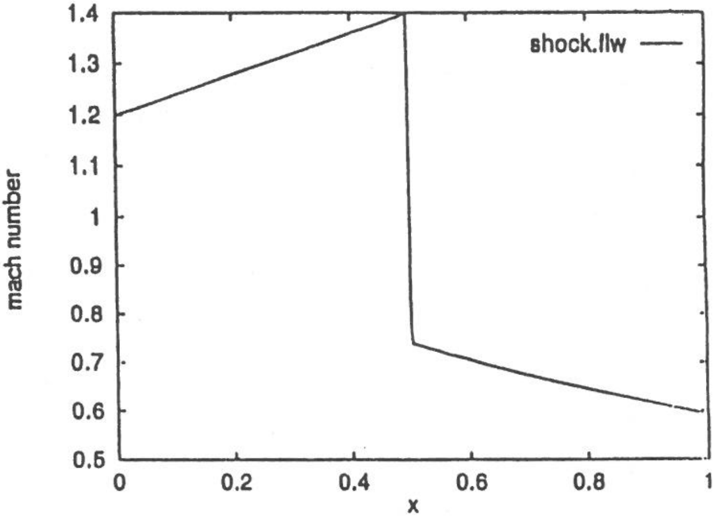
(a)


shock.flw
area
x
1.3
1.25
1.2
1.15
1.1
1.05
1
0
0.2
0.4
0.6
0.8
1

(b)


shock.flw
pressure
x
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0
0.2
0.4
0.6
0.8
1

(c)



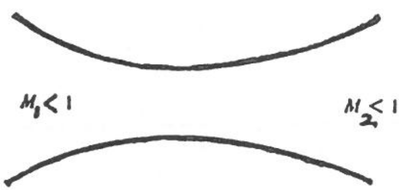
(d)

Fig. 7. Diverging channel (shock).

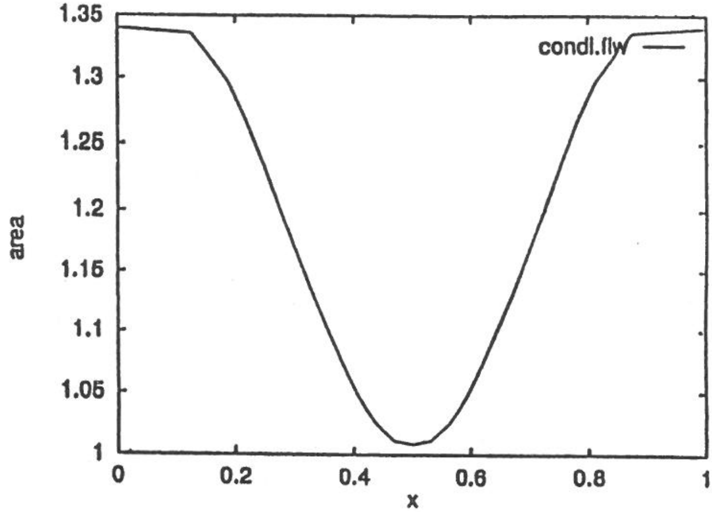
(see Figs. 7(c) and 7(d) at $x=0.5$). The pressure is decreasing before the shock and increasing after (Fig. 7(c)), and the Mach number is increasing before the shock and decreasing after (Fig. 7(d)).

converging-diverging channel

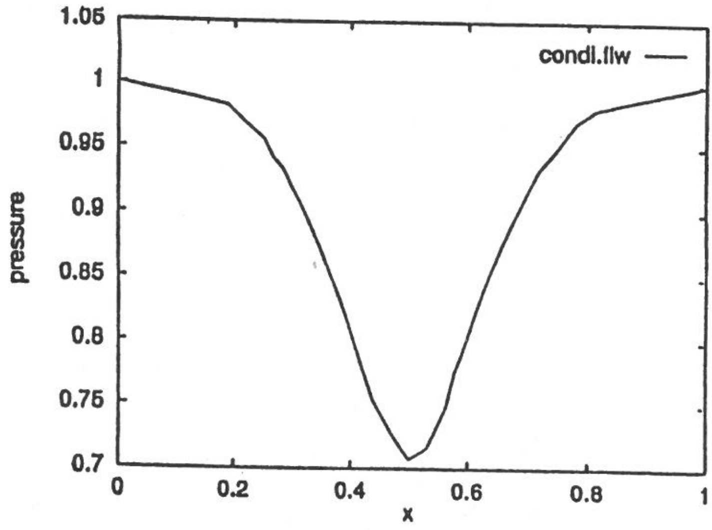
Finally, a converging-divering channel[7~9] is considered (Figs. 8(a) and 8(b)). Figure 8(c) shows the result of the pressure P versus the distance X for the case illustrated in Fig. 8(d).



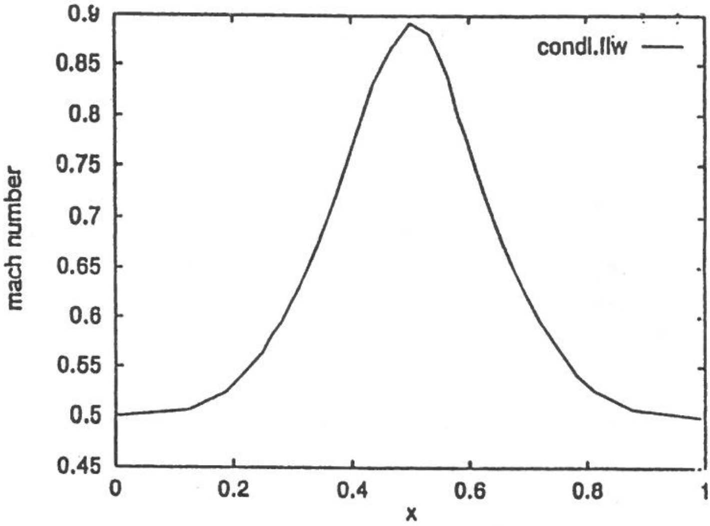
(a)


1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
area
0
0.2
0.4
0.6
0.8
1
x
condl.flw

(b)


1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
pressure
0
0.2
0.4
0.6
0.8
1
x
condl.flw

(c)



(d)

Fig. 8. Converging-diverging channel.

6. CONCLUSION AND DISCUSSION

The present paper has described a data structure which is dynamic and involves the use of an indirect addressing system. The benefit of the data structure is to generate unstructured meshes effectively. It is believed that the idea of using the C programming language is an appropriate choice to implement the designed data structure. This data structure has the potential to be extended and/or modified in two or three dimensional space, and further work will be processeded in this direction.

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建立非結構性網格之資料結構

黃貞瑛　莊心公

輔仁大學資訊工程系

摘　要

電腦科技的快速發展與進步，使得利用計算流體力學來分析複雜幾何形體上的流體，變得越來越重要與實用了。在早期計算流體的發展中，許多有效率的計算方法，已經建立了，為了驗證這些方法，常用簡單的幾何形體來測試。例如機翼、道渠，而這些形態的幾何體，可以很容易地用結構性網格法來劃分。多數使用結構性網格法的電腦程式，計算上都非常有效率，尤其在向量或平行電腦上。但是有時候，對於複雜的幾何形體，傳統的結構性網格法，並無法合理適當地分割。因此，最近這些年來，非結構性網格法便廣受計算流體力學研究人員的採用。但由於非結構性網格法的不規則資料結構形態，使得大多數利用此法的電腦程式，在平行或向量的電腦上執行，並不是很有效率。所以，對於非結構性網格法的計算法仍有待努力去改進。

本研究的目的，便在於利用 C 語言發展出一資料結構，產生一有效率的非結構性網格法。此一結構包含三個子結構，分別為「節點」、「邊線」，與「層次」。它們的優點在於 (1) 提供一個間接的位置指引系統，連接各子結構，對於非結構性網格法，這是一個妥切的方法，因為非結構性的網格一般是隨機排列的。(2) 此結構為動態性的，可以在程式執行當中改變元素個數的多寡。本文將分別描述三個子結構，並利用此一完整結構在擴張管道與收縮一擴張管道的問題中。

關鍵詞：可壓縮氣體、計算流體力學、非結構性網格法、有限體積法、安定流體、不安定流體。

臺灣地區餐飲從業人員採購知識之研究

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摘 要

本研究係以臺灣23個縣市餐飲採購人員 1,531 人爲對象，採問卷調查方式，問卷內容包括食品採購的營養、選購、貯存知識。結果顯示各縣市餐飲從業人員採購知識偏低，答對比率只有 59%；23 個地區餐飲從業人員採購知識無差異；若將營養部份剔除後發現南部餐飲從業人員採購知識優於北部，其餘地區不具差異性。

一、前 言

農業在整個產業的結構中爲初級產業，農業的發展不再以「增產報國」爲其經營方針，而是將農產品商品化後以現代化的方式來經營，因此深入研究農業市場將有助於推動農產品達到行銷的目的。

Webster 和 Wind (1972) 將影響產業購買的因素歸爲四大類：環境、組織、人際和個人因素，在研究影響消費行爲各項因素中認知占極重要的地位，吳文淸 (1987) 指出認知是個人選擇、組織和解釋各項輸入資訊，並將其轉變成具有特殊意義的形象之過程。

一個人受外界刺激後必須經過選擇性接觸、選擇性誤解與選擇性保留才能產生認知上的反應，不同的認知反應將產生不同的消費行爲，而由個人的知識測驗可得知一個人對事物的認知程度（鄭伯勳，1987；蕭鏡堂，1985；吳文淸，1987）。

Kotschevar (1975)、Stokes (1976)、韓傑 (1993) 指出餐飲機構應作食物成本、數量和品質的控制，採購是執行控制中最重要的步驟，本研究主要目的在於了解臺灣地區餐飲從業人員採購知識，並比較不同地區餐飲從業人員採購知識的差異。

二、研究方法

1. 研究對象

本研究係採用二段分層隨機抽樣法，由臺灣地區工商及服務業普查餐飲業母體中，依北、中、南、東四層經建區域，各層依比例配置 (Proportional allocation)，再依不同的餐飲業別之員工人數與年營業額依比例配置隨機抽取樣本，以觀光飯店、連鎖餐飲業、一般餐廳、速食業、中西式自助餐、盒餐業、學校餐廳、醫院內餐廳之採購人員共 1,531 人為研究對象。

2. 研究步驟

本研究係採用問卷調查法，知識測驗架構係採用林宜長（1992），實踐管理學院（1991）之研究擬訂出對食物營養、選購、貯存知識，由十位學者專家作問卷內容效度處理，刪除評分在 3 分以下的題目，再抽取 100 家餐飲機構採購人員預試，收回 67 份問卷，選出鑑別指數大於 0.2 及難度在 0.4～0.8 之間的題目，本研究問卷之內容係度 KR-20 為 0.84。

問卷設計完成後，依分層隨機抽樣法抽出樣本由郵局寄發出 2,000 份，再經電話催繳及派員親自訪問共收回 1,531 份，回收率 76.55%。

3. 資料分析

本研究係以百分比、變異數分析及變異數差異性比較來作資料分析。

三、結果及討論

1. 臺灣地區餐飲從業人員農產品採購知識得分

本研究有效問卷有 1,531 份，餐飲農產品採購知識測驗 12 題，每題 1 分，滿分為 12 分，所得結果如表一所示，知識測驗答對比率為 59 %，其中以選購知識最好，其次為營養知識，最差的為貯存知識，但經變異數差異性分析顯示各分量表未達顯著差異。

表一　臺灣地區餐飲從業人員農業品採購知識得分

分測驗表	統計量數						
	人數	平均數	標準差	題數	每題平均得分	答對比率(%)	平均數等第
營養	1,531	2.144	0.005	4	0.536	54	2
選購	1,531	3.404	0.004	5	0.680	68	1
貯存	1,531	1.503	0.006	3	0.501	50	3
知識總測驗	1,531	7.051	0.040	12	1.717	59	

表二　臺灣地區餐飲從業人員農產品採購知識變量數差異性分析

變量來源	離均差平方和	自由度	均方	*F*
受試者之間	64.0932	22	2.91	1.21
受試者之間	3,549.268	1,476	2.40	
全體	3,613.3622	1,498		

2. 不同地區餐飲從業人員採購知識得分

為了解臺灣地區餐飲從業人員採購知識得分情形，將各區得分列於表三至二十五。

由表三可知臺北市餐飲從業人員 363 人，所得的採購知識答對比率為 58.3%，在分量表方面以選購知識最好，其次依序為營養，以貯存知識最差。

由表四可知臺北縣餐飲從業人員 41 人，所得的採購知識答對比率為 61.99%，在分量表方面以選購知識最好，其次為營養，以貯存知識最差。

表三　臺北市餐飲從業人員採購知識得分結果

分量表＼統計數量	統計量數						
	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	363	2.144	0.205	4	0.536	53.6	2
選購	363	3.37	0.156	5	0.674	67.4	1
貯存	363	1.482	0.242	3	0.494	49.4	3
採購知識總分	363	6.994	1.584	12	0.583	58.3	

表四　臺北縣餐飲從業人員採購知識得分結果

分量表＼統計數量	統計量數						
	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	41	2.268	0.202	4	0.563	56.7	2
選購	41	3.585	0.109	5	0.717	71.7	1
貯存	41	1.584	0.223	3	0.528	52.8	3
採購知識總分	41	7.439	1.246	12	0.620	61.99	

由表五可知基隆市餐飲從業人員 102 人，所得的採購知識答對比率爲 58.33%，在分量表方面以選購知識最好，其次爲貯存，以營養知識最差。

由表六可知桃園縣餐飲從業人員 105 人，所得的採購知識答對比率爲 56.98%，在分量表方面以選購知識最好，其次爲營養，以貯存知識最差。

由表七可知新竹市餐飲從業人員 26 人中所得的採購知識答對比率爲 57.05%，在分量表方面以選購知識最好，其次爲營養，以貯存知識最差。

表五　基隆市餐飲從業人員採購知識得分結果

分量表＼統計數量	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	102	2.06	0.216	4	0.515	51.5	3
選購	102	3.39	0.149	5	0.678	67.8	1
貯存	102	1.548	0.247	3	0.516	51.6	2
採購知識總分	102	7.000	1.683	12	0.583	58.33	

表六　桃園縣餐飲從業人員採購知識得分結果

分量表＼統計數量	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	105	2.20	0.185	4	0.550	55.0	2
選購	105	3.26	0.139	5	0.651	65.1	1
貯存	105	1.38	0.224	3	0.460	46.0	3
採購知識總分	105	6.838	1.279	12	0.570	56.98	

表七　新竹市餐飲從業人員採購知識得分結果

分量表＼統計數量	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	26	2.152	0.262	4	0.538	53.8	2
選購	26	3.27	0.156	5	0.654	65.4	1
貯存	26	1.422	0.253	3	0.474	47.4	3
採購知識總分	26	6.846	1.826	12	0.571	57.05	

由表八可知新竹縣餐飲從業人員22人，所得的採購知識答對比率爲61.36%，在分量表方面以選購知識最好，其次爲營養，以貯存知識最差。

由表九可知苗栗縣餐飲從業人員17人，所得的採購知識答對比率爲59.31%，在分量表方面以選購知識最好，其次爲營養，以貯存知識最差。

由表十可知臺中市餐飲從業人員170人，所得的採購知識答對比率爲60.05%，在分量表方面以選購知識最好，其次爲營養，以貯存知識最差。

表八　新竹縣餐飲從業人員採購知識得分結果

統計數量 / 分量表	人數	平均數	標準差	題數（滿分）	每題平均得分	答對比率(%)	平均數等第
營養	22	2.32	0.210	4	0.580	58.0	2
選購	22	3.37	0.145	5	0.673	67.3	1
貯存	22	1.68	0.260	3	0.561	56.1	3
採購知識總分	22	7.364	1.706	12	0.614	61.36	

表九　苗栗縣餐飲從業人員採購知識得分結果

統計數量 / 分量表	人數	平均數	標準差	題數（滿分）	每題平均得分	答對比率(%)	平均數等第
營養	17	2.41	0.218	4	0.603	60.3	2
選購	17	3.53	0.125	5	0.706	70.6	1
貯存	17	1.18	0.294	3	0.392	39.2	3
採購知識總分	17	7.118	14.95	12	0.593	59.31	

表十　臺中市餐飲從業人員採購知識得分結果

統計數量 / 分量表	人數	平均數	標準差	題數（滿分）	每題平均得分	答對比率(%)	平均數等第
營養	170	2.212	0.196	4	0.553	55.3	2
選購	170	3.455	0.134	5	0.691	69.1	1
貯存	170	1.542	0.254	3	0.514	51.4	3
採購知識總分	170	7.206	1.561	12	0.601	60.05	

由表十一可知臺中縣餐飲從業人員 38 人，所得的採購知識答對比率為 58.33%，在分量表方面以選購知識最好，其次為營養，以貯存知識最差。

由表十二可知彰化縣餐飲從業人員 119 人，所得的採購知識答對比率為 58.96%，在分量表方面以選購知識最好，其次為營養，以貯存知識最差。

由表十三可知南投縣餐飲從業人員 19 人，所得的採購知識答對比率為 55.7%，在分量表方面以選購知識最好，其次為貯存，以營養知識最差。

表十一　臺中縣餐飲從業人員採購知識得分結果

統計數量／分量表	統計量數						
	人數	平均數	標準差	題數（滿分）	每題平均得分	答對比率(%)	平均數等第
營養	38	2.21	0.203	4	0.553	55.3	2
選購	38	3.32	0.115	5	0.663	66.3	1
貯存	38	1.47	0.242	3	0.491	49.1	3
採購知識總分	38	7.00	1.273	12	0.583	58.33	

表十二　彰化縣餐飲從業人員採購知識得分結果

統計數量／分量表	統計量數						
	人數	平均數	標準差	題數（滿分）	每題平均得分	答對比率(%)	平均數等第
營養	119	2.108	0.210	4	0.527	52.7	2
選購	119	3.47	0.142	5	0.694	69.4	1
貯存	119	1.497	0.233	3	1.499	49.9	3
採購知識總分	119	7.076	1.485	12	0.590	58.96	

表十三　南投縣餐飲從業人員採購知識得分結果

統計數量／分量表	統計量數						
	人數	平均數	標準差	題數（滿分）	每題平均得分	答對比率(%)	平均數等第
營養	19	1.736	0.163	4	0.434	43.4	3
選購	19	3.475	0.154	5	0.695	69.5	1
貯存	19	1.473	0.204	3	0.491	49.1	2
採購知識總分	19	6.684	1.293	12	0.557	55.7	

由表十四可知雲林縣餐飲從業人員 27 人,所得的採購知識答對比率為 59.6%，在分量表方面以選購知識最好，其次為貯存，以營養知識最差。

由表十五可知嘉義市餐飲從業人員 16 人，所得的採購知識答對比率為 55.87%，在分量表方面以選購知識最好，其次為營養，以貯存知識最差。

由表十六可知嘉義縣餐飲從業人員 34 人，所得的採購知識答對比率為 60.78%，在分量表方面以選購知識最好，其次為貯存，以營養知識最差。

表十四　雲林縣餐飲從業人員採購知識得分結果

統計數量／分量表	統	計	量	數			
	人 數	平均數	標準差	題 數（滿分）	每題平均得分	答 對比率(%)	平均數等 第
營 養	27	2.036	0.190	4	0.509	50.9	3
選 購	27	3.52	0.129	5	0.704	70.4	1
貯 存	27	1.593	0.296	3	0.531	53.1	2
採購知識總分	27	7.148	1.634	12	0.596	59.56	

表十五　嘉義市餐飲從業人員採購知識得分結果

統計數量／分量表	統	計	量	數			
	人 數	平均數	標準差	題 數（滿分）	每題平均得分	答 對比率(%)	平均數等 第
營 養	16	2.312	0.176	4	0.578	57.8	2
選 購	16	3.315	0.159	5	0.663	66.3	1
貯 存	16	1.125	0.240	3	0.375	37.5	3
採購知識總分	16	6.750	1.238	12	0.563	55.87	

表十六　嘉義縣餐飲從業人員採購知識得分結果

統計數量／分量表	統	計	量	數			
	人 數	平均數	標準差	題 數（滿分）	每題平均得分	答 對比率(%)	平均數等 第
營 養	34	2.236	0.231	4	0.559	55.9	3
選 購	34	3.135	0.121	5	0.676	67.6	1
貯 存	34	1.677	0.228	3	0.559	55.9	2
採購知識總分	34	7.294	1.426	12	0.608	60.78	

由表十七可知臺南市餐飲從業人員 51 人，所得的採購知識答對比率爲 59.31%，在分量表方面以選購知識最好，其次依序爲營養，以貯存知識最差。

由表十八可知臺南縣餐飲從業人員 27 人中採購知識答對比率占 53.74%，在分量表方面以選購知識最好，其次爲貯存，以營養知識最差。

由表十九可知高雄市餐飲從業人員 195 人中採購知識答對比率占 60.51%，在分量表方面以選購知識最好，其次爲營養，以貯存知識最差。

表十七　臺南市餐飲從業人員採購知識得分結果

統計數量 / 分量表	統計量數						
	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	51	2.136	0.250	4	0.534	53.4	2
選購	51	3.41	0.134	5	0.682	68.2	1
貯存	51	1.569	0.252	3	0.523	52.3	3
採購知識總分	51	7.118	1.492	12	0.593	59.31	

表十八　臺南縣餐飲從業人員採購知識得分結果

統計數量 / 分量表	統計量數						
	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	27	1.816	0.197	4	0.454	45.4	3
選購	27	3.22	0.187	5	0.644	64.4	1
貯存	27	1.407	0.266	3	0.469	46.9	2
採購知識總分	27	6.444	1.888	12	0.537	53.7	

表十九　高雄市餐飲從業人員採購知識得分結果

統計數量 / 分量表	統計量數						
	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	195	2.2	0.213	4	0.550	55.0	2
選購	195	3.465	0.154	5	0.693	69.3	1
貯存	195	1.596	0.250	3	0.532	53.2	3
採購知識總分	195	7.262	1.652	12	0.605	60.51	

由表二十可知高雄縣餐飲從業人員 30 人中採購知識答對比率占 56.9%，在分量表方面以選購知識最好，其次爲貯存，以營養知識最差。

由表二十一可知屏東縣餐飲從業人員 18 人，採購知識答對比率占 59.26%，在分量表方面以選購知識最好，其次爲營養，以貯存最差。

由表二十二可知宜蘭縣餐飲從業人員 18 人中採購知識答對比率占 62.5%，在分量表方面以選購知識最好，其次爲營養，以貯存最差。

表二十 高雄縣餐飲從業人員採購知識得分結果

統計數量 / 分量表	統計量數						
	人 數	平均數	標準差	題 數 (滿分)	每題平均得分	答 對 比率(%)	平均數 等 第
營 養	30	1.832	0.187	4	0.458	45.8	3
選 購	30	3.435	0.155	5	0.687	68.7	1
貯 存	30	1.566	0.226	3	0.522	52.2	2
採購知識總分	30	6.833	1.510	12	0.569	56.9	

表二十一 屏東縣餐飲從業人員採購知識得分結果

統計數量 / 分量表	統計量數						
	人 數	平均數	標準差	題 數 (滿分)	每題平均得分	答 對 比率(%)	平均數 等 第
營 養	18	2.112	0.225	4	0.528	52.8	2
選 購	18	3.665	0.119	5	0.733	73.3	1
貯 存	18	1.332	0.229	3	0.444	44.4	3
採購知識總分	18	7.111	1.711	12	0.593	59.26	

表二十二 宜蘭縣餐飲從業人員採購知識得分結果

統計數量 / 分量表	統計量數						
	人 數	平均數	標準差	題 數 (滿分)	每題平均得分	答 對 比率(%)	平均數 等 第
營 養	18	2.332	0.149	4	0.583	58.3	2
選 購	18	3.56	0.141	5	0.711	71.1	1
貯 存	18	1.61	0.232	3	0.537	53.7	3
採購知識總分	18	7.500	0.924	12	0.625	62.5	

由表二十三可知花蓮縣餐飲從業人員 21 人，採購知識答對比率占 53.58%，在分量表方面以選購知識最好，其次爲營養，以貯存知識最差。

由表二十四可知臺東縣餐飲從業人員 20 人，採購知識答對比率占 61.67%，在分量表方面以選購知識最好，其次爲營養，以貯存知識最差。

由表二十五可知澎湖縣餐飲從業人員 20 人，採購知識答對比率占 62.16%，在分量表方面以選購知識最好，其次爲營養，以貯存知識最差。

表二十三　花蓮縣餐飲從業人員採購知識得分結果

統計數量 / 分量表	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	21	2.000	0.237	4	0.500	50.0	2
選購	21	3.19	0.163	5	0.638	63.8	1
貯存	21	1.239	0.277	3	0.413	41.3	3
採購知識總分	21	6.429	1.568	12	0.536	53.58	

表二十四　臺東縣餐飲從業人員採購知識得分結果

統計數量 / 分量表	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	20	2.300	0.245	4	0.575	57.5	2
選購	20	3.550	0.121	5	0.710	71.0	1
貯存	20	1.551	0.296	3	0.517	51.7	3
採購知識總分	20	7.400	2.037	12	0.617	61.67	

表二十五　澎湖縣餐飲從業人員採購知識得分結果

統計數量 / 分量表	人數	平均數	標準差	題數(滿分)	每題平均得分	答對比率(%)	平均數等第
營養	20	2.352	0.147	4	0.588	58.8	2
選購	20	3.6	0.120	5	0.720	72.00	1
貯存	20	1.551	0.253	3	0.517	51.7	3
採購知識總分	20	7.500	1.235	12	0.625	62.5	

二、不同地區餐飲從業人員採購知識的差異性

由上述可知不同地區餐飲從業人員採購知識得分情形，現將 23 縣市知識得分的情形列於表二十六，由表二十六可知 23 縣採購知識得分由高至低的排列爲宜蘭縣、澎湖縣、臺北縣、臺東縣、新竹縣、嘉義縣、臺中市、高雄市、雲林縣、苗栗縣、臺南市、屏東縣、彰化縣、臺中縣、基隆市、臺北市、新竹市、桃園縣、高雄縣、嘉義市、南投縣、臺南縣、花蓮縣。但經變異數分析（見表二十七）未達顯著差異，因此各地區餐飲從業人員採購知識沒差異。

3. 北、中、南、東地區餐飲從業人員在農產品採購知識之差異

研究分析顯示餐飲從業人員在營養知識的得分甚低，爲了探討營養項目是否造成採購知識無顯著差異的因素，因此將比較剔除營養項目前後的分析結果。

表二十六　不同地區餐飲從業人員採購知識之平均數分析表

地區	人數	平均數	標準差	平均數等第
臺北市	363	6.994	1.584	16
臺北縣	41	7.439	1.246	3
基隆市	102	7.0	1.683	14
桃園縣	105	6.838	1.279	18
新竹市	26	6.846	1.826	17
新竹縣	22	7.364	1.706	5
苗栗縣	17	7.118	1.495	10
臺中市	170	7.206	1.561	7
臺中縣	38	7.0	1.273	14
彰化縣	119	7.076	1.485	13
南投縣	19	6.684	1.293	21
雲林縣	27	7.148	1.634	9
嘉義市	16	6.75	1.238	20
嘉義縣	34	7.294	1.426	6
臺南市	51	7.118	1.493	10
臺南縣	27	6.444	1.888	22
高雄市	195	7.262	1.652	8
高雄縣	30	6.833	1.510	19
屏東縣	18	7.111	1.711	12
宜蘭縣	18	7.5	0.924	1
花蓮縣	20	6.429	1.568	23
臺東縣	20	7.4	2.037	4
澎湖縣	20	7.5	1.235	2

(1) 未剔除營養知識部分之差異性

由表二十八資料顯示依每題數的高低排列，以南部的從業人員知識得分較高，其他依次爲中部、北部，以東部最低。

爲了解北、中、南、東地區餐飲從業人員在農產品採購知識的差異，作了變異數分析，由表二十九結果顯示不同地區餐飲從業人員在農業品採購知識方面並無顯著差異。

在知識測驗中剔除有關營養題目後之得分情況（見表三十）由每題平均數的高低排列，仍以南部的知識得分較高；其他依序爲中部、北部，以東部最低。

表二十七　不同地區餐飲從業人員知識之變異數分析

變異來源	離均差平方和	自由度	均方	*F*
受試者之間	64.093	22	2.91	1.21
受試者之內	3,549.268	1,476	2.40	
全體	3,613.362	1,498		

表二十八　北、中、南、東地區餐飲從業人員農產品採購知識得分結果

地區	統計量數				
	人數	平均數	題數	每題平均數	等第
北部	709	6.976	12	0.581	3
中部	390	7.113	12	0.592	2
南部	391	7.141	12	0.595	1
東部	41	6.902	12	0.575	4

表二十九　北、中、南、東地區餐飲從業人員農產品採購知識變異數差異性分析

變異來源	離均差平方和	自由度	均方	*F*
受試者之間	9.52466	3	3.1748874	1.29*
受試之內	3,746.5014	1,527	2.453504	
全體	3,756.0261	1,530		

* $P<0.05$

(2) 剔除知識方面有關營養部分的問題

經由變異數分析（見表三十一）發現不同地區餐飲從業人員在農產品採購知識具有差異性。

由表三十二變異數分析差異性比較結果顯示以南部地區優於北部地區，而其餘地區則不具顯著性。

表三十　北、中、南、東地區餐飲從業人員農產品採購知識剔除營養部分得分結果

地區	統計量數				
	人數	平均數	題數	每題平均數	等第
北部	709	4.836	8	0.604	3
中部	390	4.959	8	0.619	2
南部	391	4.992	8	0.624	1
東部	41	4.756	8	0.594	4

表三十一　北、中、南、東地區餐飲從業人員農產品採購知識剔除營養部分後變異數分析

變異來源	離均差平方和	自由度	均方	*F*
受試者之間	8.36444	3	2.78814	2.22*
受試之內	1,916.9027	1,527	1.25533	
全體	1,925.2671	1,530		

* $P<0.05$

表三十二　北、中、南、東地區餐飲從業人員農產品採購知識剔除營養部分後變異數差異性比較

統計量數Q值／地區別	地區別		
	北部	中部	南部
中部	−0.12259		
南部	−0.15594**	−0.03335	
東部	0.08029	0.20288	0.23623

** $P<0.01$

四、結論及建議

1. 結論

(1) 各地區餐飲從業人員採購知識得分可見各區餐飲從業人員採購知識偏低答對比率占 59%。

(2) 二十三個地區餐飲從業人員採購知識比較無顯著差異。

(3) 將二十三個地區區分爲北、中、南、東四區作比較，結果顯示餐飲從業人員採購知識無顯著差異，但將分量表中營養的題目剔除後顯示南部地區餐飲從業人員採購知識優於北部，其餘地區不具差異性。

2. 建議

應加強餐飲從業人員貯存知識，不能僅著重食物選購的知識，因選購品質好的食品若沒有適當的貯存將是餐飲機構成本一大損失，餐飲經營者應鼓勵採購人員多參加衛生機構所舉辦的衛生研習班，吸收知識，自己多閱讀食品品質控制的書籍，並由實際採購中獲取經驗，採購食品應作好管理、計劃及評估，使工作有良好績效，方可降低食物成本提高食物品質。

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The Purchasing Knowledge of Restaurant Personnel in Taiwan Style Restaurant Personnel

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ABSTRACT

This research has investigated 1,531 restaurant purchasing personnel by questionnaire in Taiwan 23 counties and cities. content of questionnaire includes knowledge of nutrition, selection and storage. The result has showed that the knowledge of restaurant purchasing personnel is pretty low. The average correct percentage is only 59%. In purchasing knowledge, there is not much different among various personnel in 23 counties and citics. If nutrition knowledge is eliminated, the purchasing knowledge of restaurant personnel in the South is better than those personnel in the North. There is not much difference among the rest areas.

不同國家校內餐飲從業人員衛生知識之研究

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摘 要

本研究為了解美國、臺灣、中國大陸不同地區校內餐飲從業人員衛生知識，採用問卷調查方式，調查對象為校內餐飲從業人員共 694 人，其中美國有 199 人，臺灣 383 人，中國大陸 112 人，問卷以是非題來塡答。

經百分比及單因子變異數分析，結果顯示衛生知識總分三個國家無差異。

以分量表來看，三個國家校內餐飲從業人員衛生知識以對微生物的認識與天然毒素食物中毒知識需加强。

三個國家校內餐飲從業人員在微生物認識、細菌性食物中毒、黴菌食物中毒無顯著差異，但在天然毒素食物中毒、化學毒素食物中毒、餐具洗滌知識則有顯著差異。

關鍵詞：國家、餐飲、從業人員、衛生、知識。

一、前 言

知識就是力量，增強員工餐飲衛生知識可以確保餐飲安全 (Reed，1989；Skelton，1991；Harrington，1992；Manning，1993) 指出食物衛生需由食物中找出直接或間接引起危害身體健康的原因。顏國欽 (1988)、Robert (1991) 指出要確保食品安全應避免微生物、天然食物、環境及食品添加物所引起的危害。Punner (1985)、Swintek (1991)、FMI (1991)、Wolf (1992) 指出病蟲、黴菌、農藥及不良食品包裝導致食品不安全。餐飲衛生就是要確保所提供的餐食具安全性 (Hobbs，1978；郭鴻鈞，1985)，Bryan (1988)、Maryanski (1990)、Snyder (1992)、John (1992)、Manning etal (1993) 指出餐飲衛生包括食品衛生、環境衛生、設備衛生及個人衛生。

在食物衛生知識研究中學者指出應包括微生物特性、化學食物中毒、自然毒素食物中毒、食物處理知識 (Mcpround，1983；Woodburn，1985；Ricci，1989；Rogers，1989；Maryanski，1990；Skelton，1991)。影響餐飲從業人員衛生的因素，有年齡、教育背景、收入、餐飲業自我衛生檢查、職務 (Woodburn，1985；Skelton，1991；黃韶顏，1993) 餐飲從業人員參加衛生訓練會造成衛生知識的差異 (黃韶顏，1993)。

Margy (1985) 指出受試者衛生知識與行為呈正相關，衛生知識越高之餐飲從業人員行為越好，對餐飲業衛生之提昇有所助益。

二、材料與方法

1. 研究對象

本研究係以不同國家（美國、臺灣、中國大陸）校內餐飲從業人員 694 人爲研究對象。

2. 研究目的

本研究之主要目的在了解美國、臺灣、中國大陸餐飲從業人員衛生知識得分，由衛生知識得分高低，可作爲各國作衛生教育加強的方向。

同時作三國餐飲從業人員衛生知識的比較，以了解不同國家餐飲從業人員衛生知識的差異。

3. 研究方法

本研究係採用問卷調查法，衛生知識題目架構係參考 Woodburn (1985)、Skelton (1991)、John (1992)、Manning (1993) 等人的理論及研究擬定而成，使用題目共 30 題，每題以 1 分計算，採用是非題的方式，滿分爲 30 分。

衛生知識測驗包括對微生物的認識（10題）、細菌性食物中毒（5 題）、黴菌食物中毒（3 題）、天然毒素中毒（4 題）、化學毒素中毒（4 題）、餐具洗滌（4 題）共 30 題。

個人基本資料有國籍、性別、年齡、教育程度、技術士執照、職務、服務年資、健康檢查、參加衛生講習、工作中衛生教育訓練、工作中使用衛生檢查表。

4. 研究過程

本研究問卷之設計過程原本以對微生物的認識，細菌性食物中毒、黴菌食物中毒、天然毒素食物中毒、化學毒素食物中毒、環境衛生等知識設計出 41 題，經 10 位學者專家作問卷內容效度 (Content Validity)，刪除每題得分在 3 分以下的題目，結果有 38 題。

將作好之問卷在臺灣地區（臺北市）選 50 位餐飲從業人員來填答，美國 (Iowa State) 選 20 位餐飲從業人員；中國大陸（上海市）選 20 位餐飲從業人員來填答，回收之問卷作項目分析，選鑑別指數 (Index of discrimination) 大於 0.2 及難度 (item of difficulty) 在 0.4～0.8 之問題，共 30 題，並求出問卷之信度 KR (Kuder-Richardzon Reliability) 20＝0.84。

在 1994 年 4 月至 6 月分別在美國中西部五個州 (Michigan，Wisconsin，Minisota，Iowa，Indiana) 九個大學、中國大陸（上海市）九個大學、臺灣

地區（臺北市）十六個大學之校內餐廳發問卷，每一個國家發出600份，回收率爲美國占 33.2%，中國大陸占 18.7%，臺灣爲 63.5%。

5. 資料分析

將問卷資料收齊後，先作資料檢誤，刪除填答不完整之問卷，以 SAS 作統計分析，統計方法採用百分比、單因子變量數分析及 T 法事後比較。

三、研究結果

本研究之結果依研究對象基本資料及餐飲從業人員衞生知識來敍述。

1. 研究對象基本資料

研究對象的特性介紹於下：

由表可知本研究共有 694 人，其中美國樣本群有 199 人，中國大陸有 112 人，臺灣有 383 人。現依自變項之特性分項敍述之：

(1) 性別

中國大陸樣本群中男、女各占一半；美國樣本群以女性所占的比例較高占 73.6%；臺灣樣本群以男性比率高占 60.6%。

(2) 年齡

中國大陸樣本群中以 21～40 歲最多，其次爲 20 歲以下、41～60 歲，以 61 歲以上的人最少；美國樣本以 41～60 歲最多，其次 21～40 歲，以 20 歲以下最少；臺灣樣本以 21～40 歲最多，其次 41～60 歲。

(3) 教育程度

本研究中中國大陸學校餐飲從業人員教育程度以國中生較多占 41.1%，其次爲國小以下占 21.4%；美國學校餐飲從業人員教育程度以高中生最多占 66.3%，其次爲大專生占 24.1%，偏向高學歷；臺灣餐飲從業人員教育程度以國中最多占 33.5%，高中占 33%。樣本群中此三個國家以美國學校餐飲從業人員偏向高學歷。

(4) 職務

樣本中中國大陸餐飲從業以主廚最多占 39.8%；美國餐飲從業人員以助厨占 38.1%，主厨占 31.2%；臺灣地區餐飲從業人員以助厨最多占 44.1%。

表一 研究對象基本資料

項目	統計量數	中國大陸 人數	中國大陸 百分比	美國 人數	美國 百分比	臺灣 人數	臺灣 百分比
性別	男	58	51.8	52	26.1	231	60.6
	女	54	48.2	147	73.6	150	39.4
年齡	20歲以下	28	25	3	1.5	20	5.2
	21～40歲	54	48.2	79	39.7	228	59.7
	41～60歲	26	23.2	103	51.8	112	29.3
	61歲以上	4	3.6	14	7.0	22	5.8
教育程度	國小以下	24	21.4	6	3.0	71	18.7
	國中	46	41.1	8	4.0	127	33.5
	高中	17	15.2	132	66.3	125	33
	大專	22	19.6	48	24.1	53	14
	研究所以上	3	2.9	5	2.5	3	0.8
職務	經理	23	21.3	9	10.3	37	9.8
	主厨	43	39.8	62	31.2	71	18.7
	助厨	11	10.2	76	38.1	167	44.1
	其他	35	31.25	43	21.7	108	28.2
服務年資	5年以下	40	44.9	30	15.2	154	40.8
	6～10年	30	33.7	40	20.3	114	30.2
	11～15年	11	12.4	52	26.4	73	19.4
	16年以上	8	9.0	75	38.1	36	9.5
健康檢查	有	84	83.2	未塡答	未塡答	351	91.9
	無	17	16.8	未塡答	未塡答	31	8.1
參加衞生講習	有	84	80.8	107	54.3	332	87.1
	無	20	19.2	70	45.7	49	12.9
工作中衞教訓練	有	84	83.2	181	92.3	319	83.7
	無	17	16.8	15	7.7	62	16.3
工作中使用衞生檢查表	有	85	85.4	未塡答	未塡答	264	69.5
	無	15	14.6	未塡答	未塡答	116	30.5

(5) 服務年資

服務年資而言，樣本群中中國大陸以服務5年以下的餐飲從業人員占44.9%，其次爲6～10年占33.7%；美國餐飲從業人員以16年以上最多占38.1%，其次爲11～15年占26.4%，以5年以下者最少；臺灣地區以5年以下塡答者

最多占 40.8%，其次爲 6～10 年占 30.2%，因此樣本群之服務年資以中國大陸與臺灣地區較相近。

(6) 健康檢查

臺灣與中國大陸餐飲從業人員經健康檢查之比例很高，均在 80%以上，美國餐飲從業人員未塡答。

(7) 參加政府擧辦的衞生講習

由表一中可知中國大陸與臺灣餐飲從業人員參加政府擧辦的衞生講習比例較高，占 80%以上，美國餐飲從業人員約一半人數參加衞生講習。

(8) 工作中衞敎訓練

由表一中顯示臺灣與美國餐飲從業人員 80%以上均參加了衞生教育訓練。

(9) 工作中使用衞生自我檢查表

在中國大陸餐飲從業人員在工作中使用自我檢查表較高，臺灣地區則較低僅 69.5%使用檢查表。

2. 餐飲從業人員衞生知識

本研究中爲了解臺灣、中國大陸、美國餐飲從業人員衞生知識，將三國抽樣人員塡答情況列於表二，爲了塡答者各分量表塡答情形並比較其差異，由表四至表十八可見結果。

由表二可知各國餐飲從業人員衞生知識，美國餐飲從業人員 199 人，每題平均得分爲 0.8204，占滿分比率 82.04%；臺灣地區校內餐飲從業人員 383 人，衞生知識答對率爲 77.5%；中國大陸校內餐廳 112人，衞生知識答對率爲 76.7%，以美國校內餐飲從業人員衞生知識最高，由表三衞生知識單因子變異數分析結果顯示不同國別衞生知識無差異。

表二　校內餐飲從業人員衞生知識塡答得分

統計量數 / 國家	人數	平均數	標準差	得分（滿分）	每題平均得分	占滿分比率（%）
美國	199	24.612	2.418	30	0.8204	82.04
臺灣	383	23.253	4.812	30	0.775	77.5
中國大陸	112	23.017	4.581	30	0.767	76.7

表三 不同國別餐飲從業人員衞生知識單因子變異數分析表

變異來源	離均差平方和	自由度	均方	F
受試者之間	0.1341	2	0.067	0.3
受試者之內	154.903	691	0.224	
全體	155.0374	693		

表四 不同國別餐飲從業人員微生物知識得分情形

統計量數 / 國家	人數	平均數	標準差	得分（滿分）	每題平均數	答對比率（%）	平均數等第
臺灣	383	6.154	1.569	10	0.6154	61.54	1
中國大陸	112	6.071	1.456	10	0.6071	60.71	2
美國	199	5.960	1.507	10	0.5960	59.60	3

表五 不同國別餐飲從業人員微生物知識單因子變異數分析表

變異來源	離均差平方和	自由度	均方	F
受試者之間	4.9659	2	2.4829	1.06
受試者之內	1,625.0181	691	2.35169	
全體	1,629.9841	693		

表六 不同國別餐飲從業人員細菌性食物中毒知識得分情形

統計量數 / 國家	人數	平均數	標準差	得分（滿分）	每題平均數	答對比率（%）	平均數等第
臺灣	383	4.277	0.810	5	0.8554	85.54	1
中國大陸	112	4.25	0.765	5	0.850	85	3
美國	199	4.271	0.845	5	0.8542	85.42	2

(1) 微生物知識方面

由表四可知三國餐飲業從業人員在微生物知識的得分均不高以臺灣地區餐飲從業人員得分最高，答對比率占 61.54% ，其次爲中國大陸，以美國餐飲從業人

員最低，但經表五變異數分析未達顯著性。顯示三國餐飲從業人員微生物知識無差異，三個國家餐飲從業人員對微生物的成長環境均需加強，可能太抽象而不易了解。

表七　不同國別餐飲從業人員細菌性食物中毒知識單因子變異數分析表

變異來源	離均差平方和	自由度	均方	*F*
受試者之間	0.0621	2	0.0310	0.05
受試者之內	457.0099	691	0.66137	
全體	457.07204	693		

表八　不同國別餐飲從業人員黴菌食物中毒得分情形

統計量數 / 國家	人數	平均數	標準差	得分(滿分)	每題平均數	答對比率(%)	平均數等第
臺灣	383	2.825	0.432	3	0.941	94.1	1
中國大陸	112	2.759	0.45	3	0.919	91.9	3
美國	199	2.814	0.483	3	0.938	93.8	2

表九　不同國別餐飲從業人員黴菌食物中毒知識單因子變異數分析表

變異來源	離均差平方和	自由度	均方	*F*
受試者之間	0.38128	2	0.1906	0.94
受試者之內	139.891	691	0.2024	
全體	140.2723	693		

表十　不同國別餐飲從業人員天然毒素中毒知識得分情形

統計量數 / 國家	人數	平均數	標準差	得分(滿分)	每題平均數	答對比率(%)	平均數等第
臺灣	383	3.057	0.695	4	0.764	76.4	3
中國大陸	112	3.071	0.732	4	0.768	76.8	2
美國	199	3.191	0.669	4	0.7982	79.8	1

表十一 不同國別餐飲從業人員天然毒素中毒知識單因子變異數分析表

變異來源	離均差平方和	自由度	均方	*F*
受試者之間	2.4285	2	1.2142	2.52*
受試者之內	332.9085	691	0.4816	
全體	335.3371	693		

* $P < 0.05$

表十二 不同國別餐飲從業人員天然毒素中毒知識差異性比較

國別 \ 統計量數 \ 國別	臺灣	中國大陸
中國大陸	0.0140	
美國	0.1335*	0.1195*

* $P < 0.05$

表十三 不同國別餐飲從業人員化學毒素食物中毒知識得分情形

國家 \ 統計量數	人數	平均數	標準差	得分(滿分)	每題平均數	答對比率(%)	平均數等第
臺灣	383	3.535	0.582	4	0.884	88.4	2
中國大陸	112	3.652	0.515	4	0.913	91.3	1
美國	199	3.467	0.650	4	0.867	86.7	3

表十四 不同國別餐飲從業人員化學毒素食物中毒知識單因子變異數分析表

變異來源	離均差平方和	自由度	均方	*F*
受試者之間	2.4385	2	1.2192	3.48*
受試者之內	242.2314	691	0.3505	
全體	224.6700	693		

* $P < 0.05$

表十五　不同國別餐飲從業人員化學毒素食物中毒知識差異性比較

國別＼統計量數＼國別	臺灣	中國大陸
中國大陸	0.1165*	
美國	−0.0679	0.1844*

* $P<0.05$

表十六　不同國別餐飲從業人員餐具洗滌知識得分情形

國家＼統計量數	人數	平均數	標準差	得分（滿分）	每題平均數	答對比率（%）	平均數等第
臺灣	383	3.405	0.724	4	0.851	85.1	2
中國大陸	112	3.214	0.663	4	0.803	80.3	3
美國	199	3.482	0.702	4	0.8705	87	1

表十七　不同國別餐飲從業人員餐具洗滌知識單因子變異數分析表

變異來源	離均差平方和	自由度	均方	F
受試者之間	5.2131	2	2.6065	5.19*
受試者之內	346.8171	691	2.5019	
全體	352.0302	693		

* $P<0.05$

表十八　不同國別餐飲從業人員餐具洗滌知識差異性比較

國別＼統計量數＼國別	臺灣	中國大陸
中國大陸	0.1904*	
美國	0.0777	0.2681*

* $P<0.05$

(2) 細菌性食物中毒知識

由表六可知三個國家餐飲從業人員在細菌性食物中毒的得分情形，答對百分比以臺灣餐飲從業人員最好，其次爲美國，最低爲中國大陸，但經表七變異分析結果顯示三國餐飲從業人員細菌性食物中毒知識無差異。

(3) 黴菌食物中毒知識

由表八可知三個國家餐飲從業人員黴菌食物中毒答對比率以臺灣得分最高占94.1％，其次爲美國，以中國大陸得分最低，但經表九變異數分析結果顯示三國餐飲從業人員黴菌食物中毒知識無差異。

(4) 天然毒素食物中毒知識

由表十可知三個國家餐飲從業人員天然毒素食物中毒的得分，答對情形以美國最高，其次爲中國大陸，以臺灣答對率最低，經表十一變異數分析顯示有差異性，再經表十二 T 法差異性比較結果顯示美國餐飲從業人員天然毒素中毒知識優於臺灣；美國餐飲從業人員天然毒素中毒優於中國大陸，但臺灣和中國大陸餐飲從業人員在天然毒素食物中毒知識無差異。

(5) 化學毒素食物中毒知識

由表十三可知三個國家餐飲從業人員化學毒素食物中毒知識得分情形以中國大陸餐飲從業人員答對比率最高，其次爲臺灣，最低爲美國，經表十四變異數分析顯示三國塡答結果有顯著差異，再經表十五差異性比較顯示中國大陸高於臺灣；中國大陸亦高於美國，但臺灣與美國餐飲從業人員塡答情形無差異。

(6) 餐具洗滌知識

由表十六可知在餐具洗滌知識，其得分情形以美國得分最高，答對比率爲87％，其次爲臺灣，最低爲中國大陸，經表十七變異數比較結果顯示三國餐飲從業人員在餐具洗滌知識有差異性，由表十八可知其中以美國高於中國大陸；臺灣高於中國大陸，但臺灣與美國無差異。

四、結論與建議

由研究中顯示不同國家餐飲從業人員在衛生知識總量表得分無差異。但在不同的知識領域內三個國家校內餐飲從業人員對微生物的認識、細菌性食物中毒、黴菌食物中毒無顯著差異，但在天然毒素食物中毒、化學毒素食物中毒、餐具洗

滌知識三個國家有所差異，結果顯示天然毒素食物中毒以美國餐飲從業人員優於臺灣與大陸，但中國大陸與臺灣無差異；化學毒素食物中毒以中國大陸高於臺灣與美國，但美國與臺灣餐飲從業人員無差異；餐具洗滌以美國高於中國大陸，臺灣高於中國大陸，但臺灣與美國無差異。

三個國家校內餐飲從業人員微生物知識得分相當低，天然毒素得分率亦不高，因此需加強此二方面的知識，可由政府協助編印宣導手册或錄影帶，用較實際的方式將知識傳授給餐飲從業人員，引導厨工認識如何避免微生物成長的溫度、濕度、營養及預防天然毒素中毒的種類，原因及預防措施，鼓勵員工參加衞生研討會，吸收報章雜誌的新知識，校內定期作餐飲從業人員的講習會，讓知識成爲改善工作行爲的良好工具。

本研究由於美國及中國大陸的回收率不高，影響結果分析，希望未來作研究時能控制回收率，使資料分析更具意義。

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In Different Countries, the Sanitation Knowledge of Foodservice Personnel on Campus

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ABSTRACT

The goal of this research is to understand the sanitation knowledge of foodservice personnel on campus in the unitedstates of America, in Taiwan and in China. We have sent questionnaire to 694 foodservice personnel, of which 199 are in the Unitedstates, 383 in Taiwan, 112 in Mainland China.

The method we used are percentage and one way ANOVA. The result shows no difference in all three countries.

In all three countries, the knowledge about bacteria and about food poisonning from natural poisons need to be improved.

The knowledge of foodservice personnel on bacteria, bacterial food poisonning and fungous food poisonning are similar, but there are obvious difference in the knowledge on natural poisons food poisonning, chemical poison, food poisonning, the cleaning of food utensils.

ABSTRACTS OF PAPERS BY FACULTY MEMBERS OF THE COLLEGE OF SCIENCE AND ENGINEERING THAT APPEARED IN OTHER REFEREED JOURNALS DURING THE 1994 ACADEMIC YEAR

Polynomial Preconditioners for Conjugate Gradient Methods

KANG C. JEA (張康) AND WEI-CHENG CHEN

Proceedings of the Workshop on Cumputational Sciences,
National Taiwan University, Taipei, Taiwan, pp. 53-57 (1994)

We consider solving a large sparse linear system by preconditioned conjugate gradient methods. The preconditioners chosen are in polynomial form as $M^{-1}=g_m(Q^{-1}A)Q^{-1}$ where $g_m(x)$ is a polynomial of degree m. The Neumann polynomials and polynomials derived from the Féjer kernel and Dirichlet kernel are considered. We derived the PNP-CG, PFK-CG and PDK-CG methods. Numerical results have shown that restarting the process every cycle of m iterations will speed up FK and DK methods, but not the NP method. Moreover, using a higher degree Neumann polynomial does not speed up the convergence of PCG method, but PFK-CG and PDK-CG methods can.

Polynomial Methods for Solving Large Linear Systems on Vector Computers

KANG C. JEA (張康) AND CHIN-TIEN YANG

高速電腦應用研討會論文集，pp. 245-248 (1994)

We consider solving the large sparse linear system $Au=b$ where A is symmetric positive definite. The idea here is trying to find a polynomial operator $G_m(A)$ where $G_m(x)$ is a polynomial of degree m which has real coefficients, suchthat the mth approximate solution is given by $u^{(m)}=G_m(A)b$. Thus, $u^{(m)}$ can be constructed by matrix-vector multiplications only, such methods ane well suited to vector/parallel computers.

First of all, we scale the linear system to include all its eigenvalues in the interval [0, 1]. The residual vector can be expressed as $r^{(m)}=F_{m+1}(A)b$, where $F_{m+1}(x)=1-xG_m(x)$. Thus, reducing $r^{(m)}$ is equivalent to choosing $F_{m+1}(x)$ such that $F_{m+1}(0)=1$, and $F_{m+1}(x)$ drops down to small values everywhere else in the interval [0, 1]. We approach $F_{m+1}(x)$ by the Féjer kernel as well as the Dirichlet kernel, and study the effectiveness of applying such methods to solve a linear system and comparing them with the classical Neumann polynomial methods. We also study the restarted versions and speeding up the convergence by forming linear combinations of the approximated solutions such that 2-norm of the residual vector is minimized.

Finite-Dimensional Filters with Nonlinear Drift II: Brockett's Problem on Classification of Finite-Dimensional Estimation Algebras

WEN-LIN CHIOU (邱文齡) AND STEPHEN S.-T. YAU

Siam J. Control and Optimization, **32**(1), 297-310 (1994)

The idea of using estimation algebras to construct finite-dimensional nonlinear filters was first proposed by Brockett and Mitter independently. It turns out that the concept of estimation algebra plays a crucial role in the investigation of finite-dimensional nonlinear filters. In his talk at the International Congress of Mathematics in 1983, Brockett proposed classifying all finite-dimensional estimation algebras. In this paper, all finite-dimensional algebras with maximal rank are classified if the dimension of the state space is less than or equal to two. Therefore, from the Lie algebraic point of view, all finite-dimensional filters are understood generically in the case where the dimension of state space is less than three.

Explicit Construction of Finite Dimensional Nonlinear Filters with State Space Dimension 2

S. S.-T. YAU AND W.-L. CHIOU (邱文齡)

The 32th IEEE Conference on Decision and Control,
San Antonio, Texas, U.S.A., pp. 710-713 (1993)

Ever since the technique of the Kalman-Bucy filter was popularized, there has been an intense interest in finding new classes of finite dimensional recursive filters. The idea of using estimation algebras to construct finite dimensional nonlinear filters was first proposed by Brockett, Clark and Mitter, independently. Recently Tam, Wong and Yau have demonstrated that the concept of estimation algebra is an invaluable tool in the study of nonlinear filtering problems. The concept of an estimation algebra with maximal rank was introduced by Chiou and Yau's paper. Let n be the dimension of the state space. For $n=1$, it turns out that all nontrivial finite dimensional estimation algebras are with maximal rank. They were classified by the worksof Tam-Wong-Yau. For $n=2$, we have classified all finite dimensional estimation algebras with maximal rank. In this paper we shall construct explicitly finite dimensional filters with state space dimension 2 via Wei-Norman approach by using the result of Chiou and Yau's paper. From the Lie algebraic point of view, these are the most general finite dimensional filters.

Raman Scattering in Multi-Component Halide Glasses
多成份鹵化物玻璃的拉曼散射

JIUNN-DER YANG AND LUU-GEN HWA (華魯根)

Chinese Journal of Materials Science, **26**(4), 319-322 (1994)

以氟化鋯 (ZrF_4) 和／或氟化鉿 (HfF_4) 爲基質的多成份氟化玻璃，展現從紫外光區到中紅外光區的極高透明度，爲了瞭解影響此玻璃對紅外光透明度的原因，我們應用偏極化拉曼散射來研究此玻璃的結構，試圖從拉曼散射光譜的譜峰位置來證實玻璃結構中各種原子的振動模態，比較氟化玻璃，與其相似成份的氟化物晶體的拉曼頻率位移，可得到玻璃基本結構中各原子的配位數大小。此外，低頻拉曼散射與玻璃無序性結構的關係，將被簡單的討論。

Effect of the Wave-Shear Interaction on Gravity Wave Activity in the Lower and Middle Atmosphere

F. S. KUO AND H. Y. LUE (呂秀鏞)

Journal of Atmospheric and Terrestrial Physics, **56**(9), 1147-1155 (1994)

Observational results of the wave activities and the vertical wave number spectra of the horizontal wind fluctuations and the temperature/density fluctuations in the lower and middle atmosphere obtained by various groups using different instruments at different locations are reviewed and summarized. Then, we use a simple analytic model of wave-shear interaction to explain the wave-energy dissipation observed in the stratosphere/lower mesosphere, the east-west anisotropy of the wave propagation, and the deceleration of the zonal mean flow, in summer and in winter in the middle mesosphere, the annual variation in the upper troposphere/stratosphere/lower mesosphere, and the semi-annual variation in the middle mesosphere. We also point out that the saturation spectra observed in the middle mesosphere and the winter troposphere are caused by wave motions in the strong background wind shear and the low stability temperature profile, and that the saturation spectrum is universally $N^2/2m^3$ (where N is the Brunt-Väisälä frequency and m is the vertical wave number).

Dynamics of Electron Photodetachment from an Aqueous Halide Ion

WEN-SHYAN SHEU (許文賢) AND PETER J. ROSSKY

Chemical Physics Letters, **213**, 233 (1993)

The dynamics following two-photon excitation of an aqueous halide ion are studied via quantum simulation. Two channels for photodetachment are observed: a direct detachment via a very early time non-adiabatic transition and a delayed adiabatic detachment from the lowest-lying charge-transfer-to-solvent state. Fast, non-diffusive, geminate recombination of electron-halogen contact pairs arising in the latter case dominates the kinetics of deactivation of excited state ions. Calculated transient emission spectra show a distinct signature for the adiabatic detachment.

The Relationship betweenDielectric and Rheological Behavior of Epoxy Resin During Cure

JUNG-YUN CHEN, PIENG-TSUNG HUANG
AND SUNG-NUNG LEE (李選能)

Journal of Polymer Research, **1**(2), 183-190 (1994)

Measurement of the frequency-dependent vector voltage (V_c) provided an in-situ and non-destructive technique to measure continuously the rheological change of a resin due to polymerization, and can be used as the basis of real-time control. The vector voltage depends on the degree of polarization of the dipolar molecules and on the change of viscosity during cure; both result from the modified structure of the epoxy resin during cure. The initial stage of curing, represented by the former portion of the V_c curve (divided at the minimum of the V_c curve), was caused mainly by the effects of temperature and viscosity. During the latter stage of the cure reaction, V_c alters because of the effect of the tightened matrix structure that inhibits algnment of dipoles. The duration of reaction, temperature of curing and degree of conversion all have the same effcts on both vector voltage and viscosity. The minimum value of vector voltage is correlated to the minimum viscosity, and there is a nearly quantitative relationship between them. One can determine the viscosity of the epoxy resin during cure from reading of the vector voltage. Various reaction mechanisms may be explained based on the graphs of vector voltage of various types.

Excited-State Intramolecular Proton Transfer for *N*-Substituted-3-hydroxypyridinones

PI-TAI CHOU, MING CHAO, JOHN H. CLEMENTS,
MARTY L. MARTINEZ AND CHEN-PIN CHANG (張鎮平)

Chem. Phys. Lett., **220**, 229-234 (1994)

The photophysics of 3-hydroxy-2-methyl-4-pyridinone (**I**), 3-hydroxyl-1,2-dimethyl-4-pyridinone (**II**) and 3-hydroxy-2-methyl-1-phenyl-4-pyridinone (**III**) are reported. The occurrence of excited-state intra-

molecular proton transfer for **I** and **II** provides a suitable model for ab initio studies of the mechanism of excited-state intramolecular proton transfer reaction. In contrast, the proton-transfer reaction is prohibited in **III**. A coupling mechanism between proton motion and *N*-phenyl torsional motion is tentatively proposed, resulting in a slow rate of proton transfer for **III**.

Photophysics of 2-(4′-Dialkylaminophenyl)benzothialzoles: Their Application for Near-UV Laser Dyes

PI-TAI CHOU, MARTY L. MARTINEZ, WILLIAM C. COOPER AND CHEN-PIN CHANG (張鎮平)

Spectroscopy, **48**, 604 (1993)

The photophysical properties and the first observation of UV laser generation of molecules based on 2-phenylbenzothiazole with electron-donating substituents at the 2′ and 4′ positions are reported. The high gain of the amplified spontaneous emission, good efficient laser output, and extreme photostability for this class of laser dyes make their practical application feasible when pumped by the third harmonic (355 nm) of the YAG laser.

A Comparative Study: The Photophysics of 2-Phenylbenzoxazoles and 2-Phenylbenzothiazoles

PI-TAI CHOU, WILLIAM C. COOPER, JOHN H. CLEMENTS, SHANNON L. STUDER AND CHEN-PIN CHANG (張鎮平)

Chem. Phys. Lett., **216**, 300 (1993)

The photophysical properties of 2-phenylbenzothiazole and 2-phenylbenzoxazole were compared. At room temperature 2-phenylbenzothiazole in *n*-heptane exhibits a broad, structureless absorption and a low fluorescence yield of ≈ 0.005 ($\tau_f < 200$ ps). In contrast, 2-phenylbenzoxazole shows a structured absorption and a high fluorescence yield, $\Phi_f \approx 0.78 \pm 0.05$ ($\tau_f \approx 1.5$ ns). These spectral differences arise from a

drastic change in the dynamics of C_1-C_i, torsioal motion, as evidenced in the temperature-dependent studies, spectral properties of their derivatives and AM1 calculations.

Preparation of Polladium (II) and Platinum (II) Phosphine Complexes Promoted by Phase-Transfer Catalysts

IVAN J. B. LIN (林志彪) AND MILES D. S. LIAW (廖德琇)

Journal of the Chinese Chemical Society, **40**, 451-454 (1993)

The synthesis of $M(PR_3)_2Cl_2$ (M=Pd and Pt, R=alkyl or aryl) from K_2MCl_4 (in H_2O) and PR_3 (in CH_2Cl_2) was promoted by the addition of phase-transfer catalysts (PTC). The greater the amount of PTC used, the more quickly the reaction completed. ^{31}P NMR spectra of some $M(PR_3)_2Cl_2$ in the presence of free PR_3 were measured; these NMR results were used to explain problems encountered during the preparations.

A Facile Synthesis of Stable Precursors to 2-Alkylated-3-(phenylthio)-1,3-butadienes

SHANG-SHING P. CHOU (周善行) AND HAI-PING TAI

Journal of the Chinese Chemical Society, **40**, 463-467 (1993)

3-Sulfolenes **3** which are stable precursors to 2-alkylated-3-(phenylthio)-1, 3-butadienes (**4**) are conveniently prepared.

Intramolecular Diels-Alder Reactions via Sulfone-Substituted 3-Sulfolenes

SHANG-SHING P. CHOU (周善行), CHING-SHIEN LEE,
MENG-CHI CHENG AND HAI-PING TAI

The Journal of Organic Chemistry, **59**, 2010-2013 (1994)

Regiospecific alkylation of the dianion of sulfone-substituted 3-sulfolenes **1-4** attached an unsaturated alkyl chain at the C_2 position to form convenient precursors for IMDA reactions. The substituents on the diene moiety have a significant effect on the reactivity of the IMDA reactions (H>Me_3Si>PhS). The stereochemistry of the cyclization reaction depends on the chain length connecting the diene and dienophile. The hydronaphthalene products **12a** and **12b** are obtained only in the trans form, and the hydroindene products **10** and **11** have predominantly the trans ring structure. All the products have the useful vinylic sulfone structure.

66. Malpighiaceae 黃褥花科

CHING-HSIA CHEN (陳擎霞)

Flora of Taiwan Second Ed., **3**, 565-570 (1994)

Tress or shrubs, often woody climbing, with often appressed medifixed hairs. Leaves simple, mostly opposite, quite entire; glands often present either on petiole or on the lower surface of the leaves; stipules small or absent. Inflorescence axillary or terminal; pedicels articulate, usually 2-bracteolate. Flower hemaphroditic, rarely polygamous, regular or irregular; calyx usually 5-partite, the segments imbricate or very valvate, one or more larger glandular outside, rarely eglandular; petals 5, clawed or not, often fimbriate, imbricate, disc obscure, small; stamens 10, hypogynous or subperigynous, equal or one much more larger than the others, the filaments free or connate at the base, the anthers 2-lobed, opening lengthwise or by a pore-like slit; ovary 3-celled, rarely 2 or 4, the styles 1-3, straight or circinate, the stigmas capitate or punctiform or lateral; ovules solitary in each cell, the micropyle superior, the raphe ventral. Fruiting carpels often winged samaras, or carpels connate into a fleshy or woody drupe. Seed exalbuminous; embryo straight or curved, the radicle superior.

A family of about 65 genera and 1,280 species, tropical America, Africa and Asia; four genera in Taiwan. One cultivated.

71. Sapindaceae 無患子科

CHING-HSIA CHEN (陳擎霞)

Flora of Taiwan Second Ed., **3**, 599-608 (19)

Trees, shrubs, vines or rarely herbs. Leaves usually alternate, pinnately or palmately compound, rare simple; stipules none or in some climbing species present. Flower usually smaal, unisexual or bisexual, in racemes, panicles or corymbs, actinomorphic or commonly zygomorphic; calyx 4-5, imbricate or valvate sepals; petals 4-5 or wanting, often with hairs or scales at the base inside; hypogynous discs well developed, situated between petals and stamens; stamens usually 8-10, the filaments distinct or united at base; ovary superior, 2-4 celled, with one or more ovules in each cell; placentation axile or parietal, the style simple or divided. Fruit various, drupaceous or capsular, entire or lobed, sometimes winged. Seeds often arillate globose or compressed, albuminous or exalbuminous.

About 150 genera and over 1,500 species, of wide distribution in the tropics and warm region.

93. Begoniaceae 秋海棠科

CHING-HSIA CHEN (陳擎霞)

Flora of Taiwan Second Ed., **3**, 845-854 (1994)

Herbs or undershrubs mostly succulent, rarely climbers. Stems distinctly jointed. Roots rhizomatous, tuberous or fiberous. Leaves alternate, subverticillate, simple, often unequal-sided or obliquely auriculate, entire or divided. Stipules semi-persistent or caducous, two to each leaf, free, membranaceous. Flowers monoecious, actinomorphic or zygomorphic, mostly in clusters of axillary bracteate cymes; perianth monochlamydeous or dichlamydeous. Staminate flower tepals 2-10, equal or unequal; stamens numerous, filaments free or connate at base; anthers 2-locular, longitudinally dehiscent, connectives often exserted. Pistillate flower tepals 2-8, equal or unequal, imbricate; staminodes small or absent; ovary inferior, angular or winged, 2-4 celled; carpels typically

3; ovules numerous in each cell, anatropous; placentas usually axile or arising from the septa, parietal; styles 2-5, free or slightly connate at base, often branched; stigmas often twisted, usually densely papillose all around. Fruit usually a capsule, rarely berry-like, longitudinally loculicidal or irregularly dehiscent, few indehiscent. Seeds minute and very numerous, with reticulate testa and scanty or no endosperm and a straight embryo.

A family of five genera with more than 800 species, widely distributed in the tropics, especially abundant in tropical northern South America, but absent from Polynesia and Australia.

Twelve species and one form within the genus *Begonia* are found in Taiwan, commonly as undergrowth on forest floors throughout the island.

Molecular Cloning, Chromosomal Mapping and Sequence Analysis of Copper-Resistance Genes from *Xanthomonas campestris* pv. *juglandis*: Homology with Small Blue Copper Proteins and Multicopper Oxidases

Y.-A. LEE (李永安), M. HENDSON, N. J. PANOPOULOS AND M. N. SCHROTH

Journal of Bacteriology, **176**, 173-188 (1994)

Copper-resistant strains of *Xanthomonas campestris* pv. *juglandis* occur in walnut orchards throughout northern California. To analyze the nature of copper resistance, the copper resistance genes from a copper-resistant strain C_5 of *X. c.* pv. *juglandis* were cloned. Thw genes were located on a 4.9 kb *Cla* I fragment which hybridized only to DNA of copper-resistant strains of *X. c.* pv. *juglandis*. Hybridization analysis revealed that the copper-resistance genes are most probably located on the chromosome. Plasmids conferring copper-resistance were not detected in the copper-resistant strains, nor did mating with copper-sensitive strains result in copper-resistant transconjugants. Further hybridization tests revealed that the copper-resistance genes (4.9 kb *Cla* I fragment) were located on an approximately 20 kb region,

which was conserved among copper-resistant strains of *X. c.* pv. *juglandis*. Copper-resistance genes from *X. c.* pv. *juglandis* shared nucleotide sequence similarity to copper-resistance genes cloned from *Pseudomonas syringae* pv. *tomato*, *P. syringae* and *Xanthomonas campestris* pv. *vesicatoria*. DNA sequence analysis of a 4.9 kilobase copper resistance determinant from *X. c.* pv. *juglandis* revealed that the sequence had an overall G+C contant of 58.7%, and four open reading frames oriented in the same direction. These four ORFs were required for full expression of copper resistance, based on Tn 3-spice insertional inactivation and deletion analysis. Comparison of the predicted amino acid sequences of each ORF with those of copper-resistance genes (*cop* A-D) from *P. s.* pv. *tomato* revealed a 65% amino acid sequence identity between ORF 1 and Cop A, 45% between ORF 2 and Cop B, 47% between ORF 3 and Cop C, and 40% between ORF 4 and Cop D, respectively. The most conserved regions within these two copper resistance genes are ORF 1 and Cop A, which share 79% similarity with 65% identity, and the C-terminal region (166 amino acids from the C-terminus) of the second ORF (ORF 2 and Cop B), which share 85% similarity with 60% identity. No significant conserved region was found for the third and fourth ORFs. The hydrophobicity profiles of each pair of predicted polypeptides are similar except the N-terminus of ORF 2 and Cop B. Four histidine-rich polypeptide regions in ORF 1 and Cop A showed significant sequence homology to the copper-binding motifs of small blue copper proteins and multicopper oxidases, such as fungal laccases, plant ascorbate oxidase, and human ceruloplasmin. Putative copper ligands of the ORF 1 polypeptide product are proposed, indicating that the polypeptide of ORF 1 might contain four copper ions: one type-1, one type-2 and two type-3 copper ions.

Increased Toxicity of Iron-Amended Copper-Containing Bactericides to the Walnut Blight Pathogen, *Xanthomonas campertris* pv. *juglandis*

Y.-A. LEE (李永安), M. N. SCHROTH, M. HENDSON, S. E. LINDOW, X.-L. WANG, B. OLSON, R. P. BUCHNER AND B. TEVIOTDALE

Phytopathology, **83**, 1460-1465 (1993)

The addition of iron to fixed copper compounds enhanced the toxicity of these materials to the walnut blight bacterium, *Xanthomonas campestris* pv. *juglandis*, by several mechanisms. Iron altered the physiology of the bacterium, causing it to be more sensitive to cupric ions. In the presence of iron, less free copper ions were needed to inhibit the growth of bacteria. The addition of soluble iron salts to fixed copper compounds also reduced pH and increased the amount of free copper ions; addition of iron caused the release of more free copper ions in suspensions of Kocide 101® (77% $Cu(OH)_2$) than did hydrochloric acid at the same pH. The spraying of walnut leaves with Kocide 101® amended with iron salts significantly increased the availability of free copper ions on leaf surfaces compared to the bactericide alone. Cells of copper-sensitive strains of *X. c.* pv. *juglandis* did not survive on leaf surfaces treated with Kocide 101®, whereas more than 25% of the cells of copper-resistant strains survived. The addition of 50 μg/ml of iron in a form of $FeCl_3 \cdot 6H_2O$ to Kocide 101® increased the concentrations of free copper ions by more than 25-fold and eliminated copper-resistant strains on leaf surfaces. In field trials, combination of Kocide 101® or Champion® with iron significantly reduced the incidence of bud infestation and blighted leaflets compared to non-amended treatments.

Least-Squares Lattice Interpolation Filters

JENQ-TAY YUAN (袁正泰)

Proceedings of IEEE 1994 International Conference on Communications (ICC-94), New Orleans, LA, May (1994)

This paper develops a time as well as order update recursion for linear least-squares lattice (LSL) interpolation filters. The LSL interpolation filter has the nice stage-to-stage modularity which allows its length to be increased or decreased "two-sidedly" (i.e., both *past* and *future*) without affecting the already computed parameters. The LSL interpolation filter is also efficient in computation, flexible in implementation and fast in convergence. The computer simulation results shown in this paper reveal that although interpolation needs more computing

power than prediction does, however, interpolation can generate much smaller error power and, thus, reduces much more temporal redundancy than prediction does.

Order-Recursive FIR Smoothers

JENQ-TAY YUAN (袁正泰) AND JOHN A. STULLER

IEEE Transactions on Signal Processing, **42**(5), May (1994)

This paper introduces order-recursive FIR smoothers and shows that order-recursive FIR filters are special forms that occur when no future data values are used to estimate the signal. The formulation leads naturally to generalizations of the concepts of prediction-error basis and Cholesky factorization which are well known in FIR filter design.

Recovery of Superquadric Primtive from Stereo Images

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Image and Vision Computing, **12**(5), 285-296 (1994)

This paper presents an integrated approach to recovering the superquadric primitive from stereo images. While the depth data obtained from stereo matching algorithms are always sparse and noisy, to extract an object from the scene and obtain a smoothed depth map of the object, occluding contour detection and surface peconstruction are incorporated into the recovery process of superquadrics. The algorithm combines the recovery processes of occluding contour, surface and volumetric models in a cooperative and synergetic manner. The performance of the algorithm is demonstrated with two examples using real images.