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Portable Profile Meter

Elastic Spheroidal Bodies

Highlights

Soil Surface Profile

Digital Water Billing System

Discovering Thoughts, Inventing Future

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Soil Surface Profile Computation using Portable Profile Meter with Image Processing and Tracking Technique

By Rashad Hegazy
Kafrelsheikh University, Egypt

Abstract- New measurement method for soil surface profile has been described in this study. This method includes new designed soil profile meter, digital imaging equipment and image tracking & analysis software. Using such modified soil profile meter can help to observe and measure changes occur in irrigation channels, small ditches and to quantify changes at specific cross sections within soil furrows. By using image processing and tracking system we can trace marked points in fixed level of meter pins, these points have vertical displacements and vary according to existing profiles and cross-sectional shape in different locations, which give us ability to record presented form of different profiles. The modified profile meter used to measure and track changes in different profiles; two types of ditches and two types of furrow. The recorded profiles heights for different locations gave us perspicuous knowledge about the geometry of furrows and ditches shapes before and after seasonal irrigation process. The differences in measurements for same locations and sites have been noted. Designed soil profile meter successfully demonstrated changes in profiles pattern due to surface irrigation erosion in term of height variations, for shallow and wide ditches, the differences in measured heights by soil profile meter after and before the irrigation generally ranged from 0 to 11 mm, while in deep ditches, differences in heights ranged from 0 to 44 mm. With ridge profiles, soil profile meter tracked variation in measured heights from 0 to 13.88 %, also, high percentage of variation obtained by studying flat top bed furrow changes, the largest percentage was 17.1 % at beginning of the furrow line. This clarifies the ability to track and record erosion effect in different furrows and ditches by using soil profile meter as a part of used image processing and tracking system.

Keywords: soil profile meter, surface irrigation, erosion, soil properties, image tracking.

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I. Introduction

Improvement in furrow irrigation performance and reduction of soil erosion due to furrow irrigation erosion are very important and always connected with the way we measure furrows and ditches profiles. Different studies on furrow irrigation have been carried out to reduce water losses and erosion related to furrow irrigation, parameters such as furrow stream size, field slope, furrow length, soil type, plant coverage and soil density have been studied (Leib et al., 2005; Szögi et al., 2007; Silva, 2006; Younts et al., 2003 and Mintesinot et al., 2004).

Each type of tillage tool and ditch creating method generate a characteristic oriented roughness and profile pattern which is relatively easy to quantify using simple geometric models. Many common techniques for collecting soil surface data and the analysis of the respective dataset have been discussed. Pin meters are the devices most widely used for their simplicity. They consist in a single probe or a row of probes spaced at pre-established intervals and designed to slide up or down until the tip just touches the soil surface. Pin positions are recorded either electronically or manually (Römkens et al., 1986 and Wagner & Yiming, 1991). The chief disadvantage to this technique is its destructive impact on the soil surface while recording data in the field. Kornecki et al. (2008) designed and tested a portable meter under typical field conditions; the tool can measure depths up to 500 mm and easily be modified for usage with large ditches. The device was successfully employed after rainfall events to assess soil erosion/deposition from quarter-drains. Measuring soil profiles by Laser technology generates also had very good laboratory results, but its field use is limited because sunlight and hidden forms or shadows interfere with the readings, while high temperatures affect the performance of the sensitive measuring devices involved (Pardini, 2003; Darboux and Huang, 2003). Moreno et al. (2008) conducted study to develop a new method for measuring soil surface roughness that would be more reliable by using the principle underlying shadow analysis is the direct relationship between soil surface roughness and the shadows cast by soil structures under fixed sunlight conditions. They showed that shadow analysis yielded results significantly correlated to the pin meter findings, but with the advantage that the time invested in gathering field data was 12 to 20 times shorter. Another work has been carried out by Borselli and Torri (2010) in order to reproduce reliable rough surfaces able to maintain stable, un-erodible surfaces to avoid changes of retention volume during tests by a set of roughness indices was computed for each surface by using roughness profiles measured with a laser profile meter, and roughness is well represented by quantiles of the Abbot–Firestone curve.

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Image analysis techniques have recently been employed to measure different soil parameters e.g. two-dimensional displacement vectors in soils obtained by a block-matching algorithm (Guler et al, 1999), however, this algorithm is incapable of tracking individual particles, let alone their rotations. Several algorithms have been developed to track soil particles and measure their movements by detecting the edges of individual soil particles. Hu and Pu (2004) observed the displacement distribution in the soil near the structure using photographs and discussed the thickness of the sand–steel interface. Classical roughness parameters such as root mean square of the heights, correlation length and tortuosity are estimated on the digital elevation models (DEMs) of the database by Taconet and Ciarletti (2007) and the study showed that stereo photogrammetry provide DEMs that enable accurate studies of the geometrical properties of soils that can definitely be of use for hydraulic and erosion studies. So, using image analysis and proper tracking codes with the new manufactured soil profile meter could be effective way to calculate the final shape and geometry of soil surface profiles.

II. Material and Methods

Soil profile meter has been developed to determine specific cross sections and furrow profiles in ditches and soil, new futures were added to soil meter to overcome some existing problems related to error measurement in fields. The main concept used with soil meter is to manufacture movable, stable and precise device to measure soil profile and ditches cross-sections without deformation, designed profile meter came with attached wheels to give smooth movement on ditches sides or within soil furrows, this movement ability can be used in field during manually recording of data sets or can be replaced with modified one. For more stability and adequate measurement, it was important to provide a modified frame with tighten methods for movable parts in the soil profile meter.

Based on above mentioned points, the manufactured soil profile meter consisted of a frame holding multiple equally spaced (every 50 mm) stainless-steel pins (2000 mm long) that can be easily positioned and fully controlled by two rows of tie-bolts. Soil profile pins can move freely under gravity or be fully controlled at the time we measure sensitive profile surfaces. The pin housing consisted of two pairs of parallel aluminium bars with 950 mm length and 850 mm height, both sides are fixed together and mounted as a frame with 2 pairs of double wheel in each side (Fig. 1). The aluminium pins were located between the aluminium housing; these bars can be easily modified or replaced with another set of different diameter pins. Hydrostatic balance tool was attached to main frame to provide sufficient levelling.

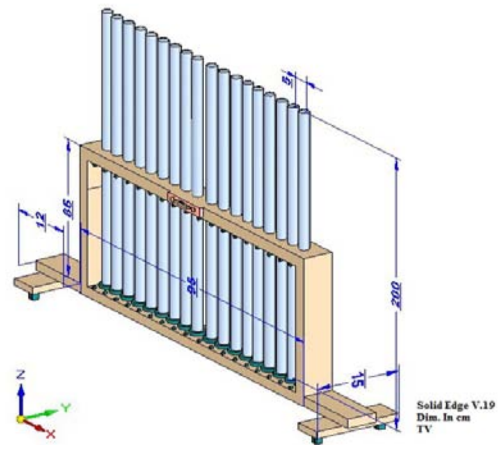

Figure 1 : Trimetric view of constructed soil profile meter

a) Image acquisition and analysis

The video and pictures for image analysis were taken by a high resolution video camera (Sony DCR-HC54E -40x optical zoom/2000x digital zoom) video camera was connected to laptop on the site of measurements as shown in Fig. 2., there is continuous video recording of soil profile meter in different locations and sets of images can be generated by using image tracking and analysis software. Practical implementation of video and image processing done by using Open CV program as a software library projected with Microsoft Visual C++ 2010 Express. Different codes used to simply access, display and trace specified marked points within images. The software classes provide C++ video recording and images capturing from video as first step for the process.

Figure 2 : Camera and sets used in experiments.

b) Tracking soil profile meter

At the time we need to record and determine profiles at fixed location, manually we can adjust pins in soil profile meter above required position without disturbing the profile form. In this case we need only to generate pictures of profile meter after and before adjusting its pins, two pictures will be generated and enough to make a comparison between them to read and analyze the vertical distance of marked points along with profile meter pins.

c) Locations, Profile measurement and differences

The designed profile meter was fabricated in January, 2012 and it used to measure different profiles before irrigation processes same year in February and again after complete irrigation season in May 2012 for fixed marked points along with the furrows and ditches. Two locations have been located in two different places, two types of ditches and two different furrows after soil preparation were noticed and marked, in each location one type of ditch and one type of furrow have been chosen. Sketching of profile geometry was done for each ditch and furrow in three different sites along with their length, these sites covered start, middle and end point of their length. Data recorded two times after and before running surface irrigation to address the change occurred in profiles and the distribution of soil erosion along subsections of ditches and furrows. Two common types of ditches were taken as ditches profile example, one type is normally made shallow and wide, and the other one made by farmers and it is deep and has no sidelong edges. Also, two type of soil furrows were profiled, ridges and flat top beds.

III. Results and Discussion

a) Images and distance differences of soil profiles

Different images generated in laboratory (Fig. 3) and field (Fig. 4) to test the concept and to adjust the image tracking and analysis software. Calibration was needed to calculate the distance constant, this constant is important to convert the distance in pictures to the actual field distances. By using Open CV program as a software library projected with Microsoft Visual C++, the marked point in each profile meter pin were clear and appeared in specific position with certain coordinates as long as the profile meter and the camera are in one fixed position Fig. 3, these coordinates can be stored to be compared directly with the new coordinates in second picture. As the soil profile meter pins moved, the distances were calculated according to the new coordinates; the distances due to marked point's movement were converted to actual field measurements to be used in drawing and to determine the soil profile geometries. Fig. 4 shows how the soil profile meter appeared in one of generated picture.

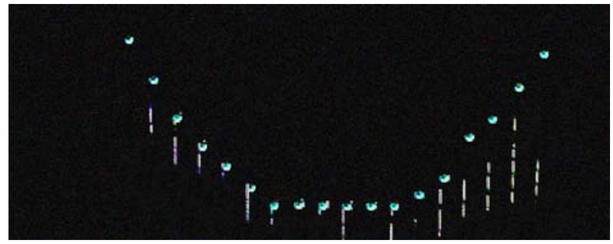

Figure 3 : Example of picture obtained during laboratory adjustment and calibration for image tracking and analysis software

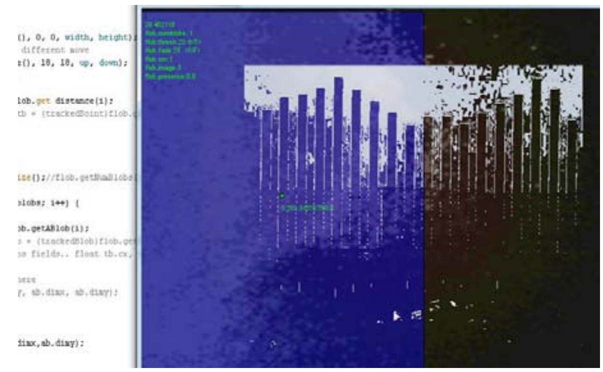

Figure 4 : Generated picture of soil profile meter with its pins in the field

b) Analysis of soil profile geometry for ditches

All measurements done by soil profile meter presented in terms of 3-D area charts. For location 1, the geometric shape of shallow and wide ditch in three different sites along with its length before and after seasonal surface irrigation presented in Fig. 5 a. at the beginning of the ditch, site 1, the maximum differences in measured height by soil profile meter concentrated in bottom of the ditch with 10, 11 and 9 mm, that's mean there is erosion occurred and affected the origin cross-section of the ditch, while in both sides of the ditch the differences in measurements after and before surface irrigation were less, 7 and 5 mm were maximum changes in readings in both sides after and before surface irrigation. In some points, there was decreasing in profile meter reading for the same point after and before irrigation, that's mean more sediment in ditch side, it was low but it was measurable, the reason may be due to accumulative of some water residue or mud in these points. At the middle of the ditch, same pattern for erosion effect but the changes occurred in soil profile meter readings were similar in bottom and sides as well. At the end of the ditch, the bottom reading by soil profile meter recorded very less change in the center of the ditch and also changes around the center, maybe due to slow water streaming at the end of the ditch made the effect of water erosion less, the changes recorded in end of the ditch generally were lower than changes notices for middle and beginning of the ditch.

For second type of ditch which was deep and has no sidelong edges in location 2, changes in side measurements for it were very less due to its special constructed shape (Fig. 5 b), but there were changes in bottom of the ditch after surface irrigation in all ditch sites, the maximum changes in reading obtained in the beginning where the differences in soil profile meter measurements were high. The values of profile meter differences reached 44, 42 and 34 mm around center point at the beginning of the ditch, while maximum difference in profile meter reading was 30 and 25 mm for center point at the middle and the end respectively.

As a comparison between erosion behaviors in above mentioned ditches, the changes occurred in the ditch in location number 1 were less and the differences in soil profile meter readings were little compared to location 2, that was because of water erosion effect was less also in location1.

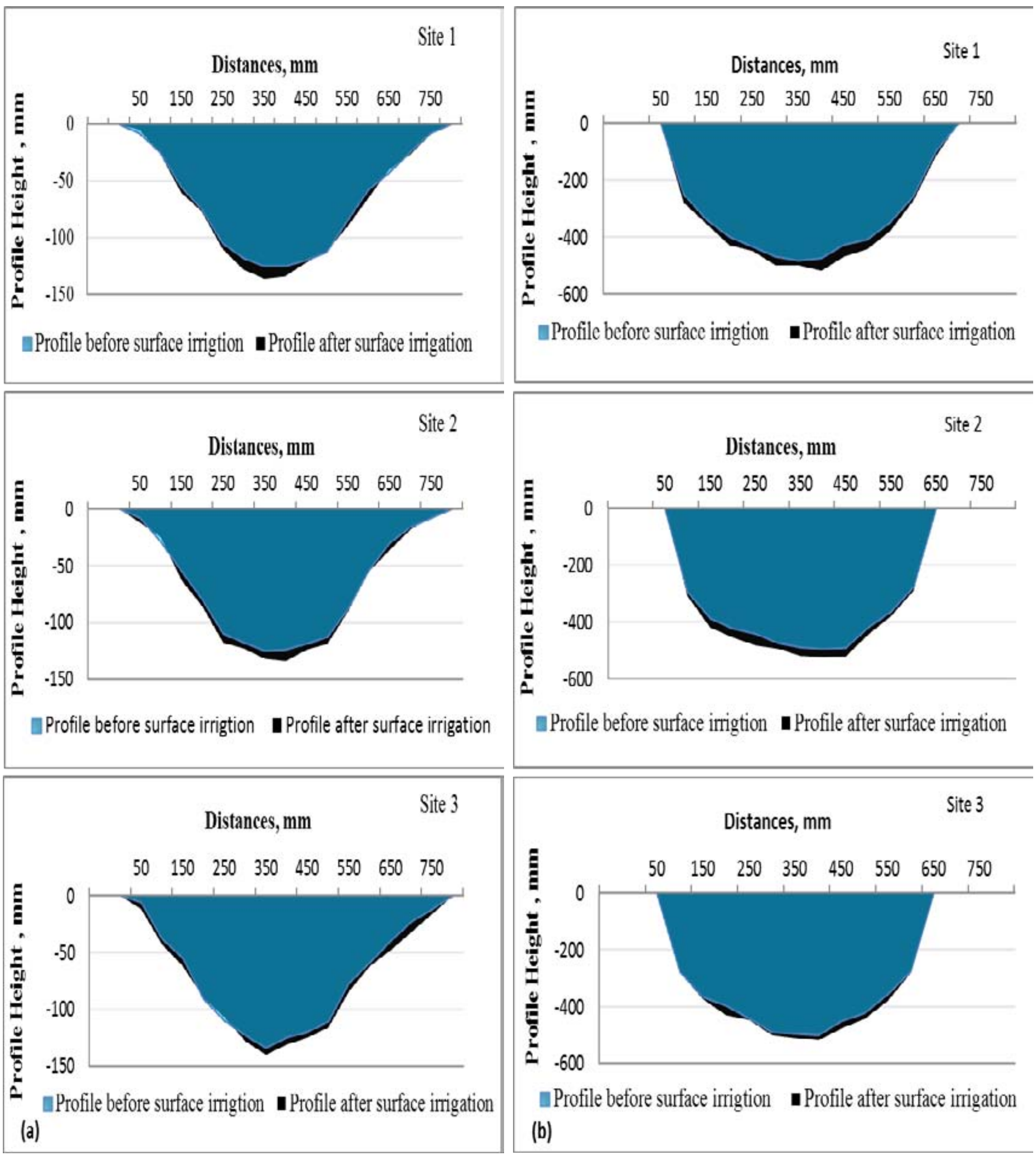

Figure 5 : Differences in Geometric shape between origin and formed ditch after surface irrigation for three different locations: (a) shallow and wide ditch in location 2 (b) deep and has no sidelong edges ditch in location 1

c) Analysis of soil profile geometry for ditches

For ridge in location 1, after using soil profile meter to measure different ridge profile points on the surface, the geometric shapes in Fig. 6 a showed that there was erosion effect along with ridge length in end, middle and beginning of the furrow. The maximum differences in measurements were about 25 mm at the beginning in the bottom followed by 22 and 15 mm for the middle and end of the furrow respectively. The differences in readings recorded by the soil profile meter for the furrow sides were very less in all furrow sites, and there were six points on ditch sides gave same profile meter reading before and after surface irrigation. For flat top bed furrow in location 2 (Fig. 6 b), same pattern was observed from data, where in the beginning of the furrow line there was maximum difference in profile meter reading followed by the middle of the furrow then the line end. Major changes done around center points in furrow bottom, but changes in both sides of the furrow were less maybe because running water in furrow remain only in bottom and don't cover all side height.

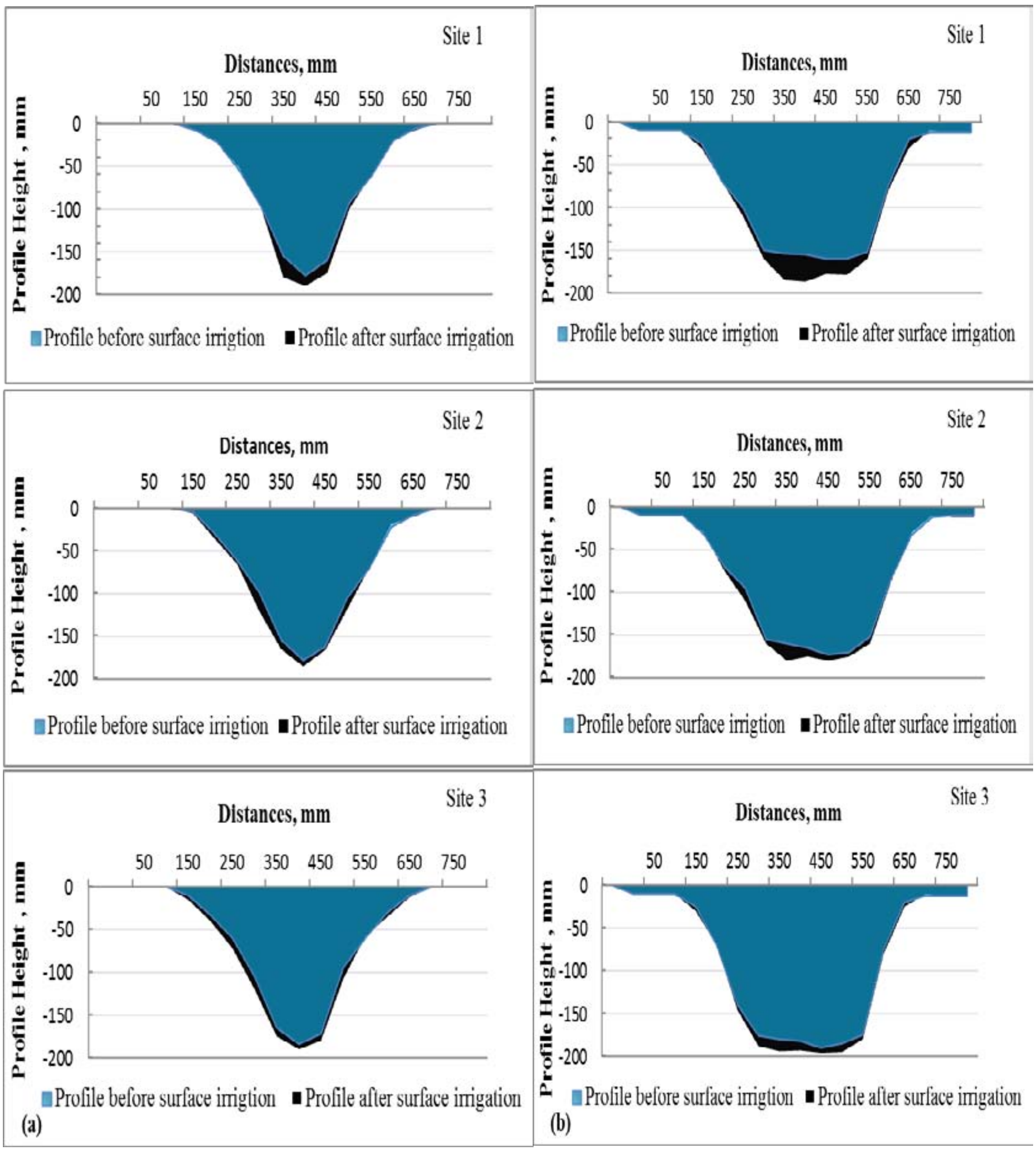

Figure 6 : Differences in Geometric shape between origin and formed furrow after surface irrigation for three different locations (a) ridge profile in location 2 (b) flat top beds in location 1

IV. Conclusion

Using soil profile meter to record different soil profiles is an effective method to which can refer to any changes could happen in soil surface. It was clear that the modified soil profile meter gave adequate results to measure different heights for different profiles, and this gave us idea about the changes happened in different locations related to seasonal surface irrigation in land. Using image tracking and analysis technique was very operative method to measure soil profiles with minimum under different conditions. In addition, designed profile meter is very flexible and can be used for a wide range to measure different type of furrows, ditches, rills and drainage canals.

V. Acknowledgements

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A Comparison Test for Net Sensitivity

By John J. Flaig
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Abstract- A common problem in supplier management involves being able to tell if the difference in quality performance between suppliers is significant. Net sensitivity is a process capability measure of the nonconformance risk associated with a supplier's product or service performance. This paper provides a two-sample confidence interval test that will allow the practitioner to determine if there is a significant risk difference between two suppliers with respect to their net sensitivities.

Keywords: process capability analysis, sensitivity analysis, net sensitivity.

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A Comparison Test for Net Sensitivity

John J. Flaig

Abstract - A common problem in supplier management involves being able to tell if the difference in quality performance between suppliers is significant. Net sensitivity is a process capability measure of the nonconformance risk associated with a supplier's product or service performance. This paper provides a two-sample confidence interval test that will allow the practitioner to determine if there is a significant risk difference between two suppliers with respect to their net sensitivities.

Keywords: process capability analysis, sensitivity analysis, net sensitivity.

I. Introduction

Individuals involved in supplier management need to be able to determine if the quality performance of one supplier is significantly different from another. This information can be used in supplier selection, allocation of the amount of product purchased from each supplier, supplier process improvement programs, and the decision to terminate the purchasing relationship. "The goal of having a good performance metric is to allow the purchaser to assess supplier related performance risk and to take appropriate action" [Bernstein, 1996].

Given a quality characteristic and specified requirements for conformance, there are several statistics that are commonly used to measure supplier process capability. These include the traditional fraction nonconforming (i.e., p or NC), and the modern capability indices C_p, C_{pk}, C_{pm}, C_{pmk}, etc. [Kotz, 1993]. The proper application of these modern indices assumes that the process distribution is stable and approximately Normal. To get around this Normality requirement, several authors have offered alternate solutions [Chou, 1998], [Somerville, 1997]. Or alternately, a Box-Cox power transform can be used to Normalize the observed non-normal data distribution.

Statistical two-sample comparison tests procedures have been developed for all of the common capability indices. However, another measure of potential process risk is net sensitivity (NS) [Flaig, 1999]. Net Sensitivity is a measure of the robustness of the process to potential changes in the mean, and/or variance, and/or specification limits. More specifically, Net Sensitivity is the instantaneous rate of change of the combined areas under the distribution curve above the USL and below the LSL given a change in parameters or specifications. It basically measures the potential effect on the nonconformance rate of changes in the distribution mean, standard deviation, USL, or LSL. This is a useful process performance measure, but it is relatively new and until now there was no two-sample comparison test procedure for practitioners to use to compare net sensitivity results.

A reasonable approach to evaluating the differences in supplier performance for the purchasing department might be to measure the nonconformance rate and the net sensitivity for each supplier and then test to see if any observed differences are significant. Since tests for differences in nonconformance rates exist, the only remaining thing to develop is a test for differences in net sensitivity. This is the goal of the next section.

a) Methodology

It is assumed that theproduct performance distributions for both suppliers' are stable,mound shaped, that the specification limits are near the tails of each distribution for the quality characteristic of interest, and that the observed distributions can be adequately approximated by Johnson distribution curves. This is illustrated in Figure 1.

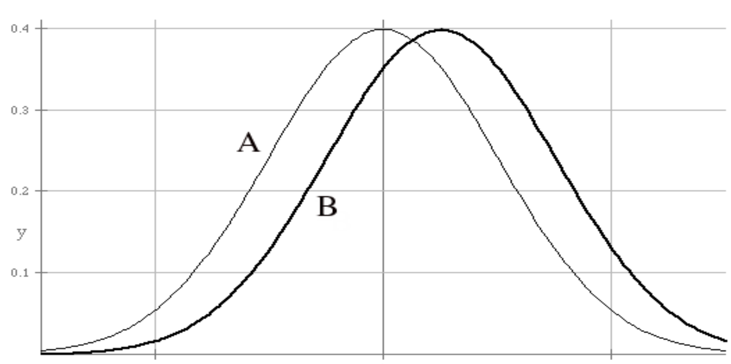

Figure 1 : The Performance Distribution of Supplier A and B

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The distribution shift sensitivities are measures of the average effect on the nonconformance rate of a change in the distribution parameters. In other words, they are measures of $\Delta F/\Delta x$, where F is the cumulative density function (cdf) of f(x). Therefore, the left and right sensitivity measures could be defined as follows:

Let A_L be the area under the Johnson curve to the left of the LSL, then

$$A_L = \int_{-\infty}^{LSL} j(x)dx = \int_{-\infty}^{Z_L} f(z)\,dz = F(z_L) - F(-\infty)$$

where j(x) is the Johnson curve and $f(z) = \frac{1}{\sqrt{2\pi}} e^{-.5z^2}$ is the standard Normal curve. Then the Sensitivity on the Left (SL) is:

$$SL = \frac{dA_L}{dx} = \frac{d}{dz}(F(z_L)\text{-}F(-\infty))\frac{dz}{dx} = f(z_L)\frac{dz}{dx}$$

Let A_U be the area under the curve to the right of the USL, then

$$A_U = 1 - \int_{-\infty}^{Z_U} f(z)dz$$

and the Sensitivity on the Right (SR) is

$$SR = \frac{dA_U}{dx} = \frac{d}{dz}(F(-\infty) - F(z_U))\frac{dz}{dx} = -f(z_U)\frac{dz}{dx}$$

Since the observed distribution can be satisfactorily modeled by a Johnson curve, then the Net Sensitivity of the combined left tail (L) and the right tail (U) is given by:

$$NS = \left[f(z_L)\text{-}f(z_U)\right]\frac{dz}{dx} = \frac{1}{\sqrt{2\pi}}\left(e^{-.5z_L^2} - e^{-.5z_U^2}\right)\frac{dz}{dx}, \text{ where } f(x),\ z, \text{ and } \frac{dz}{dx} \text{ are given by:}$$

$$f(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/2\sigma^2}, \ -\infty < \mu < \infty,\ \sigma > 0,\ -\infty < x < \infty$$

$$\frac{dz}{dx} = \frac{\eta}{\lambda}\left(\left[\frac{x-\varepsilon}{\lambda}\right]^2 + 1\right)^{-1/2}$$ for SU type distributions (i.e., unbounded)

$$\frac{dz}{dx} = \eta\left|\frac{\lambda}{(x-\varepsilon)(\lambda+\varepsilon-x)}\right|$$ for SB type distributions (i.e., bounded)

$$\frac{dz}{dx} = \frac{1}{\sigma}$$ for Normal distributions

where $z = \gamma + \eta k_i(x,\lambda,\varepsilon)$ and where the k_i are given by:

$$k_1(x,\lambda,\varepsilon) = \sinh^{-1}\left(\frac{x-\varepsilon}{\lambda}\right)$$ for SU type distributions

$$k_2(x,\lambda,\varepsilon) = \ln\left(\frac{x-\varepsilon}{\lambda+\varepsilon-x}\right)$$ for SB type distributions

x_L = LSL and z_L is the transformed value

x_U = USL and z_U is the transformed value

The formula used to compute the constants η, γ, λ, and ε for the SU and SB distributions are given by Farnum [Farnum, 1996].

If the observed distribution is approximately Normal or can be transformed into an approximately Normal distribution, then the Net Sensitivity (NS) can be approximated by:

$$NS = [f(z_L)\text{-}f(z_U)]\frac{dz}{dx} = \frac{1}{\sigma\sqrt{2\pi}}(e^{-.5z_L^2} - e^{-.5z_U^2})$$

$$\hat{NS} = \frac{1}{s\sqrt{2\pi}}(e^{-.5(LSL-m)^2/s^2} - e^{-.5(USL-m)^2/s^2}) \qquad (1)$$

Net Sensitivity is an estimate of the instantaneous rate of change in the fraction nonconforming (i.e., the area under the approximating curve to the left of the LSL combined with the area to the right of the USL) given a change in the mean or standard deviation, or the specification limits of the process.

The variability of NS is determined by the random variables in equation (1). The fixed variables in equation (1) are the specification limits (i.e., USL and LSL) and the random variables are the mean and standard deviation (i.e., m and s). The two distributions making up NS are Normal and the mean and standard deviation are independent for Normal distributions, so the variability of NS follows from the sampling distribution of the random variables m and s. The standard error of the mean is $SEm = s/\sqrt{n}$, andthe standard error of the standard deviation is $SEs = s/\sqrt{2n}$ respectively.

II. Example

Let the following supplier management scenario, product specifications, and performance results for two suppliers form the basis for the comparison. The supply base manager would like to know if the nonconformance risk performance difference between the two suppliers is significant at a 95% confidence level. The procedure for answering this question might go as follows:

1. The engineer selects Net Sensitivity as the metric to assess the processes nonconformance risk.
2. Assume H_0:NS_A = NS_B and H_1: $NS_A \neq NS_B$
3. The product has characteristic performance requirements of LSL = -1, and USL = 2
4. The characteristic performance distributions for each supplier are approximately Normal
5. The sample characteristic performance statistics from each supplier are:

   Supplier A: n = 100, m = 0, s = 1

   Supplier B: n = 100, m = 1.7, s = 1

$$NS(+,+) = \frac{1}{(s+t(\alpha/2,df)*SEs)\sqrt{2\pi}} e^{-.5(LSL-(m+t(\alpha/2,df)*SEm)^2/(s+t(\alpha/2,df)*SEs)} - \frac{1}{(s+t(\alpha/2,df)*SEs)\sqrt{2\pi}} e^{-.5(USL-(m+t(\alpha/2,df)*SEm)^2/(s+t(\alpha/2,df)*SEs)}$$

where t(α/2, df) = 1.98, $SEm = s/\sqrt{n}$ = .1000, and $SEs = s/\sqrt{2n}$ = .0707. Evaluation of the four cases yields:

NS(+,+) = 101,000 DPM/unit x, where DPM is Defects Per Million

NS(+,-) = 124,000 DPM/unit x

NS(-,+) = 219,000 DPM/unit x

NS(-,-) = 283,000 DPM/unit x

Given the sample estimate of the supplier's net sensitivity, then the confidence interval for the population value of NS is denoted:

$$NS_L < NS < NS_U$$

The lower and upper values of the confidence interval for NS are computed as follows:

$$NS_L = \min\{NS(+,+), NS(+,-), NS(-,+), NS(-,-)\} = 101,000 \text{ DPM/unit x},$$

and

$$NS_U = \max\{NS(+,+), NS(+,-), NS(-,+), NS(-,-)\} = 283,000 \text{ DPM/unit x}$$

The result is the 100*(1 - α) % confidence internal for NS, i.e., $NS_L < NS < NS_U$.

$$CI_A = (101,000 < NS_A < 283,000)$$

$$\mathrm{Min}(\mathrm{Abs}(NS_A)) = 101,000 \text{ DPM/unit x}$$

Similarly, the confidence interval for the net sensitivity of supplier B's performance (NS_B) is:

$$CI_B = (-459,000 < NS_B < -286,000)$$

$$\mathrm{Min}(\mathrm{Abs}(NS_B)) = 286,000 \text{ DPM/unit x}$$

The objective in robust process design is to have the value of Net Sensitivity (NS) as close to zero as possible. So in this case, there is sufficient evidence to reject the Null Hypothesis and conclude that the nonconformance risk of supplier A is significantly smaller than that of supplier B with 95% confidence.

The practitioner needs exercise care when applying equation (1) to non-Normal data as it can lead to significant errors because NS is quite sensitive to the distribution shape. Hence when computing the confidence interval for non-Normal data the practitioner must apply the correct dz/dx formula for the type of Johnson curve that is being used to approximate the observed data distribution, or alternately use the Box-Cox transformation to Normalize the observed data distribution.

Then the 95% confidence interval (CI) for the net sensitivity of supplier A's performance (NS_A) is:

$$CI_A = (101,000 < NS_A < 283,000)$$

The two sided 100*(1- α)% confidence limits for the upper and lower limits are found by evaluating equation (1) using the t-distribution t(α/2, df) for the four combinations of the mean ± t(α/2, df)*SEm, and the standard deviation ± t(α/2, df)*SEs. For example,

III. Summary

Sensitivity analysis provides a way of assessing the robustness of a process to the possible impact of changes in the process distribution parameters or specification limits on process capability. So it is important to be able to determine if the net sensitivity of one supplier is significantly different from another. However, this test should be combined with a test for the difference in fraction nonconforming to get a more complete picture of the similarities and differences between suppliers. In some sense, the nonconformance test is a test of expected performance and the net sensitivity is a test of the potential variance of performance. Applying both tests provides a rigorous decision making tool for supplier management.

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Resonances of Elastic Spheroidal Bodies

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Abstract- At the basis of the dynamic elasticity theory with the use of Debye's potentials are found resonances of elastic spheroidal bodies (prolate and oblate) as entire so and in form of shells. In addition to analytic solutions, computer calculations are performed of moduluses of the angular characteristics of the scattering and sections of the scattering of spheroidal bodies.

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Abstract- At the basis of the dynamic elasticity theory with the use of Debye's potentials are found resonances of elastic spheroidal bodies (prolate and oblate) as entire so and in form of shells. In addition to analytic solutions, computer calculations are performed of moduluses of the angular characteristics of the scattering and sections of the scattering of spheroidal bodies.

Keywords: diffraction, debye's potential, elastic shell, boundary conditions.

I. Introduction

In the paper are investigated resonances of prolate and oblate spheroidal bodies (entire and in the form of shells) by the three-dimensional and axis-symmetrical irradiation. By the three-dimensional irradiation for the solution of the problem of the diffraction are used Debye's potentials. To resonances of elastic spheroidal bodies are devoted publications [1 – 9].

II. The First Part of the Article Investigat the Solution of the Three-Dimensional Problem of the Diffraction at the Elastic Spheroidal Body with Help of Debye's Potentials

Debye first proposed expanding the vector potential $\vec{A}$ in the scalar potentials U and V in his publication [10] devoted to studying the behavior of light waves near the local point or local line. Later, this approach was used in solving diffraction problems for cases of the electromagnetic wave diffraction of a sphere, a circular disk and a paraboloid of a revolution [11 – 16], as well as for the diffraction of longitudinal and transverse waves by spheroidal bodies [7, 17].

As applied to problems based on the dynamic elasticity theory, the introduction of Debye's potentials occurs as follows.The displacement vector $\vec{u}$ of an elastic isotropic medium
obeys the Lame equation:

$$(\lambda+\mu)graddiv\vec{u}-\mu curlcurl\vec{u}=-\rho\omega^2\vec{u}, \qquad (1)$$

where λ and μ are Lame constans, ρ is the density of the isotropic medium and ω is the circular frequency of harmonic vibrations. According to the Helmholtz theorem, the displacement vector $\vec{u}$ is expressed through scalar Φ and vector $\vec{\Psi}$ potentials:

$$\vec{u}=-grad\Phi+curl\vec{\Psi} \qquad (2)$$

Substituting Eg. (2) in Eg. (1), we obtain two Helmholtz equations, which include one scalar equation for Φ and one vector equation for $\vec{\Psi}$:

$$\Delta\Phi+h^2\Phi=0, \qquad (3)$$

$$\Delta\vec{\Psi}+k_2^2\vec{\Psi}=0. \qquad (4)$$

Here $h=\omega/c_1$ is the wavenumber of the longitudinal elastic wave, c_1 is the velocity of this wave, $k_2=\omega/c_2$ is the wavenumber of the transverse elastic wave and c_2 is the velocity of the transverse wave.

In the three-dimensional case, variables involved in scalar equation (3) can be separated into 11 coordinate systems. As for Eq. (4), in the three-dimensional problem, this equation yields three independent equations for each of components of the vector function $\vec{\Psi}$ in Cartesian coordinate system alone. To overcome this difficulty, one can use Debye's potentials U and V, which obey the Helmholtz scalar equation

$$\Delta V+k_2^2V=0;\ \Delta U+k_2^2U=0. \qquad (5)$$

Vector potential $\vec{\Psi}$ (according to Debye) is expanded in potentials V and U as

$$\vec{\Psi}=curlcurl(\vec{R}U)+ik_2curl(\vec{R}V), \qquad (6)$$

where $\vec{R}$ is the radius vector of a point of the elastic body or the elastic medium.

Let us demonstrate the efficiency of using Debye's potentials in solving the three-dimensional diffraction problem for the case of diffraction by an elastic spheroidal shell. The advantage of the representation (6) becomes evident, if we take into account that potentials V and U obey the Helmholtz scalar equation. It is convenient to represent components of $\vec{\Psi}$ in the spherical coordinate system by expressing them through U, V and $\vec{R}$ and then, using formulas of the vector analysis, to change to spheroidal components. The expressions for spherical components of the vector function $\vec{\Psi}(\Psi_R,\Psi_\theta,\Psi_\varphi)$ in terms of Debye's potentials have the form [7]:

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$$\Psi_R = (\partial\xi/\partial R)^2(\partial^2 B/\partial\xi^2) + 2\ \partial\xi(/\partial R)(\partial\eta/\partial R)(\partial^2 B/\partial\xi\partial\eta) + (\partial\eta/\partial R)^2(\partial^2 B/\partial\eta^2) + (\partial^2\xi/\partial R^2)(\partial B/\partial\xi) + (\partial^2\eta/\partial R^2)(\partial B/\partial\eta) + k_2^2 B, \quad (7)$$

$$\Psi_\theta = [h_0(\xi^2 - 1 + \eta^2)]^{-1}[(\partial\xi/\partial\theta)(\partial\xi/\partial R)(\partial^2 B/\partial\xi^2) + (\partial\xi/\partial\theta)(\partial\eta/\partial R)(\partial^2 B/\partial\xi\partial\eta) + (\partial\xi/\partial R)(\partial\eta/\partial\theta)(\partial^2 B/\partial\xi\partial\eta) + (\partial\eta/\partial R)(\partial\eta/\partial\theta)(\partial^2 B/\partial\eta^2) + (\partial B/\partial\xi)(\partial^2\xi/\partial R\partial\theta) + (\partial B/\partial\eta)(\partial^2\eta/\partial R\partial\theta)] + ik_2(\sin\theta)^{-1}(\partial V/\partial\varphi), \quad (8)$$

$$\Psi_\varphi = [h_0(\xi^2 - 1 + \eta^2)^{1/2}\sin\theta]^{-1}[\partial\xi/\partial R)(\partial^2 B/\partial\xi\partial\varphi) + (\partial\eta/\partial R)(\partial^2 B/\partial\eta\partial\varphi) - ik_2 \times [(\partial\xi/\partial\theta)(\partial V/\partial\xi) + (\partial\eta/\partial\theta)(\partial V/\partial\eta)], \quad (9)$$

where:

$$B = h_0(\xi^2 - 1 + \eta^2)^{1/2}U; -1 \le \eta \le +1; 1 \le \xi \le +\infty.$$

Spheroidal components of the function $\overrightarrow{\Psi}(\Psi_\xi, \Psi_\eta, \Psi_\varphi)$ are expressed as follows [7]:

$$\Psi_\xi = \Psi_R(h_0/h_\xi)\xi(\xi^2 - 1 + \eta^2)^{-1/2} + \Psi_\theta(h_0/h_\xi)(\xi^2 - 1 + \eta^2)^{1/2}(\partial\theta/\partial\xi), \quad (10)$$

$$\Psi_\eta = \Psi_R(h_0/h_\eta)\eta(\xi^2 - 1 + \eta^2)^{-1/2} + \Psi_\theta(h_0/h_\eta)(\xi^2 - 1 + \eta^2)^{1/2}(\partial\theta/\partial\eta), \quad (11)$$

$$\Psi_\varphi \equiv \Psi_\varphi, \quad (12)$$

where:

$$h_\xi = h_0(\xi^2 - \eta^2)^{1/2}(\xi^2 - 1)^{1/2};\ h_\eta = (\xi^2 - \eta^2)^{1/2}(1 - \eta^2)^{1/2}.$$

Let us consider in the form of an isotropic elastic spheroidal shell (Fig. 1). All potentials, including the plane wave potential Φ_0, the scattered wave potential Φ_1, the scalar shell poten-tial Φ_2, Debye's potentials U and V and potential Φ_3 of the gas filling the shell, can be ex-panded in spheroidal functions:

$$\Phi_0 = 2\sum_{m=0}^{\infty}\sum_{n\ge m}^{\infty} i^{-n}\varepsilon_m \overline{S}_{m,n}(C_1,\eta_0)\overline{S}_{m,n}(C_1,\eta)R^{(1)}_{m,n}(C_1,\xi)\cos m\varphi \quad (13)$$

$$\Phi_1 = 2\sum_{m=0}^{\infty}\sum_{n\ge m}^{\infty} B_{m,n}\overline{S}_{m,n}(C_1,\eta)R^{(3)}_{m,n}(C_1,\xi)\cos m\varphi \quad (14)$$

$$\Phi_2 = 2\sum_{m=0}^{\infty}\sum_{n\ge m}^{\infty}[C_{m,n}R^{(1)}_{m,n}(C_l,\xi) + D_{m,n}R^{(2)}_{m,n}(C_l,\xi)]\overline{S}_{m,n}(C_l,\xi)\cos m\varphi \quad (15)$$

$$\Phi_3 = 2\sum_{m=0}^{\infty}\sum_{n\ge m}^{\infty} E_{m,n}R^{(1)}_{m,n}(C_2,\xi)\overline{S}_{m,n}(C_2,\eta)\cos m\varphi \quad (16)$$

$$U = 2\sum_{m=1}^{\infty}\sum_{n\ge m}^{\infty}[F_{m,n}R^{(1)}_{m,n}(C_t,\xi) + G_{m,n}R^{(2)}_{m,n}(C_t,\xi)]\overline{S}_{m,n}(C_t,\eta)\sin m\varphi; \quad (17)$$

$$V = 2\sum_{m=0}^{\infty}\sum_{n\ge m}^{\infty}[H_{m,n}R^{(1)}_{m,n}(C_t,\xi) + I_{m,n}R^{(2)}_{m,n}(C_t,\xi)]\overline{S}_{m,n}(C_t,\eta)\cos m\varphi \quad (18)$$

where:

$\overline{S}_{m,n}(C_1,\eta)-$ the angular spheroidal function; $R^{(1)}_{m,n}(C_1,\xi)$, $R^{(2)}_{m,n}(C_1,\xi)$ and $R^{(3)}_{m,n}(C_1,\xi)-$ radial spheroidal functions of first, second and third genders; $C_l = hh_0$; $C_t = k_2h_0$; $C_1 = kh_0$, $k-$ is the wavenumber of the sound wave in the liquid; $C_2 = k_1h_0$, k_1- is the wavenumber of the sound wave in the gas filling the shell; h_o- the half – focal distance; $B_{m,n}, C_{m,n}, D_{m,n}, E_{m,n}, F_{m,n}, G_{m\,n}, H_{m\,n}, I_{m\,n}-$ are unknown expansion coefficients.

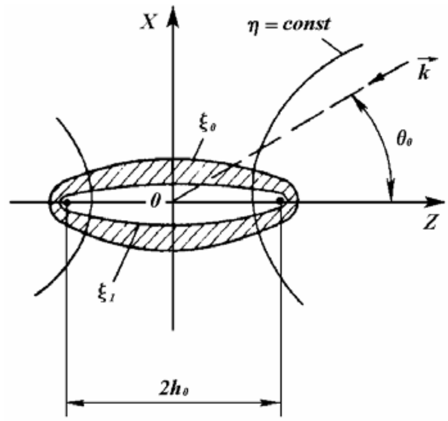

Figure 1 : Elastic spheroidal shell in a plane harmonic wave field

Expansion coefficients are determined from physical boundary conditions preset at two surfaces of the shell (ξ_0 and ξ_1, see Fig. 1) [7]:

1. the continuity of the normal displacement component at both of the boundaries ξ_0 and ξ_1;
2. the identity between the normal stress in the elastic shell and the sound pressure in the liquid (ξ_0) or in the gas (ξ_1);
3. the absence of tangential stresses at both of the shell boundaries, ξ_0 and ξ_1.

The corresponding expressions for boundary conditions have the form [7]:

$$(h_\xi)^{-1}(\partial/\partial\xi)(\Phi_0+\Phi_1)=(h_\xi)^{-1}(\partial\Phi_2/\partial\xi)+(h_\eta h_\varphi)^{-1}[(\partial/\partial\eta)(h_\varphi\Psi_\varphi)-(\partial/\partial\varphi)(h_\eta\Psi_\eta)]_{\xi=\xi_0}; \quad (19)$$

$$(h_\xi)^{-1}(\partial\Phi_1/\partial\xi)=(h_\xi)^{-1}(\partial\Phi_2/\partial\xi)+(h_\eta h_\varphi)^{-1}[(\partial/\partial\eta)(h_\varphi\Psi_\varphi)-(\partial/\partial\varphi)(h_\eta\Psi_\eta)]_{\xi=\xi_1}; \quad (20)$$

$$-\lambda_0 k^2(\Phi_0+\Phi_1)=-\lambda h^2\Phi_2+2\mu[(h_\xi h_\eta)^{-1}(\partial h_\xi/\partial\eta)u_\eta+(h_\xi)^{-1}(\partial u_\xi/\partial\xi)]_{\xi=\xi_0}; \quad (21)$$

$$-\lambda_1 k_1^2\Phi_3=-\lambda h^2\Phi_2+2\mu[(h_\xi h_\eta)^{-1}(\partial h_\xi/\partial\eta)u_\eta+(h_\xi)^{-1}(\partial u_\xi/\partial\xi)]_{\xi=\xi_1}; \quad (22)$$

$$0=(h_\eta/h_\xi)(\partial/\partial\xi)(u_\eta/h_\eta)+(h_\xi/h_\eta)(\partial/\partial\eta)(u_\xi/h_\xi)_{\xi=\xi_0;\xi=\xi_1}; \quad (23)$$

$$0=(h_\varphi/h_\xi)(\partial/\partial\xi)(u_\varphi/h_\varphi)+(h_\xi/h_\varphi)(\partial/\partial\varphi)(u_\xi/h_\xi)_{\xi=\xi_0;\xi=\xi_1}, \quad (24)$$

where:

$h_\varphi=h_0(\xi^2-1)^{1/2}(1-\eta^2)^{1/2}$; λ_0- is the bulk compression coefficient of the liquid; λ_1- is the bulk compression coefficient of the gas filling the shell;

$$u_\xi=(h_\xi)^{-1}(\partial\Phi_2/\partial\xi)+(h_\eta h_\varphi)^{-1}[(\partial/\partial\eta)(h_\varphi\Psi_\varphi)-(\partial/\partial\varphi)(h_\eta\Psi_\eta)];$$

$$u_\eta=(h_\eta)^{-1}(\partial\Phi_2/\partial\eta)+(h_\xi h_\varphi)^{-1}[(\partial/\partial\varphi)(h_\xi\Psi_\xi)-(\partial/\partial\xi)(h_\varphi\Psi_\varphi)];$$

$$u_\varphi=(h_\varphi)^{-1}(\partial\Phi_2/\partial\varphi)+(h_\xi h_\eta)^{-1}[(\partial/\partial\xi)(h_\eta\Psi_\eta)-(\partial/\partial\eta)(h_\xi\Psi_\xi)].$$

The substitution of series (13) – (18) in boundary conditions (19) – (24) yields an infinite system of equations for the determining of desired coefficients. Because of the ortogonality of trigonometric functions $\cos m\varphi$ and $\sin m\varphi$, the infinite system of equations breaks into infinite subsystems with fixed numbers m Each of subsystems is solved by the truncation method. The number of retained terms of expansions (13) – (18) is the greater the wave size for the given potential.The solution of the axissymmetrical problem of the diffraction at elastic spheroidal bodies was presented in [1, 2, 7 – 9].

III. The Second Part of the Article Investigates Results of Numerical Experiment for Determination of Low Frequency Resonances of Elastic Spheroidal Bodies

Characteristics of the prolate gas – filled shell were calculated for two angles of the irradiation $\theta_0 = 0^0$ and $\theta_0 = 90^0$. At the Fig. 2 are presented in the different scale moduluses of angular characteristics of the scattering $|D(\theta)|$ of the steel prolate gas – filled spheroidal shell (curve 1), of the soft prolate spheroid (curve 2) and of the hard spheroid (curve 3) by $\theta_0 = 0^0$ and $C_1 = 1,0$.

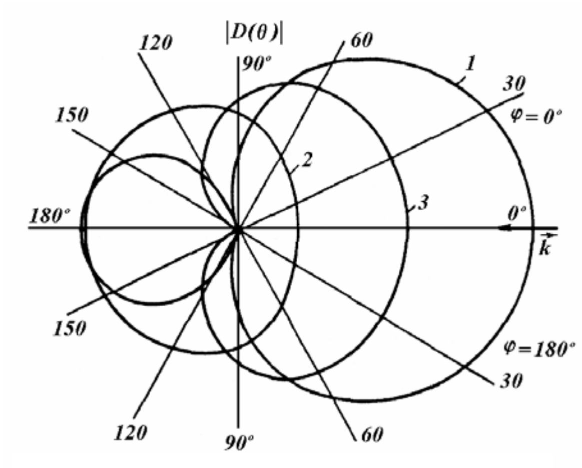

Figure 2 : Moduluses of angular characteristics of scattering of spheroidal scatterers

Same angular distributions, but by $C_1 = 3,1$ (the elastic shell, $C_1 = 3,0 -$ for ideal sphe-roids) and $C_1 = 10,0$ according are presented at Fig. 3 and 4. Notations of curves at all three Fig. identical. The analysis of presented results shows, what by the angle of the irradiation $\theta_0 = 0^0$ and the wave dimension $C_1 = 1,0$ (see Fig. 2) the angular characteristic of the elastic shell is similarly at the characteristic of the hard spheroid. By $C_1 = 3,1$ and by the angle of the irradiation $\theta_0 = 0^0$ the situation becomes indeterminated: the angular characteristic of the shell has dipole character as and by the hard spheroid (see Fig. 3). By the increase of the wave dimension C_1 the character of the sound scattering by the shell remains complicated (see Fig. 4): in the lit region the characteristic $|D(\theta)|$ of the hard spheroid, but in the shade region it is nearer to the shade lobe of the soft spheroid.

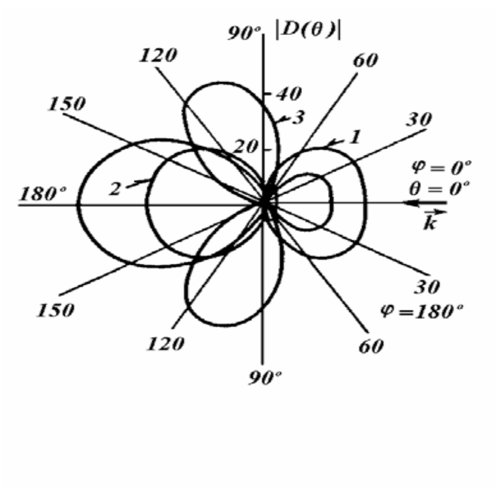

Figure 3 : Moduluses of angular characteristics of spheroidal scatterers

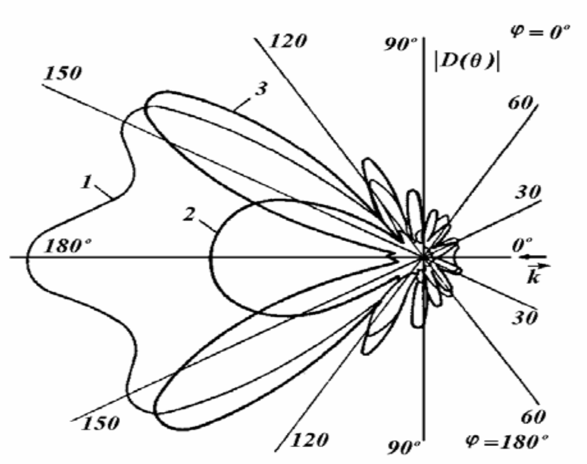

Figure 4 : Moduluses of angular chararacteristics of spheroidal scatterers

Over known angular characteristics of the scattering $D(\theta,\varphi)$ can be calculated back- scattering cross sections σ_0 of elastic spheroidal bodies [7]. At Fig. 5 are presented meanings of relative backscattering cross sections σ_0 of prolate spheroids with a correlation of semi – axises 1 : 10 (($\xi_0 = 1{,}005$) by the axially symmrtric irradiation $(\theta_0 = 0^0)$. The continuous elastic sphe-roid over the its conduct is very near to the ideal hard scatterer. This was seen by the compare-son of angular characteristics $D(\theta,\varphi)$ of steel and ideal spheroids. A coincidence is observed every where with the exception of a resonant point $C = 7{,}4$. Thies resonance is called by the surface wave of the "type of the Rayleigh wave" [5]. By the wave dimension $C =$ 7,4 on the surface along a contour of the steel continuous prolate spheroid is gone 2,5 λ_R, where λ_R is a length of the wave of the wave of the "type Rayleigh wave". A velocity this wave c_R is equal 2889 m/s, but on the plane boundary steel – vacuum a velocity of the Rayleigh wave is equal 2980 m/s.

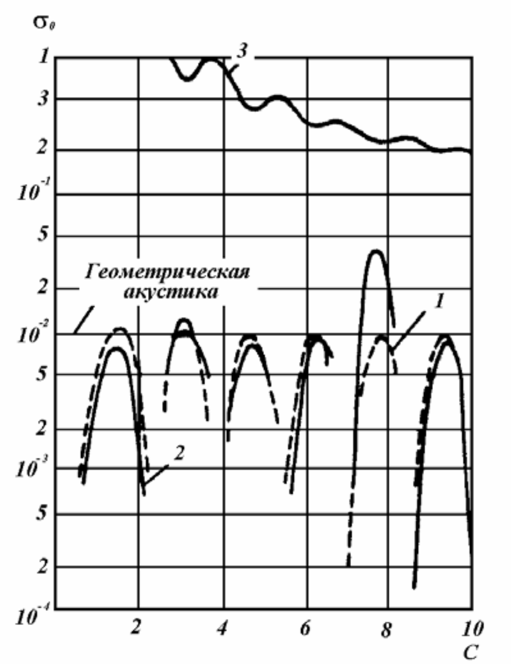

Figure 5 : Relative backscattering cross sections of prolate spheroids

On the Fig. 6 are presented relative back-scattering cross sections σ_0 of oblate spheroids with the correlation of the semi – axises 1:10 $(\xi_0 = 0{,}1005)$ by the axially symmetric irradiation $\theta_0 = 0^0$, the notations coincide with the Fig. 5. Until the resonance of rhe zero antisymmetrical-

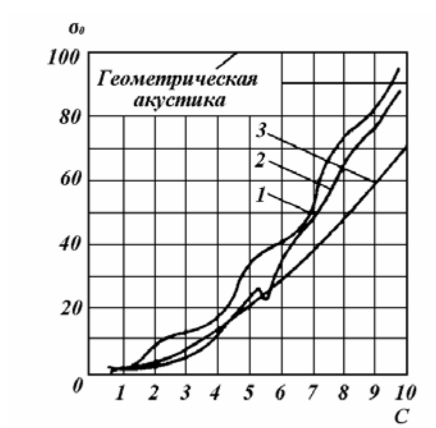

Figure 6 : Relative backscattering cross sections of oblate spheroids

flexural wave $(C \approx$ 5,3) σ_0 of the steel oblate spheroid over a level nearer to σ of the soft

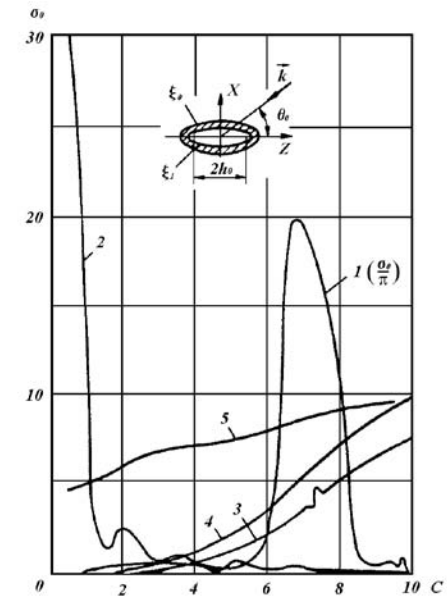

Figure 7 : Relative backscatterings cross sections of prolate spheroidal scatterers

spheroid, but by $C > 5,3$ draws near to σ_0 of the hard spheroid, at least the angular characteristic $D(\theta)$ of the elastic spheroid by $\theta_0 = 0^0$ and by all meanings of the wave dimension C is near to the angular characteristic $D(\theta)$ of the hard spheroid. On the Fig. 7 are presented sections σ_0 of the prolate spheroidal scatterers. The steel prolate spheroid and by $\theta_0 = 90^0$ has the resonance of the surface wave by same meaning $C =$ 7,4 (see curve 2, Fig. 5) [7]. Itself section of the scattering σ_0 of t5he steel continuous spheroid (curve 3) by $\theta_0 = 90^0$ is visibley nearer to σ_0 of the hard spheroid (curve 4) over the comparison with σ_0 of the soft spheroid (curve 5). This nearness of the scattering properties of continuous elastic and hard spheroids was shown too in the angular characteristic $D(\theta,\varphi)$. A frequency dependence of the relative section σ_0 of the prolate spheroidal shell (curve 1) by $\theta_0 = 0^0$ shows a prwesente of the considerable resonan- ce by $C = 6,75$ [1, 7 – 9]. On a Fig. 8 are shown moduluses of angular characteristics $|D(\theta)|$ of prolate spheroidal scatterers. A curve 1 concerns to the steel gas – filled shell by the wave dimension $C = 6,75$ corresponding its resonance, the curve 2 concerns to a soft spheroid, a curve 3 concerns to a hard spheroid, for ideal spheroids a wave dimension C is equal 10,0. From the

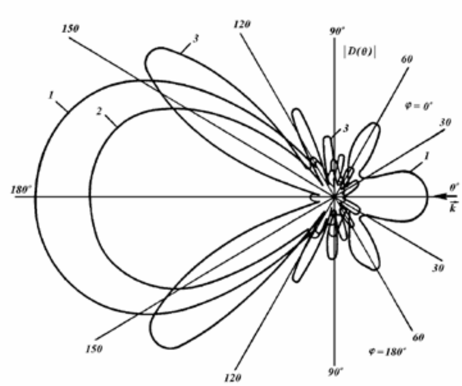

Figure 8 : Moduluses of angular characteristics of prolate spheroidal bodies

comparison of three curves we see, what a shade lobe of the angular characteristic of the shell shows at “the soft background”, but the lobe of the backscattering shows at “the hard background”. A relative.

Table 1

Wave dimension, C	σ_0 by $\theta_0 = 90^\circ$		
	Spheroidal gas – filled shell ($\xi_0 = 1{,}005075;\ \xi_1 = 1{,}005$)	Hard spheroid ($\xi_0 = 1{,}005$)	Soft spheroid ($\xi_0 = 1{,}005$)
0,5	$0{,}3012 \cdot 10^{-3}$	$0{,}2452 \cdot 10^{-3}$	4,506
1,0	$0{,}4748 \cdot 10^{-2}$	$0{,}3908 \cdot 10^{-2}$	4,760
1,5	$0{,}2365 \cdot 10^{-1}$	$0{,}1965 \cdot 10^{-1}$	5,194
2,0	$0{,}7354 \cdot 10^{-1}$	$0{,}6147 \cdot 10^{-1}$	5,748
2,5	0,1751	0,1479	6,300
3,0	0,3470	0,3006	6,754
3,5	0,6068	0,5418	7,094
4,0	0,9736	0,8911	7,358
4,5	1,447	1,362	7,592
5,0	2,014	1,960	7,815
5,5	2,599	2,680	8,029

backscattering cross section σ_0 of a spheroidal shell by $\theta_0 = 90^0$ was calculated until a wave dimension $C = 5{,}5$. Meanings σ_0 of a ashell are very near to σ_0 of a hard spheroid, what was shown worth while compare these sections with sections of t spheroid in a table form. As we see from a table 1 by this angle of a irradiation until $C = 5{,}5$ is shown "a hard background" o9f a scattering, what we see and from comparison of angular characteristics of a scattering $D(\theta,\varphi)$. A full scattering cross section σ [7] is determined through a square of a modulus of a angular characteristic of a sound scattering

$$D(\theta,\varphi): \sigma = \int_0^{\pi}\int_0^{2\pi} |D(\theta,\varphi)|^2 \sin\theta d\theta d\varphi.$$

A relative scattering cross section σ_r, by a way, is equal

$$\sigma_r = \sigma / 2A_0,$$

where A_0 is an area of a geometrical shade of a scatterer.

With a help of an optical theorem a scattering cross section σ cab be found through a meaning of an imaginaty part of of an angular characteristic in a direction of a falling wave (a scattering "forward") $\operatorname{Im} D(180^0 - \theta_0; 180^0)$ [7]:

$$\sigma = (4\pi / k) \operatorname{Im} D(180^0 - \theta_0; 180^0),$$

where θ_0 is an angle of a fall; $\varphi_0 = 0^0$.

At an analogy with the scattering cross section σ can introduce an idea of a section σ_{rad} of an elastic or liquid body under an action of a point source [7]:

$$\sigma_{rad} = \int_0^{\pi}\int_0^{2\pi} |F(\theta,\varphi)|^2 \sin\theta d\theta d\varphi,$$

where $F(\theta,\varphi)$ is an angular characteristic of a sound radiation of a body under an action of a point source.

At a basis of presented formulas was made an account of full σ and relative σ_r scattering cross sections and a radiation cross section σ_{rad} of spheroidal (prolate and oblate) bodies. On a Fig.9 are presented relative sections of a scattering σ_r of an ideal hard oblate spheroid (curve 1), of a steel oblate spheroid (curve 2) and of an ideal soft oblate spheroid (xcurve 3). In all three ca-ses a relation of a semi – axises $a/b = 1:10(\xi_0 = 0{,}1005)$, but an angle of an irradiation $\theta_0 = 0^0$. A relative section σ_r of an elastic spheroid shows a r5esonance of a coincidence as this was and in a relative backscattering σ_0 (see Fig. 6), but a point of a maximum was by $C = 5{,}25$, for σ_r is by $C - 5{,}35$. With an increase C a curve 2 draws near to a meaning $\sigma_r = 1{,}0$ corresp0onding a geometrical acoustics. Calculations show, what by $C = 15{,}0$ for an elastic oblate spheroid $\sigma_r = 0{,}866$, but by $C = 20{,}0 \to \sigma_r = 0{,}941$. On a Fig. 10 are presented relative sections of a sections of a scattering σ_r (curves 1 and 2) and a section of a radiation σ_{rad} (curve 3) of prolate spheroidal bodies. A curve 1 shows a frequency dependence $\sigma_r(C)$ of an ideal soft prolate spheroid $[a/b = 1:10(\xi_0 = 1{,}005)]$, a curve 2 corresponds $\sigma_r(C)$ of steel gas – filled prolate spheroi-

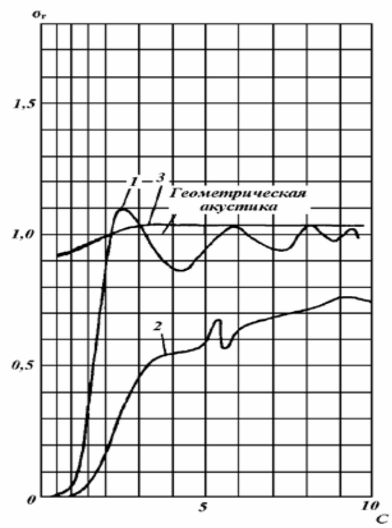

Figure 9 : Relative scattering cross sections of oblate spheroids

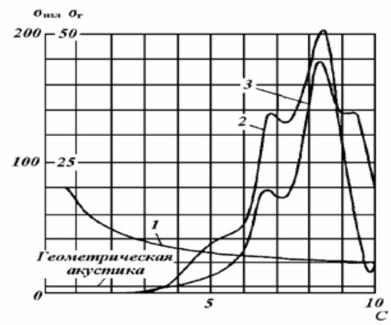

Figure 10 : Relative scattering cross sections and the section of radiating of prolate spheroidal bodies

dal shell $(\xi_0 = 1,005075; \xi_1 = 1,005)$. Both curves correspond $\theta_0 = 0^0$ (an axially symmetric problem). A curve 2 for an elastic shell unlike from an its relative backscattering section (curve 1 on a Fig. 7) has two maximums (two resonances). A first from theirs is observed by $C = 6,7$ (unlike from $C = 6,75$ for σ_0), a second resonance is observed by $C \approx 8,25$ and corresponds $L = 1,5\Lambda$, where L is a length of a contour of a neutral surface of a shell, Λ is a length of a longitudinal wave (of a zero symmetrical Lamb's wave) spreading with a velocity $c_1 \approx 5420 \ \ m/s.$ A curve 1 for an ideal soft spheroid aspires asymptotical to a meaning of a geometrical acoustics $\sigma_r = 1,0)$: $\sigma_r(15,0) = 4,16; \sigma_r(65,0) = 2,23; \sigma_r(100) = 1,93.$ A curve 3 characterises a radiating faculty of a same shell, if it is exited from an outside by a point source by $\theta_0 = 0^0 (h_0 = 50 \ \ m).$ A section of a radiation σ_{rad} has an extremums in those points, what and a relative section of a scattering $\sigma_{r.}$ A comparison of curves 2 and 3 presented on a Fig. 10 with curve 1 of a Fig. 7 shows, what a relative backscattering section does not give sometimes of a full information about a resonant properties of elastic scattering.

IV. Conclusions

With the help of the numerical experiment are found low frequency resonances of elastic spheroidal bodies (entire and in the form of shells) both prolate and oblate by the three – dimensional and axissymmetrical irradiation.

V. Acknowledgments

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Cost Effective Digital Water Billing System

By P. Mondal, M. R. Ali, N.Paul, P. K. Halder, M. Rahman, M. A. Rob & T. Ghosh
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Abstract- People, mainly in developing country are not aware about the pure water problem around the world. This paper focuses on water uses and wastage in developing country.It shows an automatic water measuring and billing system. Implementing high end technology for developing country like Bangladesh is very difficult. So a very cheap and cost effective water billing system is being introduced in the paper to save water for future.

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COSTEFFECTIVEDIGITALWATERBILLINGSYSTEM

Strictly as per the compliance and regulations of :

Cost Effective Digital Water Billing System

P. Mondal [α], M. R. Ali [σ], N.Paul [ρ], P. K. Halder [Ѡ], M. Rahman [¥], M. A. Rob [§] & T. Ghosh [χ]

Abstract- People, mainly in developing country are not aware about the pure water problem around the world. This paper focuses on water uses and wastage in developing country.It shows an automatic water measuring and billing system. Implementing high end technology for developing country like Bangladesh is very difficult. So a very cheap and cost effective water billing system is being introduced in the paper to save water for future.

I. Introduction

Water is an essential element for various purposes. It has a wide range of uses. But water, strictly saying usable water is being wasted by people in every moment because of poor management of related organizations mainly in developing country like Bangladesh. One of the examples is Dhaka WASA. Common people also are not aware about it. So, it is very important to find an automatic system for the management of water. In Bangladesh, there is 6.4% of water [1] but pure drinking water is far less than that. Again Arsenic contamination of the ground water including water pollution has reduced the safe water coverage [2]. Because of greenhouse effect and climate change northern part of the county is facing water problem and drought. 19 draught periods occur during 1960 to 1991 [3].

People living in City area in Bangladesh are not very aware of water problem and waste huge amount of water. Implementation of a modern billing system can reduce the wastage of water showing the bill depending on the amount of water used. In developed countries water meter is used at a wide range. But in Bangladesh, it is a new one. On the other hand, importing devices at a wide range is costly. While this device is very economical and can stop the wastage up to large extent.

II. Project Outline

When fluid passes through a venture pipe, it creates a pressure drop. These two pressures need to be measured and pressure is directly related to flow rate [4].i.e. $Q \infty (P_1 - P_2)$;Where, Q= flow rate and P_1, P_2 = pressure at two different cross section.

Various instruments are used in this project. Table 1 shows the list of the instruments.

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Authors ρ χ: Bangladesh University of Engineering & Technology, Bangladesh.
Author Ѡ: Jessore Science & Technology University, Bangladesh.

Table 1 : List of Instruments

Mechanical	Pipe
	Reducer
	Bellows
	Sticks
	Wood Board
	Clamp
	Screw
Electrical	Variable resistance
	IC7805
	Capacitor
	Microcontroller chip
	Diode
	Resistor
	Switch
	Transformer
	Printed circuit board
	LCD Display Board

Two bellows are used which will expand as a result of pressure. A stick is attached with variable resistance and bellow to measure the displacement. Figure 1 shows the arrangement. As a result, the variable resistance changes its value with the displacement of sticks and it is being converted into voltage to give as an input to the display with the help of microcontroller. Then calibration is done to determine the actual volume. Figure 2(a) and 2(b) shows setup and schematic diagram for water billing system.

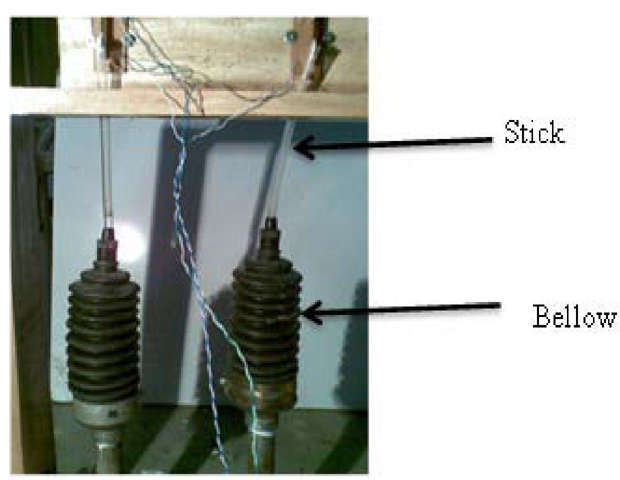

Figure 1 : Attachment of Bellows with the Sticks

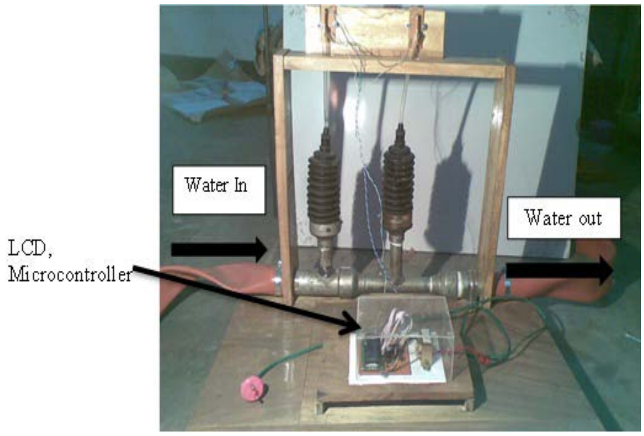

Figure 2(a) : Set up of the System

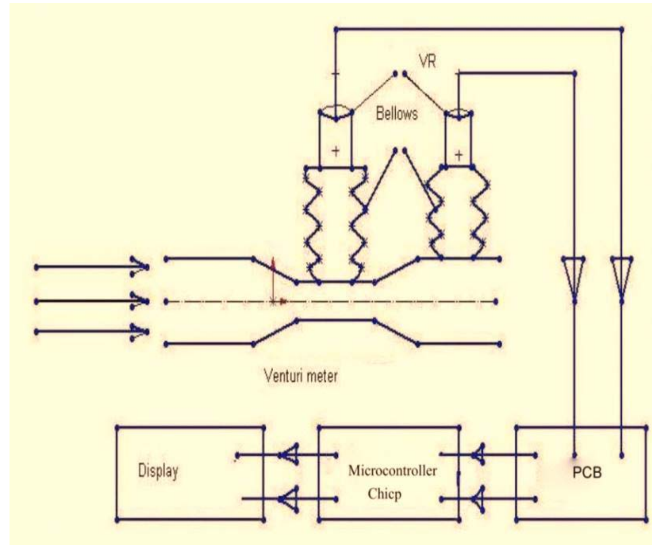

Figure 2(b) : Schematic Diagram for Water Billing System

III. Working Procedure

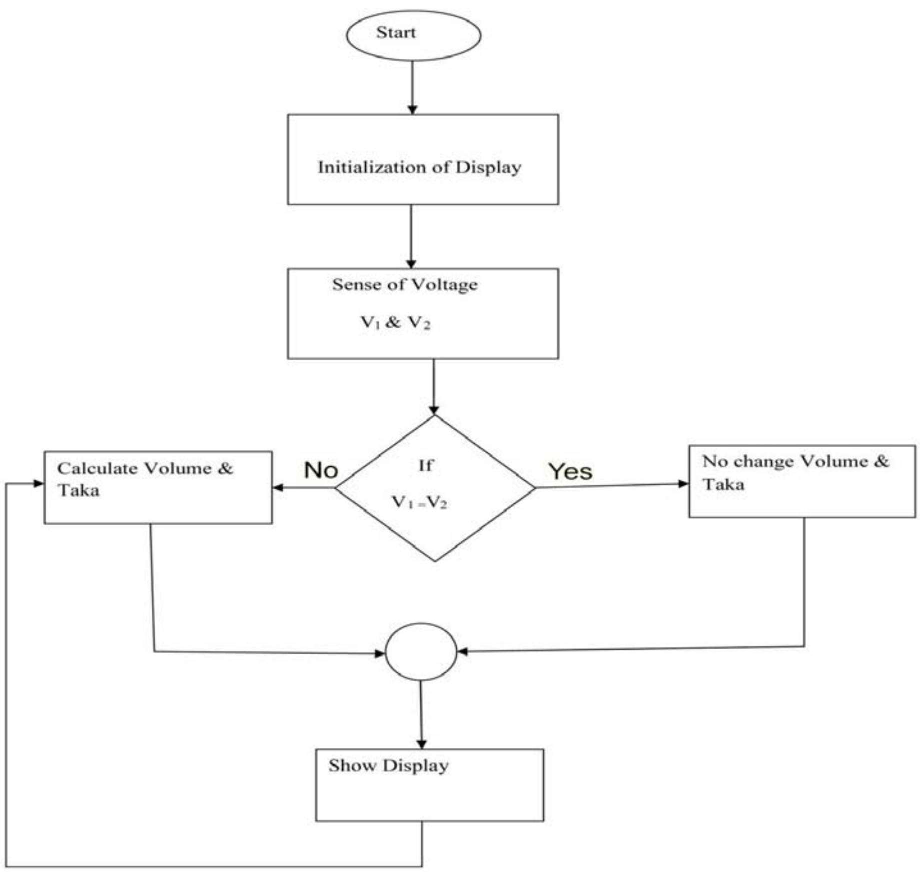

Figure 3 : Working Process of Automatic Water Billing System

IV. Calibration

Calibration is the process of comparing a value with a standard value. It is an important task for any experiment. From the calibration graph, actual volume of the water is achieved. Then on this basis, final program is being burnt in microcontroller.

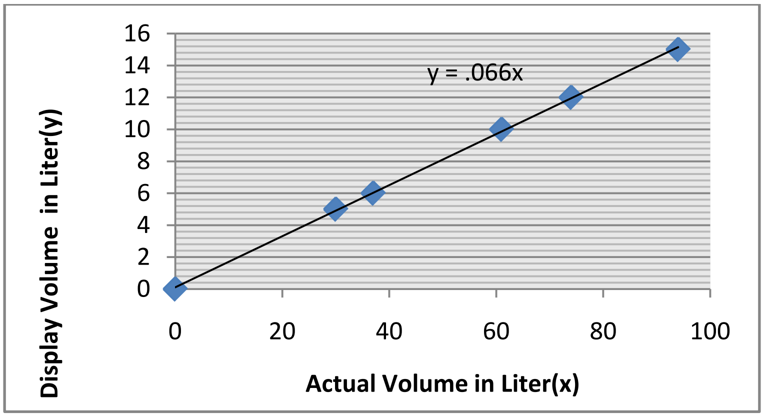

Figure 4 : Calibration Curve

V. Cost Analysis

Name of component	Specifications/details	Cost (BDT)
Mechanical parts		
3/2 inches MS Pipe	6 inches;2 pieces	130
3/4 inches MS Pipe	6 inches;2 pieces	52
Reducer	1.5" - .75"; 4 pieces	260
Bellows	2 pieces	300
2 inches Rubber Pipe	6 feet	90
3/2 inches MS Pipe	6 inches;2 pieces	130
3/4 inches MS Pipe	6 inches;2 pieces	52
Reducer	1.5" - .75"; 4 pieces	260
Bellows	2 pieces	300
2 inches Rubber Pipe	6 feet	90
U-clamp	3 pieces	15
Round clamp	3pieces	50
Stick	1 feet	5
5/2 inch screw	2 pieces	6
1 inch screw	8 pieces	12
Tape	1piece	10
Electrical Parts		
LCD	1 pieces	250
PCB	1 pieces	25
Power supply	1 pieces	55
Microcontroller	1 pieces	75
Variable resistance	2 pieces	40
Connecting wire	2 yard	10
Diode	2 pieces	10
Capacitor	2 pieces	10
Resistor	3 pieces	8
Plug & wire	1 pieces & 2 yard	15
Wooden structure	1piece	300
Accessories		450
Welding, circuit assembly etc.		200
Total		2378 (USD 30.52 as on 03 Sep 2013)

VI. Conclusion

Digital Water Billing System will introduce a new era in Bangladesh. Principle target of the project is to ensure proper utilization of the limited natural resource, water. This system is very useful as it gives direct observation of the billing and amount of water used for a particular time. It may be weekly, quarterly or monthly. This can be re-adjusted according to consumer choice and need. If this product can be spread throughout the country, people will become aware about the use of water. That will control the wastage of water.

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Statistical Study of NC Address

By Sebaa F. & Rahou M
Tlemcen Algeria, Algeria

Abstract- The programming of NC machines based on standard programming commands. These standards are incomplete. Builders directors CNC fit the specifications of their machines. This work aims to study the statistical inconsistencies addresses digital control FANUC, FAGOR, NUM SINUMRIK in turning and milling. Both parties have been developed. The first is to highlight the differences preparatory functions and their impact on programming. The second part presents a statistical study of the NC addresses for different programming languages to aid selection of the Director of CNC.

Keywords: *NC, Statistical, address.*

GJRE-J Classification : *FOR Code: 091307*

STATISTICALSTUDYOFNCADDRESS

Strictly as per the compliance and regulations of :

Statistical Study of NC Address

Sebaa F. [α] & Rahou M [σ]

Abstract- The programming of NC machines based on standard programming commands. These standards are incomplete. Builders directors CNC fit the specifications of their machines. This work aims to study the statistical inconsistencies addresses digital control FANUC, FAGOR, NUM SINUMRIK in turning and milling. Both parties have been developed. The first is to highlight the differences preparatory functions and their impact on programming. The second part presents a statistical study of the NC addresses for different programming languages to aid selection of the Director of CNC.

Keywords: NC, Statistical, address.

I. Introduction

The NC is a technique of controlling the operation of a machine from a program without direct operator intervention during execution. With the advances in microelectronics and computer industry, whose costs have continued to decline while the performance and usability have increased significantly, this method of control is increasingly present in the workshops. This technological evolution has replaced controls hardwired equipment by microprocessors that provide real-time calculations that previously had to be done when programming.

With the help of computers, parametric programming enables adaptation procedures. In addition to reducing outstanding (splitting long series production and just-in-time), the flexibility of labor, the development of CN's goal is compliance with more stringent time by optimizing the time of preparation of dead time and machining time as well as accurate and easily reusable machining programs.

The program content is developed with reference to the ISO regarding the machine language frequently in control manager regarding the specificities of each manufacturer DNC[1]. Given that each manufacturer of control manager by trying all means of differentiate its products from those of the competition and develops programming languages standard FANUC SINUMERIK, NUM, PHILIPS, BOSCH, FAGOR, MAZOL, ...

Some manufacturers offer features that differentiate the potential of their governing control compete on the guiding control microprocessor, the programming language is interpreted to be translated into a workable framework. Despite numerous efforts to standardize the machines have different languages, resulting in the need to adapt to the peculiarities of the machine on which they should be loaded.

NF standards (ISO 6983-1) (NF Z68-037), NF [ISO 4342] describe programming languages. Each manufacturer of control manager tries by all means to differentiate their products from the competition and develop standard programming languages. These incompatibilities have despite many efforts to standardize.. The non-uniformity of the language used creates confusion such as differences in the timing of a function, the ambiguities of appointment (eg tool) and the programming of machines of the same manufacturer [2].

This work aim to study the incompatibility of NC commands the most used .

II. Conflicts of Preparatory Functions

Table 1 show the differences G preparatory functions most used in industry controls (FANUC [3,7] SINUMERIK [4] NUM [5,9] and FAGOR [6,8]). Common codes to four commands such as G00, G01, G02, G03, G40, G41, G42 ....

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Table 1 : Statistical study

CODE	FANUC		SINUM		NUM		FAGOR	
G	TR	ML	TR	ML	TR	ML	TR	ML
05		+			+			
07					+			
09		+						
10		+						+
11		+						+
12								+
13								+
14							*	*
15							*	*
16		+					*	*
17				+		+		+
18				+		+		+
19				+		+		+
20					+		*	*
21					+		*	*
22					+		*	*
23							*	*
24							*	*
25	+						*	*
26	+						*	*
27							*	*
28							*	*
29		+				+	*	*
30							+	
31						+	+	
32	+						*	*
33		+			+			
34	+							
36	+							
37	+							
38					+			
39		+						
43		+						+
44		+						+
45		+				+		
46		+				+		
56		+						
57		+						
58		+						
59		+						
60		+						+
61		+						+
62		+						+
63		+			+			+
64		+			+			+
65					+		*	*
66					+		*	*
67								+
68	*	*					*	*
69	*	*					*	*
70	+							
71	+							
72	+							
73	*	*						+
74	*	*						
75	+							
76	*	*					*	*
77								+
78								+
79								+
80				+				+
81		+		+			*	*
82		+		+			*	*
83				+				
84				+			*	*
85		+		+			*	*
86				+		+	*	*
87	*	*		+			*	*
88	*	*		+		+	*	*
89				+			*	*
90	*	*						
91		+						

47		+					*	*	92	*	*	+		+			
48		+					*	*	93						+		
49		+					*	*	94	*	*						
50	*	*					*	*	95		+						
51		+					*	*	96	+		+		+			
52		+					*	*	97	+		+		+			
53		+							98	*	*						+
54		+							99	*	*						+
55		+															

+ : Code in turning or in Milling.

* : The same code has two different designations in turning or milling.

III. Statistical Study of Conflicts of Preparatory Functions

Statistical analysis showed differences in the command codes studied in terms of existence of code, number of codes used number of standardized codes and other criteria as shown in Table 2.

Table 2 : Statistical study

command / code		FANUC			NUM			SINUMERIK			FAGOR		
		TR	ML	%	TR	ML	%	TR	ML	%	TR	ML	%
Number of codes used		53	75		61	97		34	45		73	93	
unstandardized	TR	25	23	47,16	22	16	36,06	08	08	23,52	30	38	41,09
	FR			31,50			16,49			17,77			40,86
Common codes	TR	28		52,83	47		77,04	32		91,42	38		52,05
	FR			37,33			82,45			71,11			40,86
Code in turning		12		22,63	14		22,95	03		08,57	02		02,73
Code in milling			34	45,33		10	16,94		13	28,26		22	34,37
Code in turning and milling		13	13	02,96	00		00	00		00	33	33	27,52

This study highlights a proposal for the following classification:

- ✓ SINUMERIK
- ✓ FANUC
- ✓ NUM
- ✓ FAGOR

On the commercial side, the manufacturer FANUC offers two control options to reduce the existing differences in relation to other competing manufacturers, allowing it to be used in the majority of CAM software.

The advantage of the Sinumerik (Siemens) lies in the lack of differences for the same code when there and turning and milling unlike Fagor or the difference is relatively large order.

NC programming in ISO code is considered unfriendly given the complexity of the addresses used in the programming of machining cycles such instructions: G.. EH .. EF .. EI .. EJ .. EQ .. ER ... ranging from one code to another, hence the diversity of managers control Regarding the auxiliary functions, there is a correlation between the main functions such as starting, stopping the spindle lubrication, rotation, change tools, end of the program.... With the exception of auxiliary functions used by different manufacturers in a competitive purpose, the main difference lies in the subroutine call and end subroutine respectively coded M98 and M99 in the case of FANUC, unlike other commands (FAGOR, NUM) using preparatory functions G, while SINUMERIK uses the letter L followed by the number of the desired machining cycle.

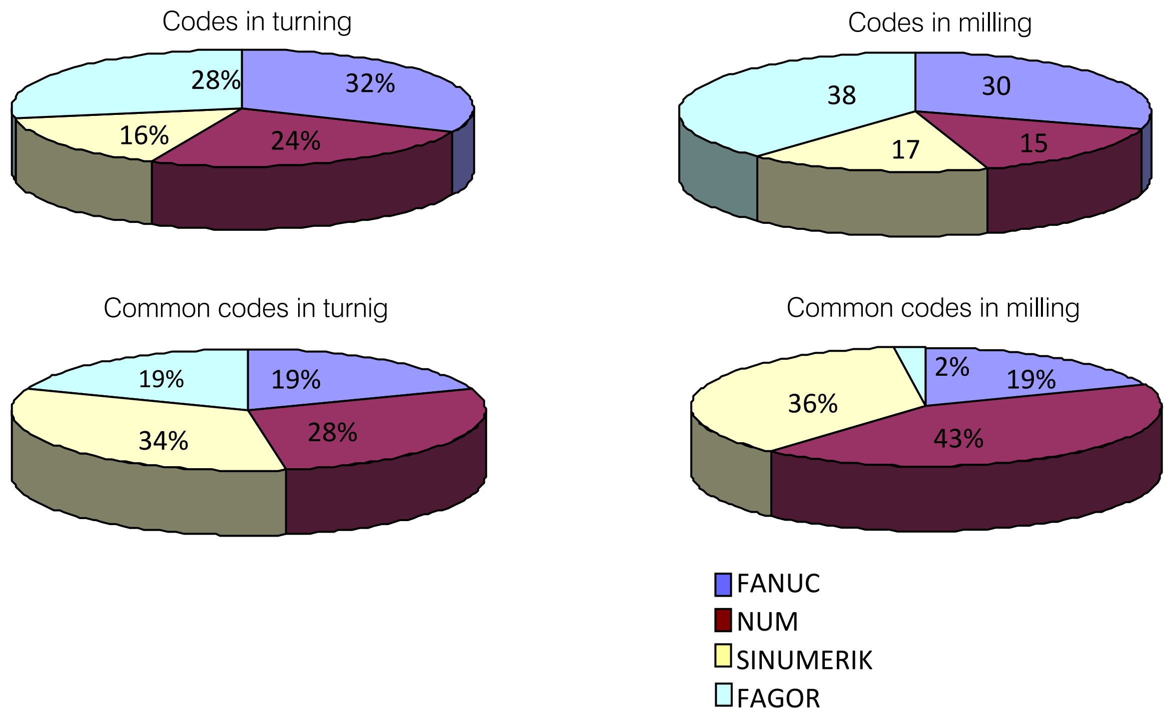

Figure 1 : Representation by sector

IV. Conclusion

This work has helped to highlight the differences and incompatibilities between the addresses of the various commands. We find that 62.50% of the addresses using one or two appointments, while the remaining addresses, or 37.50%, using four to nine nominations. This study could be used as a criterion of choice of material depending on the desired goal.

About a third of the addresses do not change regardless of the order designations used. The syntax for writing a block of program database used for the development of an adaptation module of the NC machining instructions and learning NC programming

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Recent Trends in Industrial and other Engineering Applications of Non Destructive Testing: A Review

By Sanjay Kumar & Dalgobind Mahto
GHEC Solan, India

Abstract- The field of NDT is a very broad, interdisciplinary field that plays a critical role in inspecting that structural component and systems perform their function in a reliable fashion. Certain standards has been also implemented to assure the reliability of the NDT tests and prevent certain errors due to either the fault in the equipment used, the miss application of the methods or the skill and the knowledge of the inspectors. Successful NDT tests allow locating and characterizing material conditions and flaws that might otherwise cause planes to crash, reactors to fail, trains to derail, pipelines to burst, and variety of less visible, but equally troubling events. However, these techniques generally require considerable operator skill and interpreting test results accurately may be difficult because the results can be subjective. This paper presents the reviews of different works in the area of NDT and tries to find out latest developments and trends available in industries and other fields in order to minimize the total equipment cost, minimize damages and maximize the safety of machines, structures and materials.

Keywords: non destructive testing, objectives, literature review, summary of literature review and conclusion.

GJRE-J Classification : FOR Code: 290502

RECENTTRENDSININDUSTRIALANDOTHERENGINEERINGAPPLICATIONSOFNONDESTRUCTIVETESTINGAREVIEW

Recent Trends in Industrial and other Engineering Applications of Non Destructive Testing: A Review

Sanjay Kumar [α] & Dalgobind Mahto [σ]

Abstract - The field of NDT is a very broad, interdisciplinary field that plays a critical role in inspecting that structural component and systems perform their function in a reliable fashion. Certain standards has been also implemented to assure the reliability of the NDT tests and prevent certain errors due to either the fault in the equipment used, the miss application of the methods or the skill and the knowledge of the inspectors. Successful NDT tests allow locating and characterizing material conditions and flaws that might otherwise cause planes to crash, reactors to fail, trains to derail, pipelines to burst, and variety of less visible, but equally troubling events. However, these techniques generally require considerable operator skill and interpreting test results accurately may be difficult because the results can be subjective. This paper presents the reviews of different works in the area of NDT and tries to find out latest developments and trends available in industries and other fields in order to minimize the total equipment cost, minimize damages and maximize the safety of machines, structures and materials.

Keywords: non destructive testing, objectives, literature review, summary of literature review and conclusion.

I. Introduction

Non-Destructive Testing (NDT) is defined by the American Society for Non-destructive Testing (ASNT) as: "The determination of the physical condition of an object without affecting that object's ability to fulfil its intended function. Non-destructive testing techniques typically use a probing energy form to determine material properties or to indicate the presence of material discontinuities (surface, internal or concealed)." The application of physical principles for detecting in homogeneities in materials without impairing the usefulness of the materials has brought into being a technique known as "non-destructive testing".

The term NDT is often considered to be concerned only with the detection and location of flaws. Actually, the methods and techniques used in NDT measure physical properties or non-uniformity in physical properties of materials as well. Variations or non uniformities in physical properties may or may not affect the usefulness of a material, depending upon the particular application under consideration. Non destructive testing is the testing of materials, for surface or internal flaws or metallurgical condition, without interfering in any way with the integrity of the material or its suitability for service. The technique can be applied on a sampling basis for individual investigation or may be used for 100% checking of material in a production quality control system.

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II. Non Destructive Testing Methods

The common NDT methods are:

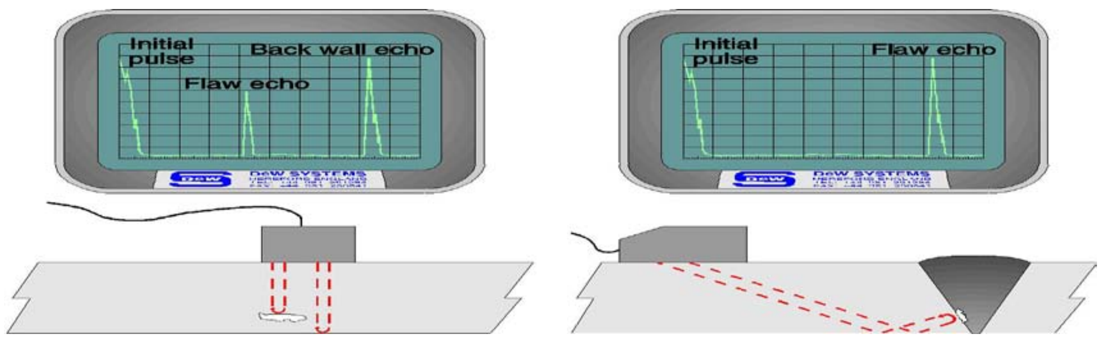
- Visual and optical Testing
- Ultrasonic Testing
- Electromagnetic Testing
- Thermographic Testing
- Radiographic Testing
- Liquid Penetrant Testing
- Magnetic particle Testing
- Acoustic Emission testing
- Magnetic Resonance Imaging Testing
- Near-Infrared Spectroscopy
- Optical Microscope Testing

a) Visual and Optical Testing

Visual inspection is particularly effective detecting macroscopic flaws, such as poor welds. Many welding flaws are macroscopic: crater cracking, undercutting, slag inclusion, incomplete penetration welds, and the like. Likewise, VI is also suitable for detecting flaws in composite structures and piping of all types. Bad welds or joints, missing fasteners or components, poor fits, wrong dimensions, improper surface finish, large cracks, cavities, dents, inadequate size, wrong parts, lack of code approval stamps and similar proofs of testing.

b) Ultrasonic Testing

This technique is used for the detection of internal and surface (particularly distant surface) defects in sound conducting materials. The principle is in some respects similar to echo sounding. A short pulse of ultrasound is generated by means of an electric charge applied to a piezoelectric crystal, which vibrates for a very short period at a frequency related to the thickness of the crystal. In flaw detection this frequency is usually in the range of 1 MHz to 6 MHz. Vibrations or sound waves at this frequency have the ability to travel a considerable distance in homogeneous elastic material, such as many metals with little attenuation. For example the velocity in steel is 5900 metres per second, and in water 1400 metres per second. Ultrasonic testing employs an extremely diverse set of methods based upon the generation and detection of mechanical vibrations or waves within test objects. The test objects are not restricted to metals, or even to solids. The standard method of presenting information in ultrasonic testing is by means of a cathode ray tube, in which horizontal movement of the spot from left to right represents time elapsed. The rate at which the spot moves is such that it gives the appearance of a horizontal line on the screen. The system is synchronised electronically so that at the instant the probe receives its electrical pulse the spot begins to traverse the screen. An upward deflection (peak) of the line on the left hand side of the screen is an indication of this occurrence.



Schematic diagram of ultrasonic detection of slag in steel section using a normal probe.

Schematic diagram of the use of an angle probe to detect defects not directly under the probe. Such as in weld inspection.

Figure 1 : An Illustration of Ultrasonic Flaw Detection

c) Electromagnetic Testing

Electromagnetic Testing (ET), as a form of NDT, is the process of inducing electric currents or magnetic fields or both inside a test object and observing the electromagnetic response. If the test is set up properly, a defect inside the test object creates a measurable response. The main applications of the eddy current technique are for the detection of surface or subsurface flaws, conductivity measurement and coating thickness measurement. Eddy currents can be produced in any electrically conducting material that is subjected to an alternating magnetic field (typically 10Hz to 10MHz). The alternating magnetic field is normally generated by passing an alternating current through a coil. The coil can have many shapes and can between 10 and 500 turns of wire. The magnitude of the eddy currents generated in the product is dependent on conductivity, permeability and the set up geometry. Any change in the material or geometry can be detected by the excitation coil as a change in the coil impedance. The simplest coil comprises a ferrite rod with several turns of wire wound at one end and which is positioned close to the surface of the product to be tested. When a crack, for example, occurs in the product surface the eddy currents must travel farther around the crack and this is detected by the impedance change.

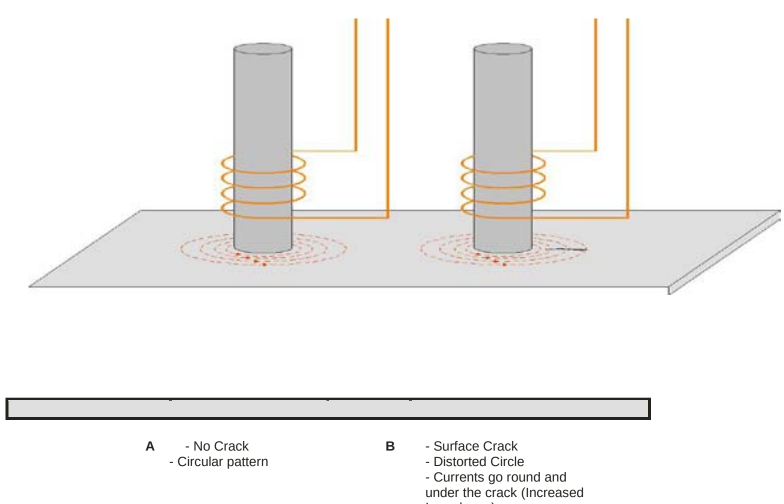


Figure 2 : An Illustration of Coil with single winding

d) Thermographic Testing

Infrared Thermography is the science of measuring and mapping surface temperatures. Infrared and thermal testing methods are characterized by the use of thermal measurements of a test object as it undergoes a response to a stimulus. Thermal imaging cameras are the most common sensing method. Passive imaging of machinery or electronics may be used to detect hot spots indicative of problems. Imaging of test objects after the application of energy can be used to monitor the flow of heat in the object, which is a function of material properties as well as boundaries. Flash thermography techniques have been very successful in imaging disbonds and delaminations in composite parts. Another significant recent advancement is the use of mechanical energy to stimulate localized heating at sub-surface discontinuities, such as cracks in metals, opening up a new field of application for the IR method. Infrared thermography, a nondestructive, remote sensing technique, has proved to be an effective, convenient, and economical method of testing concrete. It can detect internal voids, delaminations, and cracks in concrete structures such as bridge decks, highway pavements, garage floors, parking lot pavements, and building walls. An infrared thermographic scanning system can measure and view temperature patterns based upon temperature differences as small as a few hundredths of a degree Celsius. Infrared thermographic testing may be performed during day or night, depending on environmental conditions and the desired results. All objects emit electromagnetic radiation of a wavelength dependent on the object's temperature. The frequency of the radiation is inversely proportional to the temperature. In infrared thermography, the radiation is detected and measured with infrared imagers (radiometers). The imagers contain an infrared detector that converts the emitting radiation into electrical signals that are displayed on a colour or black & white computer display monitor.

e) Radiography Testing

Radiography has an advantage over some of the other processes in that the radiography provides a permanent reference for the internal soundness of the object that is radiographed. The x-ray emitted from a source has an ability to penetrate metals as a function of the accelerating voltage in the x-ray emitting tube. If a void present in the object being radiographed, more x rays will pass in that area and the film under the part in turn will have more exposure than in the non-void areas. The sensitivity of x-rays is nominally 2% of the materials thickness. Thus for a piece of steel with a 25mm thickness, the smallest void that could be detected would be 0.5mm in dimension. For this reason, parts are often radiographed in different planes. A thin crack does not show up unless the x-rays ran parallel to the plane the crack. Gamma radiography is identical to x-ray radiography in function. The difference is the source of the penetrating electromagnetic radiation which is a radioactive material such m Co 60. However this method is less popular because of the hazards of handling radioactive materials. This technique is suitable for the detection of internal defects in ferrous and non ferrous metals and other materials. X-rays, generated electrically, and Gamma rays emitted from radio-active isotopes, are penetrating radiation which is differentially absorbed by the material through which it passes; the greater the thickness, the greater the absorption.

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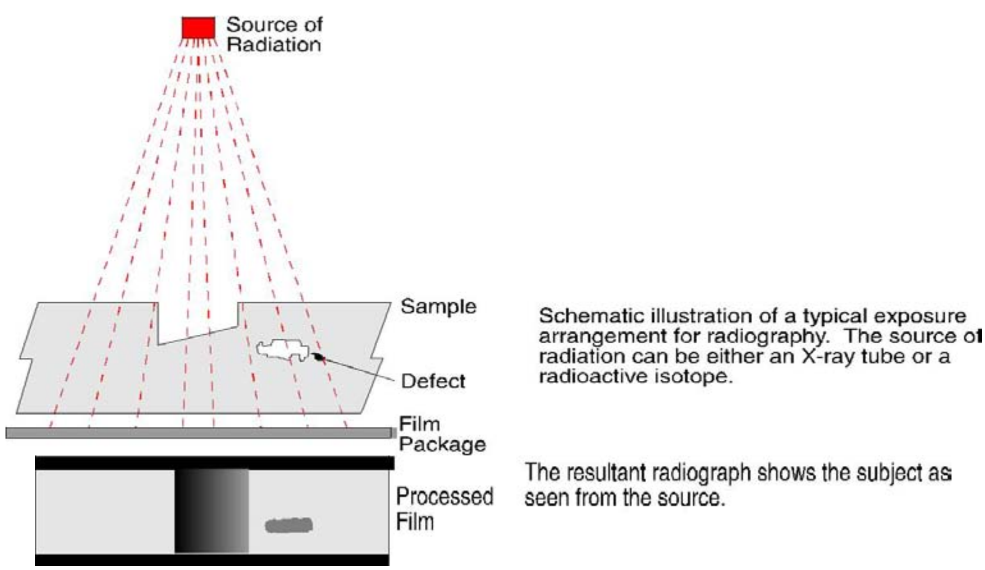

Figure 3 : An Illustration of Radiography Testing

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f) Liquid Penetrant Testing

The technique is based on the ability of a liquid to be drawn into a "clean" surface breaking flaw by capillary action. This method is an inexpensive and convenient technique for surface defect inspection. Materials that are commonly inspected using LPI include the following; metals (aluminium, copper, steel, titanium, etc.), glass, many ceramic materials, rubber, plastics. The penetrant may be applied to all non-ferrous materials and ferrous materials; although for ferrous components magnetic-particle inspection is often used instead for its subsurface detection capability. LPI is used to detect casting, forging and welding surface defects such as hairline cracks, surface porosity, leaks in new products, and fatigue cracks on in-service components. LPI is based upon capillary action, where low surface tension fluid penetrates into clean and dry surface-breaking discontinuities. Penetrant may be applied to the test component by dipping, spraying, or brushing. After adequate penetration time has been allowed, the excess penetrant is removed and a developer is applied. The developer helps to draw penetrant out of the flaw so that an invisible indication becomes visible to the inspector. Inspection is performed under ultraviolet or white light, depending on the type of dye used fluorescent or nonfluorescent (visible).

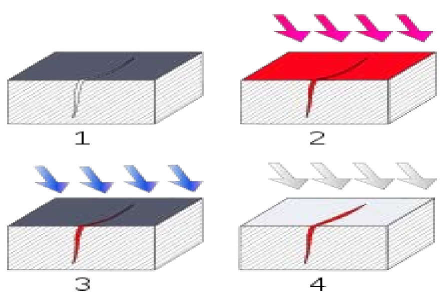

Figure 4 : An Illustration of Liquid Penetration Testing.

- Section of material with a surface-breaking crack that is not visible to the naked eye.
- Penetrant is applied to the surface.
- Excess penetrant is removed.
- Developer is applied, rendering the crack visible.

g) Magnetic Particle Inspection

This method uses magnetic fields and small magnetic particles, such as iron filings to detect flaws in components. The only requirement from an inspect ability standpoint is that the component being inspected must be made of a ferromagnetic material such iron, nickel, cobalt, or some of their alloys, since these materials are materials that can be magnetized to a level that will allow the inspection to be effective. In its simplest application, an electromagnet yoke is placed on the surface of the part to be examined, a kerosene-iron filling suspension is poured on the surface and the electromagnet is energized. If there is a discontinuity such as a crack or a flaw on the surface of the part, magnetic flux will be broken and a new south and north pole will form at each edge of the discontinuity. Then just like if iron particles are scattered on a cracked magnet, the particles will be attracted to and cluster at the pole ends of the magnet, the iron particles will also be attracted at the edges of the crack behaving poles of the magnet. This cluster of particles is much easier to see than the actual crack and this is the basis for magnetic particle inspection. For the best sensitivity, the lines of magnetic force should be perpendicular to the defect. This method is suitable for the detection of surface and near surface discontinuities in magnetic material, mainly ferrite steel and iron.

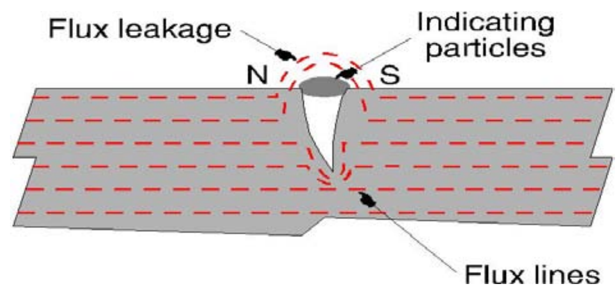

Figure 5 : An Illustration of The Principle of Magnetic Particle Inspection

h) Acoustic Method

There are two different kind of acoustic methods: (a) acoustic emission; (b) acoustic impact technique.

i. *Acoustic Emission*

Acoustic emission (AE) is the sound waves produced when a material undergoes stress (internal change), as a result of an external force. AE is a phenomenon occurring in for instance mechanical loading generating sources of elastic waves. This occurrence is the result of a small surface displacement of a material produced due to stress waves generated when the energy in a material, or on its surface is released rapidly. The wave generated by the source is of practical interest in methods used to stimulate and capture AE in a controlled fashion, for study and/or use in inspection, quality control, system feedback, process monitoring and others.

ii. *Acoustic Impact Technique*

This technique consists of tapping the surface of an object and listening to and analyzing the signals to detect discontinuities and flaws. The principle is basically the same as when one taps walls, desktops or countertops in various locations with a finger or a hammer and listens to the sound emitted. Vitrified grinding wheels are tested in a similar manner to detect cracks in the wheel that may not be visible to the naked eye. This technique is easy to perform and can be instrumented and automated. However, the results depend on the geometry and mass of the part so a reference standard is necessary for identifying flaws.

i) Magnetic Resonance Imaging

Magnetic resonance imaging (MRI), nuclear magnetic resonance imaging (NMRI), or magnetic resonance tomography (MRT) is a medical imaging technique used in radiology to visualize internal structures of the body in detail. MRI makes use of the property of nuclear magnetic resonance (NMR) to image nuclei of atoms inside the body. MRI can create more detailed images of the human body than are possible with X-rays.

An MRI scanner is a device in which the patient lies within a large, powerful magnet where the magnetic field is used to align the magnetization of some atomic nuclei in the body, and radio frequency magnetic fields are applied to systematically alter the alignment of this magnetization. This causes the nuclei to produce a rotating magnetic field detectable by the scanner and this information is recorded to construct an image of the scanned area of the body. Magnetic field gradients cause nuclei at different locations to process at different speeds, which allows spatial information to be recovered using Fourier analysis of the measured signal. By using gradients in different directions, 2D images or 3D volumes can be obtained in any arbitrary orientation.

j) Near-Infrared Spectroscopy

Near-infrared spectroscopy (NIRS) is a spectroscopic method that uses the near-infrared region of the electromagnetic spectrum (from about 800 nm to 2500 nm). Typical applications include pharmaceutical, medical diagnostics (including blood sugar and pulse oximetry), food and agrochemical quality control, and combustion research, as well as research in functional neuroimaging, sports medicine & science, elite sports training, ergonomics, rehabilitation, neonatal research, brain computer interface, urology (bladder contraction) and neurology (neurovascular coupling).

Near-infrared spectroscopy is based on molecular overtone and combination vibrations. Such transitions are forbidden by the selection rules of quantum mechanics. As a result, the molar absorptivity in the near IR region is typically quite small. One advantage is that NIR can typically penetrate much farther into a sample than mid infrared radiation. Near infrared spectroscopy is, therefore, not a particularly sensitive technique, but it can be very useful in probing bulk material with little or no sample preparation.

k) Optical Microscope

The microscope has a digital camera, and is attached to a computer. The optical microscope, often referred to as the "light microscope", is a type of microscope which uses visible light and a system of lenses to magnify images of small samples. Optical microscopes are the oldest design of microscope and were possibly designed in their present compound form in the 17th century. Basic optical microscopes can be very simple, although there are many complex designs which aim to improve resolution and sample contrast. Historically optical microscopes were easy to develop and are popular because they use visible light so that samples may be directly observed by eye. The image from an optical microscope can be captured by normal light-sensitive cameras to generate a micrograph. Originally images were captured by photographic film but modern developments in CMOS and charge-coupled device (CCD) cameras allow the capture of digital images. Purely digital microscopes are now available which use a CCD camera to examine a sample, showing the resulting image directly on a computer screen without the need for eyepieces.

III. Objectives

- Providing better quality of products.
- Reducing costs and increasing production.
- Detection of unwanted failures in the very beginning phase.
- Providing the ability to inspect the equipments in operational state.
- Reaching to higher levels of reliability.
- Gaining consumer satisfaction.
- Avoiding or reducing downtime and wastage of material.
- Thickness measurements.
- Evaluation of surface characteristics.
- Determining areas with high stress concentration.
- Prediction of material behaviour.
- To evaluate the properties of a material, component or system without causing damage.
- Internal characteristics of solid structures can be examined without permanently affecting the structure.

IV. Literature Survey

D. Bates et al [1] compares the use of different thermal non-destructive testing techniques to rapidly inspect carbon fibre composite aircraft components. Samples were prepared to simulate inclusions and barely visible impact damage in carbon fibre reinforced plastic laminate which represent faults in the manufacturing process and in-service environment respectively. The limits of material fault detection were then compared for transient and lock-in thermography and the results were verified with underwater ultrasonic c-scans.

Infrared thermography (thermal imaging) is an important and powerful technique for consideration when investigating any structural situation where a ready source of surface heating (or cooling) is available. The methods used are totally non-destructive and non-invasive, and can be highly cost-effective. D.J. Titman

Global Journal of Researches in Engineering (J) Volume XIII Issue III Version I Year 2013

[2] explores a wide range of applications, particularly relating to structural investigation situations. Some guidance is given on optimum timing, conditions and viewing locations for the various situations described as well as limitations of the technique.

P Cawley [3] states that The NDT market is dominated by the 'big five' techniques: radiography, ultrasonic, eddy current, magnetic particle and penetrant testing. There is therefore a continuing drive to increase the speed of inspection, to reduce the preparation required and, if possible, to inspect without the need to shut down operation.

Jacek Jarmulak et al [4] present how the case-based reasoning methodology (where interpretation of new data is based on previous data-interpretation cases) can be used to tackle the problem of NDT data interpretation. The article presents the characteristics of CBR, which make it an interesting alternative to statistical classifiers and to expert systems.

Non destructive testing is an important method of insuring quality of the composites. Comparing with other non destructive testing methods, the ultrasonic inspection can be considered an effective method of checking the common defects and damages in composites, and its development of studying and application is introduced by Li Zhijun [5].

G. S. Park et al [6] describes the design method of a magnetic system to maximize the magnetic flux leakage (MFL) in a non-destructive testing (NDT) system. The defect signals in a MFL type NDT system mainly depend on the change of the magnetic leakage flux in the region of a defect.

The basis of the wave propagation and the principles of the hyperbolic triangulation are presented by P. Tschelisnig [7]. The state-of-the-art AE inspection system is explained with examples drawn from the TUV Vienna's 32-channel equipment and software. The AE tests performed at TUV Vienna and the results gained are discussed under the headings of integrity analysis and leakage tests.

Non-destructive testing provides the ability to differentiate different structures of materials or to measure internal and induced stresses, thus providing data for the calculation of reliability and potential lifetime [8]. Here, a closer monitoring of fast processes like crack propagation, especially under an impact load, may provide a better understanding of materials behaviour.

In Pulse Echo Ultrasonic testing piezoelectric transducers generate ultrasonic pulses, which are transmitted into the specimen to check for cracks and other defects [9]. Flaws in the specimen will reflect the signals back to be detected by the transducers. The amplitude and size of reflected pulses indicate the size and location of the flaw. Ultrasonics is limited in its capability to characterise near surface defects because of the interference between transmitted and received pulses in this area.

A new non-destructive testing (NDT) method for defect detection in concrete structures is presented by K. Mori et al [10]. The method is based on the dynamic response of flawed concrete structures subjected to impact loading. Conversely to similar NDT techniques, such as the impact-echo method, the present method uses non-contacting devices for both impact generation (a shock tube producing shock waves) and response monitoring (laser vibrometers measuring concrete surface velocity). According to the experimental and numerical results, it appears that the present method enables an effective detection of defects, particularly in the range of shallow defects.

The use of infrared thermography in the architectural restoration field is examined by Giovanni M. Carlomagnoet al [11]. Three samples, made of a support of marble, brick, or tuff, covered with a layer of plaster with inclusions to simulate detachments or cracks in frescoes, are considered. Different techniques: pulse thermography, lateral heating thermography, lock-in or modulated thermography and pulse phase thermography are employed to detect the flaws artificially created.

M.R Clark et al[12] shows that even with the low ambient temperatures experienced in Europe it is possible to use infrared thermography to identify correctly known areas of delamination in a concrete bridge structure and also to investigate the internal structure of a masonry bridge.

M.D. Beard et al [13] are aimed at the development of a portable non-destructive testing instrument for evaluating the condition of rock bolts. In applications such as coal mine roof reinforcement, the opportunities for rock bolt inspection are currently limited to destructive techniques such as the pull-out test.

Spectral Analysis of surface waves (SASW) in concrete structures consists of the generation, measurement and processing of dispersive surface waves [14]. In SASW test, the surface of the media under consideration is subject to an impact using, for example, a 12-mm steel ball, to generate surface wave energy at various frequencies. Two vertical accelerometer receivers detect the energy transmitted through the testing media.

The optimum elements of the suitably defined matrices of the magnetic variables, based on the measurement of families of minor hysteresis loops, are more sensitive than any of the traditional parameters obtained from the saturation-to-saturation loop [15]. In order to get the optimum elements, the samples do not have to be measured up to their saturation value, but to a pre-determined lower magnetization value only.

The development of non-destructive techniques (NDT) techniques for the in-service inspection of railroad wheels and gauge corners was the main activity of the NDT division. Firstly the inspection of the wheels rim and disk should be carried out without dismantling the wheels and using ultrasonic techniques [16]. On the other hand, the inspection of the railroad track surface at a train speed of about 70 km/h should be guaranteed using eddy current techniques.

Thermal non-destructive testing (NDT) is commonly used for assessing aircraft composites. In this work, certain applications of transient thermal NDT relating to the assessment of aircraft composites are presented by N.P. Avdelid et al [17]. Real-time monitoring of all features was obtained using pulsed thermography. However, in the composite repairs cases thermal modelling and pulsed-phase thermography were also used with the intention of providing supplementary results.

Pulsed eddy current techniques, which are believed to be potentially rich of information, are also sensitive to the effect. Gui Yun Tian et al[18] gives an approach using normalisation and two reference signals to reduce the lift-off problem with pulsed eddy current techniques is proposed. The technique can also be applied for measurement of metal thickness beneath non-conductive coatings, microstructure, strain/stress measurement, where the output is sensitive to the lift-off effect.

C. Hakan Gur et al. [19] investigate the effect of quenching and tempering on sound velocity of steels, and to contribute to the non destructive control and optimisation of the quenching/tempering systems. Microstructures of the samples were characterised by metallographic examinations and hardness measurements. The reference values were obtained for as-quenched and tempered structures by measuring sound velocities for both longitudinal and transversal waves.

Impulse-thermography is well suited for the detection of voids and honeycombing in concrete up to concrete covers of 10 cm and more [20]. For quantitative analysis, a computer program for numerical simulation of the heating up and cooling down processes was developed based on Finite Differences. With this program parameter studies have been performed for investigating the influence of environmental conditions, material parameters and geometry on the thermal behaviour.

Yi-mei Mao et al [21] gives a detection technique for locating and determining the extent of defects and cracks in oil pipelines based on Hilbert-Huang time-frequency analysis is proposed. The ultrasonic signals reflected from defect-free pipelines and from pipelines with defects were processed using Hilbert-Huang transform, a recently developed signal processing technique based on direct extraction of the energy associated with the intrinsic time scales in the signal.

A non-destructive method is described by Gary S. Schajer et al [22] to estimate fibber (grain) direction, moisture density, and dry density of an orthotropic material such as wood, from measurements of the complex attenuation of microwaves transmitted through the material. The complex attenuation in an orthotropic material has a tensor character, similar to other tensor quantities such as stress and strain.

Allen G. Davis et al [23] describes the use of non-destructive testing to examine the efficiency of tunnel lining grouting programmes, with particular emphasis on results obtained by the impulse response and impulse radar methods.

K. Kosmas et al [24] presents a laboratory developed Hall sensor for non-destructive testing of ferromagnetic surfaces, based on magnetic anomaly detection phenomena. The principle of operation is based on the detection of the magnetic flux leakage in the dimensional boundaries of a gap.

Bruce W. et al [25] bring together the most relevant published work on arrays for non-destructive evaluation applications, comment on the state-of the art and discuss future directions. There is also a significant body of published literature referring to use of arrays in the medical and sonar fields and the most relevant papers from these related areas are also reviewed.

Impulse-thermography is an active method for quantitative investigations of the near surface region of various structures [26]. It has recently been applied and optimised to applications in civil engineering. By using either an internal or external heat source, parts of the structure under investigation are heated up and the transient heat flux is observed by recording the temperature change at the surface as a function of time.

Carosena Meola et al [27] study was focused on the aid provided by lock-in thermography for non-destructive evaluation of aerospace materials and structures. The experimental analysis was performed by testing several specimens, which were made of different materials employed in the fabrication of aircraft (composites, hybrid composites, sandwiches, metals) and which included the most commonly encountered kinds of damage (delamination, impact damage, fatigue failure).

Christoph Kohl et al [28] present the results of measurements carried out in the laboratory at BAM and on-site at several bridges using reconstructed and fused radar and ultrasonic echo data sets. In this context different scanning systems, developed for the on-site application of NDT-methods (e.g. reinforced concrete bridges) are introduced.

The diagnosis based on the propagation of guided ultrasonic waves along the pipes offers an attractive solution for the fault identification and classification. Francesca Cau et al [29] studied this problem by means of suitable Artificial Neural Network models. Numerical techniques have been used to simulate the guided wave propagation in the pipes. In particular, the finite element method has been used to model different kinds of pipes and faults, and to obtain several returning echoes containing the faults information.

In the first project material degradation due to thermal aging is investigated, in the second project neutron exposed specimens from national surveillance programmes of nuclear power plant (NPP) pressure vessels were characterised in the hot cell of the research reactor in Patten [30]. Fatigue specimens especially prepared in LCF tests were measured by electromagnetic and micro-magnetic non-destructive testing and evaluation techniques.

The steel cord rubber belt is one of the most important parts of a conveyor. The durability of the belt depends mainly on the steel cord durability. When a conveyer belt is in use the ropes of the cord can be broken or corroded [31]. Rope splice damage is also possible. A scanner with set of eddy current probes installed at the belt under the test surface is significantly lighter than a magnetic one and can work in the gap up to 10-20 mm between the probes and the belt.

D. Bracun et al [32] presents a laser-based method for three-dimensional (3D) measurements of the shape of an electrode indentation. The method is based on the illumination of the indentation with structured light and the detection of the image of the illuminated indentation by means of a digital camera. Image processing algorithms are employed to determine the 3D shape of the indentation.

Janez Marko Slabe et al[33] treats the results obtained in simultaneous measurements of Acoustic Emission (AE) with PZT AE sensors and of deformations with resistance measuring rosettes carried out during and immediately after laser cutting-out of a deep-drawn sheet product, i.e., mudguard. It was found that the main source of AE during laser cutting was the cutting gas jet.

In ultrasonic non-destructive testing it is very difficult to detect flaws in materials with coarse-grain structure. The ultrasonic signals measured on these materials contain echoes which are very similar to fault echoes. These echoes arise from grains which are contained in the material. For the detection of flaws various methods for suppressing echoes from grains have to be used. Vaclav Matz et al [34 used the method for filtering ultrasonic signals based on discrete wavelet transform. For the classification of ultrasonic signals in A-scan we used a pattern recognition method called support vector machines. In this study we classify signals with fault echoes, echo from weld and back-wall echo. Ultrasonic signals were measured on materials used for constructing aeroplane engines.

Defects need to be banned and dimensional measurement of complex geometries with high resolution is required. In addition, throughput is high and production cycles may last only a few seconds. These objectives call for non-destructive testing that keeps step with the production cycle [35]. Production and quality measurement techniques therefore play an important role in providing customers with more economical and reliable products. We briefly compare various NDT techniques and demonstrate the feasibility of X-ray tomography as a technique suitable for the dimensional measurement of complex structures with sub-μm resolution.

Dye Penetrant Inspection (DPI) and Magnetic Particles Inspection (MPI) are two of the most commonly used NDT techniques in industry. Both techniques do rely heavily on human judgment and visual capability to identify any faults or defects on the specimen at the end of the process. Despite the fact that human plays an important role on the reliability of the NDT test results, very little research work has been carried out to study the ergonomics and human factors in using these NDT methods. Several human factors which could affect the reliability of the tests are discussed and some recommendations are also provided to improve the tests [36].

The designed software can be used to calculate mechanical and physical properties of an unknown sample if the chemical composition and hardness value of that sample is available, where the effect of every element in the unknown sample on its mechanical and physical properties can be deduced from the comparison between the data of the same element in the standard samples [37]. In this work, tensile strength, elongation, and microscopic structure of 15 standard steel samples of low and medium carbon steel were determined by using destructive testing methods.

Non-destructive testing (NDT) was carried out using ultrasonic pulse velocity (UPV) and impact rebound hammer (IRH) techniques to establish a correlation with the compressive strengths of compression tests. The resulting correlation curve for each test is obtained by changing the level of compaction, water/cement ratio and concrete age of specimens. The resulting calibration curves for strength estimation were compared with others from previous published literature [38].

Satellite nozzles are manufactured from C/SiC, using the Liquid Polymer Infiltration (LPI) process. In this article the applicability of different non-destructive analysis methods for the characterisation of C/SiC components will be discussed [39]. Synchrotron radiation using tomography on small samples with a resolution of 1.4 μm, i.e. the fibre scale, was used to characterise three dimensionally fibre orientation and integrity, matrix homogeneity and dimensions and distributions of micro pores.

E. Bayraktar et al [40] gives a comparative study on the new developments in non-destructive controls of the composite materials and applications in the manufacturing engineering and also reviews essentially the performance and advantages of X-rays computed tomography (XR-CT) medical scanner about its usage at multiple scales (macro, micro, meso and nano), the method and also the terminology.

Rodrigo Benenson et al [41] address the problem of autonomous navigation of a car-like robot evolving in an urban environment. Such an environment exhibits a heterogeneous geometry and is cluttered with moving obstacles.

An approach for the analysis of gamma ray incoherent scattering on free and binding electrons is presented for Non destructive Testing (NDT) [42]. The method is based on computational simulation and backscattering gamma ray measurements for carbon steel walls. The results of thickness measurements for steel walls are described by the theory of the energy transfer model.

Lattice defects and microstructure in homogeneities like vacancies, dissolved atoms dislocations and precipitations are normally not discussed as defects but they are influence parameters which mainly predict the macroscopic properties, the physical properties as well as the mechanical ones[43]. In order to keep these properties constant in materials production more and more material characterization by NDT is integrated in the production processes.

The current dynamic process in computing, microelectronics, smart sensors and automation provide NDT system engineers with challenging opportunities for improved NDT solutions. Peter Bieder et al [44] focus on the quantification of inspection results with respect to flaw type, flaw location and flaw size, at high inspection speeds.

U.C. Hasar et al [45] shows microwave reflection and transmission properties measured from various sides of hardened mortar and concrete specimens with different water to cement ratios. These properties are important in predicting/measuring accurate electrical properties of cement-based materials which can eventually be utilized in structural health monitoring, public safety, and propagation-related research.

Pulsed thermography, an infrared non-destructive evaluation (NDE) technique, is proposed by M. Genest et al [46] for the detection of disbond and monitoring of disbond growth in bonded graphite repairs. Correlated results with ultrasonic pulse echo c-scan inspections and destructive testing show good disbond detection capability with accuracy similar to that of ultrasonic inspection.

Zoltán Orbán et al [47] present methods of inspection and testing for masonry arch railway bridges. An overview of a selection of available non-destructive, minor-destructive and monitoring methods is given and their efficacy for the assessment of masonry arch bridges is discussed.

S. Chaki et al [48] deals with a guided ultrasonic wave procedure for monitoring the stress levels in seven-wire steel strands (15.7 mm in diameter). The mechanical and geometrical characteristics of the prestressed strands were taken into account for optimizing the measurement configuration and then the choice of the guided ultrasonic mode at a suitable frequency.

A.A. Shah et al [49] present findings on nonlinear ultrasonic testing of concrete. The study was focused on testing cubic concrete specimens. It consisted of the non-destructive evaluation of concrete cubes using nonlinear ultrasonic technique with different frequency transducers. The transducer used at the wave-transmitting end had a broadband frequency of 100 kHz.

Ahmed Haddad et al [50] examine the applicability of eddy current techniques in-process for monitoring of powder density particle size and the time necessary to structure variation. An eddy current based monitoring system developed to measure metal powder density is expanded for monitoring metal powder diameter in metal compounds.

The assessment of creep damage in steels employed in the power generation industry is usually carried out by means of replica metallography, but the several shortcomings of this method have prompted a search for alternative or complementary non-destructive techniques, ranging from ultrasonic to electromagnetic methods, hardness measurements and nuclear techniques. A critical review [51] of the main results obtained to date in the secondary and tertiary stages of creep is presented in this paper, and the advantages and disadvantages of each method are discussed.

Pulsed eddy current (PEC) testing is a new emerging and effective electromagnetic non-destructive testing (NDT) technique. The main purpose [52] of this study is to identify surface defects and sub-surface defects using features-based rectangular pulsed eddy current sensor. The further study of PEC rectangular sensor proposed in author's previous work has been made to classify the different types of defects in specimen. In different directions of sensor scanning, peak waves of pick-up coil are studied.

Maryam Sargolzahi et al [53] deal with the application of various test methods for monitoring the progression of alkali–silica reaction (ASR) in laboratory concrete mixtures. The effectiveness of each method is reported. Mechanical properties were assessed with conventional destructive test and with non-destructive tests (ultrasonic pulse velocity, dynamic modulus of elasticity and nonlinear acoustics). Petrographic examination was performed to confirm damage associated with ASR.

The purpose of this study is non-destructive determination of residual stresses in the welded steel plates by Magnetic Barkhausen Noise (MBN) technique

[54]. A MBN-stress calibration set-up and a residual stress measurement system with scanning ability were developed. To control the accuracy and the effectiveness of the developed system and procedure, various MBN measurements were carried out. The MBN results were verified by the hole-drilling method. Microstructural investigation and hardness measurements were also conducted.

J. HOŁA et al [55] presents a survey of state-of-the-art non-destructive diagnostic techniques of testing building structures and examples of their applications. Much attention is devoted to acoustic techniques since they have been greatly developed in recent years and there is a clear trend towards acquiring information on a tested element or structure from acoustic signals processed by proper software using complex data analysis algorithms.

Highly automated processes ensure high quality on a constant level, if it is connected with a high degree of (automated) monitoring and control. Meanwhile, continuous process and quality monitoring by non-destructive testing (NDT) [56] is an accepted procedure to early diagnosis of irregular process conditions, followed by an NDT-based feedback control and optimization. Consequently, the development of process integrated NDT is an important scientific task.

Yong-Kai Zhu et al [57] provides a review of the main optical NDT technologies, including fibre optics, electronic speckle, infrared thermography, endoscopic and terahertz technology. Among them, fibre optics features easy integration and embedding, electronic speckle focuses on whole-field high precision detection, infrared thermography has unique advantages for tests of combined materials, endoscopic technology provides images of the internal surface of the object directly, and terahertz technology opens a new direction of internal NDT because of its excellent penetration capability to most of non-metallic materials.

Surface defects in metals are not necessarily confined to orientations normal to the sample surface; however, much of the previous work investigating the interaction of ultrasonic surface waves with surface-breaking defects has assumed cracks inclined at 90° to the surface. B. Dutton et al [58] explores the interaction of Rayleigh waves with cracks which have a wide range of angles and depths relative to the surface, using a non-contact laser generation and detection system. Additional insight is acquired using 3D model generated using finite element method software.

Javier Garcia Martin et al [59] gives an overview of the fundamentals and main variables of eddy current testing. It also describes the state-of-the-art sensors and modern techniques such as multi-frequency and pulsed systems. Recent advances in complex models towards solving crack-sensor interaction, developments in instrumentation due to advances in electronic devices, and the evolution of data processing suggest that eddy current testing systems will be increasingly used in the future.

Cast irons look like 'composites' made of a steel matrix and graphite filler. The standard description of matrix and graphite structure properties, e.g., after EN 945 is not satisfactory. Physical description of its structure can be better carried out using rigidity and hardness of matrix [60]. The expression of this description in a plane using bi-dimensional vector of tension strength or yield strength offers new useful relations to manufacturing metallurgy.

Vijay R. Rathod et al [61] proposed research experimentation has been established in Central Foundry Forge Plant (CFFP) of Bharat Heavy Electrical Ltd. India (BHEL). The proposed image segmentation techniques are introduced to detect and assess the weld flaws from the weldments and calculate the features such as length, width, area, perimeter, major axis length, minor axis length, orientation and resolution. Software has fully written in Mat lab.

A novel ultrasonic non-destructive technique (NDT) based on application of a transmission tomography of guided ultrasonic waves is proposed for floor inspection of large storage tanks and detection of non-uniformities, such as corrosion [62]. The technique needs access only to the outer edge of the tank floor and does not require emptying the tank. Estimation of the attenuation of different wave modes propagating in steel plates and determination of the losses in the lap welds showed that most suitable is S0 Lamb wave mode which possesses smallest losses and consequently enables investigation of tank floors up to average diameter 20-30 m.

Antonio J. Salazar et al [64] reports the influence of surface roughness on the characterisation, through the use of ultrasonic signals, of AISI-SAE 4340 steel samples. The samples were prepared with varying surface roughnesses, applied through mechanical methods and measured using a Mitutoyo Surfest-211. A normal incidence direct contact pulse-echo method was applied, using transducers of 5, 7.5 and 10 MHz, all with a 0.375 inch diameter.

Sharad Shrivastava et al [65] deals with the existing research gap in medical field by the application of non-destructive testing technique. They give a general idea about the various non-destructive testing techniques used in biomedical field. It also covers the disadvantages of various techniques and how these disadvantages can be taken care by Acoustic emission and Acousto–ultrasonic technique

Christian Garnier et al [66] evaluate the efficiency of these NDT methods in the detection of in site defects resulting from Barely Visible Impact Damages (BVID) or in-service damages to complex surfaces such as wings or rods. The size and position of all the defects were determined by GVI (General Visual Inspection). The evaluation of the three NDT techniques enabled conclusions to be drawn regarding defect detection and size.

NDT techniques that provide surface and internal information of the blade are necessary. I. Amenabar et al [67] inspect the detection capabilities and performance of ultrasonic, shearography, thermography and X-ray CT techniques for the inspection of wind turbine blades with delamination defects have been analyzed.

F. Van den Abeele et al [68] gives the philosophy of risk based inspection is introduced and recent advances in non destructive testing (in particular ultrasonic and electromagnetic techniques) are reviewed. Then, the use of fracture mechanics based damage models is demonstrated to predict fatigue failure for offshore structures.

The capability of the new approach of AE acquisition in discriminating between different loading and damage states is shown and discussed by T.H. Loutas et al [69]. Interesting findings on the effect of the oil temperature upon AE recordings only speculated theoretically so far are also presented. Both methods yielded interesting results and showed an ability to distinguish between healthy and defected gears.

Bo Li et al [70] study focused on the relationship between primary friction stir welding process parameters and varied types of weld-defect discovered in aluminium 2219-T6 friction stir butt-welds of thick plates, meanwhile, the weld-defect forming mechanisms were investigated. Besides a series of optical metallographic examinations for friction stir butt welds, multiple non-destructive testing methods including X-ray detection, ultrasonic C-scan testing, ultrasonic phased array inspection and fluorescent penetrating fluid inspection were successfully used aiming to examine the shapes and existence locations of different weld-defects.

A. Lopes Ribeiro et al [71] show that a simple algorithm used to model the eddy current inspection of an aluminium plate can be used to preview the acquired voltage signals. Thus, the algorithm is suitable to work as a forward problem solver to determine the expected measurement signal obtained with a uniform excitation field probe including a giant magneto resistor sensor. The algorithm is based on a conformal transformation and is able to preview the shape of the electrical current lines when a metallic plate with a superficial straight crack is subject to a sinusoidal excitation field with constant amplitude and orientation in a bounded zone around the sensor element.

Umesh Singh et al [72] reviews magnetic particle crack detection (MPCD) in terms of principle, advantages, disadvantages and limitations. Different mine gear components are evaluated through MPCD technique and results are analyzed in terms of their suitability by applying acceptance/rejection norms followed by the mining industry in India. MPCD is now a widely acceptable technique in the world and has simplified inspection processes, leading to significant cost reductions and quality control enhancement and confidence.

Rodrigo Velázquez Castillo et al [73] analyze the relevance of Non Destructive Technique (NDT) thermal infrared imaging (TIRI) as a way of reference to the heritage conservation. The assessment of thermography testing was done in order to evaluate the correspondence concerning the physical and chemical characterization and compatibility among original and restored plastered mortars and stuccos, considering the correlation between thermal emissivity values and other well-known materials characterization methods such as Fourier Transform Infrared (FTIR), X-ray diffraction (XRD).

Bo Hu et al [74] propose a non-destructive testing method for thin-plate aluminium alloys based on the geomagnetic field. A high-precision magnetic sensor was used to measure slight changes in the magnetic field strength. The relative permeability of aluminium alloys was proven to be greater than that of aluminium through the magnetization of aluminium alloy materials. Therefore, aluminium and its alloys are paramagnetic materials. The aims of the current study are to analyze the effect of magnetic field on defects and to determine the test mechanism based on the differences in relative permeability.

The inspection of voids in external PT tendons is important and necessary in order to protect strands before corrosion occurs. Based on literature review [75], several Non Destructive Testing (NDT) methods are compared for effectiveness of identifying voids in external PT tendons, and the Impact Echo (IE), ultrasonic, and sounding inspection methods are then selected and assessed using small-scale and mock-up specimens.

A variety of NDT tests were targeted at different parts of the bridge elements, and have been conducted as part of a major investigation into the bridges [76]. The NDT tests performed included; Magnetic Flux Leakage Tests and Radiographic Tests at hanger sockets and Dye Penetrant Testing / Magnetic Particle Testing of the welding, non destructive testing on the concrete parts in anchorage rooms comprised of Schmidt Hammer Tests and Carbonation Depth Tests of concrete.

I. Afara et al [76] evaluates the viability of near infrared (NIR) spectroscopy, an EM method for rapid non-destructive evaluation of articular cartilage. Intact, visually normal cartilage-on-bone plugs from 2-3yr old bovine patellae were exposed to NIR light from a diffuse reflectance fibre-optic probe and tested mechanically to obtain their thickness, stress, and stiffness.

A recently developed frequency-modulated thermal wave imaging (FMTWI) has been applied for subsurface defect detection of jute fibre-reinforced

Global Journal of Researches in Engineering (J) Volume XIII Issue III Version I Year 2013

polypropylene (PP) matrix composite [77]. Composites are subject to manufacturing and in-service defects like voids, delamination, cracks and so on. Active thermography like lock-in thermography (LT) and pulsed thermography (PT) has been widely used for non-destructive testing of composites and laminates.

V. Summary of Literature Survey

The summery researches done by experts in the area of NDT have been presented in Table1 which Carries the Author name, year and investigated problem types.

Table 1 : Summary of the developments in NDT on literature survey.

Sr. no.	Author Name (Year)	Investigated Problem Type
1	Bates, D. and Smith, G et al (2000)	Rapid thermal non-destructive testing of aircraft components
2	D.J. Titman et al. (2001)	Applications of thermography in non-destructive testing of structures
3	P Cawley (2001)	NDT current capabilities and future directions.
4	Jacek Jarmulak et al (2001)	Case-based reasoning for interpretation of data from NDT.
5	Li Zhijun (2001)	Non-Destructive Testing of Advanced Composites.
6	G. S. Park et al. (2001)	Optimum Design of a NDT System to Maximize Magnetic Flux Leakage.
7	P. Tschelisnig (2001)	Acoustic emission testing (AET) – an integral NDT method.
8	H. A. Crostack, W. Reimers (2001)	Evaluation of component integrity by non-destructive testing
9	Zahran, 0. S., Shihab, S. et al (2002)	Recent Developments in Ultrasonic Techniques for Rail-track Inspection.
10	K Mori, A Spagnoli et al (2002)	A non contacting NDT method for defect detection in concrete
11	Carosena Meola et al (2002)	Comparison between thermographic techniques
12	M.R Clark, D.M McCann, et al (2003)	Application of infrared thermography to the NDT of concrete and masonry bridges
13	M.D. Beard, M.J.S. Lowe et al. (2003)	NDT of rock bolts using guided ultrasonic waves
14	Young S. Cho, (2003)	NDT of high strength concrete using spectral analysis of surface waves
15	I. Tomaš (2004)	Non-destructive magnetic adaptive testing of ferromagnetic materials
16	Rainer Pohl , A Erhard et al. (2004)	NDT techniques for railroad wheel and gauge corner inspection
17	N.P. Avdelidis. et al. (2004)	Aircraft composites assessment by means of transient thermal NDT
18	Gui Yun Tian et al. (2005)	Reduction of lift-off effects for pulsed eddy current NDT
19	C. Hakan Gur et al. (2005)	Non destructive investigation of the effect of quenching and tempering on medium carbon low alloy steels
20	Ch. Maierhofer et al. (2005)	Impulse thermography as NDT method in civil engineering
21	Yi-mei Mao et al. (2005)	Application of Hilbert Huang signal processing to ultrasonic NDT of oil pipelines
22	Gary S. Schajer et al. (2005)	Microwave NDT of Wood and Similar Orthotropic Materials
23	Allen G. Davis et al. (2005)	Rapid and economical evaluation of concrete tunnel linings with impulse response and impulse radar NDT
24	K. Kosmas et al. (2005)	Non destructive evaluation of magnetic metallic materials using Hall sensors
25	Bruce W et al (2006)	Ultrasonic arrays for non-destructive evaluation
26	Ch. Maierhofer, R. Arndt et al (2006)	NDT Application of impulse thermography for non-destructive assessment of concrete structures
27	Carosena Meola et al (2006)	Non-destructive evaluation of aerospace materials with lock-in thermography
28	Christoph Kohl et al. (2006)	Results of reconstructed and fused NDT data measured in the laboratory and on site at bridges
29	Francesca Cau et al. (2006)	A signal processing tool for NDT of inaccessible pipes
30	Gerd Dobmann (2006)	NDE for material characterisation of ageing due to thermal embrittlement, fatigue and neutron degradation

31	V. Sukhorukov (2006)	Steel cord conveyor belt NDT
32	D. Bracun et al (2006)	Indentation shape parameters as indicators of spot weld quality
33	Janez Marko Slabe et al (2006)	Measurement of acoustic emission and deformations in laser cutting of deep drawn sheet parts
34	Vaclav Matz et al (2006)	Classification of ultrasonic signals
35	Ralf B. Bergmann et al (2007)	Non-Destructive Testing in the Automotive Supply Industry
36	B. L. Luk et al (2007)	Human Factors and Ergonomics in Dye Penetrant and Magnetic Particles
37	Sayed H. El-Nekhaly (2007)	Electrochemical NDT for deducing physical and mechanical properties of steels.
38	Brian Hobbs et al (2007)	NDT for the forensic engineering investigation of reinforced concrete buildings
39	J. Rebelo Kornmeie et al (2007)	NDT of satellite nozzles made of carbon fibre ceramic matrix composite
40	E. Bayraktar et al. (2008)	New developments in non-destructive controls of the composite materials and applications in manufacturing engineering
41	Rodrigo Benenson et al (2008)	Towards urban driverless vehicles
42	Tran Dai Nghiep et al (2008)	Analysis of gamma ray incoherent scattering for NDT
43	Gerd Dobmann et al (2008)	Materials characterization a challenge in NDT for quality management
44	Peter Bieder et al (2008)	Current NDT Research & Development for NPP Inspections
45	U.C. Hasar (2009)	NDT of hardened cement specimens at microwave frequencies using a simple free-space method
46	M. Genest et al. (2009)	Pulsed thermography for non-destructive evaluation and damage growth monitoring of bonded repairs
47	Zoltán Orbán et al. (2009)	Assessment of masonry arch railway bridges using NDT
48	S. Chaki et al. (2009)	Guided ultrasonic waves for non-destructive monitoring of the stress levels in prestressed steel strands
49	A.A. Shah et al. (2009)	Non destructive evaluation of concrete in damaged and undamaged states.
50	Ahmed Haddad et al (2010)	Monitoring of metal powder by eddy current
51	G. Sposito et al (2010)	A review of NDT for the detection of creep damage in power plant steels
52	Yunze He et al (2010)	Defect classification based on rectangular pulsed eddy current sensor in different directions
53	Maryam Sargolzahi et al (2010)	Effectiveness of NDT for the evaluation of alkali–silica reaction in concrete
54	H. Ilker Yelbay et al. (2010)	Non-destructive determination of residual stress state in steel weldments by Magnetic Barkhausen Noise technique
55	J. HOŁA et al. (2010)	State-of-the-art non-destructive methods for diagnostic testing of building structures anticipated development trends.
56	Bernd Wolter et al (2011)	NDT Based Process Monitoring and Control
57	Yong-Kai Zhu et al (2011)	A Review of Optical NDT Technologies
58	B. Dutton et al. (2011)	Non-contact ultrasonic detection of angled surface defects
59	Javier Garcia Martin et al (2011)	NDT Based on Eddy Current Testing
60	Bretislav Skrbek et al. (2011)	Quantitative NDT structuroscopy of cast iron castings for vehicles
61	Vijay R. Rathod et al. (2011)	Analysis of radiographical weld flaws using image processing approach
62	Liudas Mazeika et al. (2011)	Ultrasonic guided wave tomography for the inspection of the fuel tanks floor.
63	Antonio J. Salazar et al. (2011)	Studies of the effect of surface roughness in the behaviour of ultrasonic signals in steel: spectral and wavelets analysis

Global Journal of Researches in Engineering (J) Volume XIII Issue III Version I Year 2013

64	Sharad Shrivastava et al. (2011)	Future research directions with Acoustic Emission and Acousto Ultrasonic technique.
65	Christian Garnier et al. (2011)	The detection of aeronautical defects in situ on composite structures using NDT.
66	I. Amenabar et al. (2011)	Comparison and analysis of NDT suitable for delamination inspection in wind turbine blades.
67	F. Van den Abeele et al (2011)	Non destructive testing techniques for risk based inspection
68	T.H. Loutas et al. (2011)	On the application of NDT techniques on rotating machinery
69	Bo Li, Yifu Shen, et al (2011)	The study on defects in aluminium thick butt friction stir welds with the application of multiple non-destructive testing methods
70	A. Lopes Ribeiro et al (2012)	A simple forward direct problem solver for eddy current NDI of aluminium plates using uniform field probes
71	Umesh Singh et al. (2012)	Analysis study on surface and sub surface imperfections through magnetic particle crack detection for nonlinear dynamic model of some mining components
72	Rodrigo Velázquez Castillo et al. (2012)	Thermal Imaging as a NDT Implemented in Heritage Conservation.
73	Bo Hu et al (2012)	Magnetic NDT method for thin-plate aluminium alloys
74	Seok Been Im et al. (2012)	NDT Methods to Identify Voids in External Post Tensioned Tendons
75	Y. Dost et al. (2013)	Non-Destructive Testing of Bosphorus Bridges
76	I. Afara et al. (2013)	Near Infrared for Non-Destructive Testing of Articular Cartilage
77	D. Banerjee et al. (2013)	Non-destructive testing of jute–polypropylene composite using frequency-modulated thermal wave imaging

VI. Discussion

- The ultrasonic inspection can be considered an effective method of checking the common defects and damages in composites.
- AET as a NDT tool will make an important contribution to increased security for pressure vessels and better protection against environmental pollution.
- Pulse thermography is easy and fast to use for information about the state of the art treasures, but data may be affected by non-uniform heating and local variation of thermal emission.
- NDT is essential in the inspection of alteration, repair and new construction in construction industry and Spectral analysis of surface waves (SASW) in concrete structures is widely used.
- In the composite repairs cases thermal modelling and pulsed-phase thermography were also used, whilst in the case of through skin imaging thermal modelling was also used in order to demonstrate the importance of thermal contact resistance between two surfaces (skin and strut).
- Lock in Thermography is a more powerful technique to detect impact damage and that transient thermography is more suitable for detecting inclusions.
- A detection technique for locating and determining the extent of defects and cracks in oil pipelines based on Hilbert-Huang time-frequency analysis is proposed.
- The use of NDT to examine the efficiency of tunnel lining grouting programmes, with particular emphasis obtained by the impulse response and impulse radar methods.
- A new idea of NDT was applied for low and medium carbon steel, and high manganese steel known as Electrochemical Non destructive Testing (ECNDT).
- Gamma ray incoherent scattering on free and binding electrons method is based on computational simulation and back scattering gamma ray measurements for thickness carbon steel walls by the theory of the energy transfer model.
- An eddy current based monitoring system developed to measure metal powder density is expanded for monitoring metal powder diameter in metal compounds.
- Pulsed eddy current (PEC) testing is a new emerging and effective electromagnetic NDT technique, used to identify surface defects and sub-surface defects using features based rectangular pulsed eddy current sensor.
- Eddy current testing is one of the most extensively used non-destructive techniques for inspecting electrically conductive materials at very high speeds that does not require any contact between the test piece and the sensor.

- A novel ultrasonic NDT based on application of a transmission tomography of guided ultrasonic waves is proposed for floor inspection of large storage tanks and detection of non-uniformities like corrosion.
- The diagnosis of artificial defects in a single stage gearbox using two non-destructive techniques (vibration and acoustic emission) and advanced signal processing techniques to discriminate between different load and defect states.
- Magnetic particle crack detection (MPCD) is now a widely acceptable technique in the world and has simplified inspection processes, leading to significant cost reductions and quality control enhancement and confidence.
- A recently developed frequency-modulated thermal wave imaging (FMTWI) has been applied for subsurface defect detection of jute fibre-reinforced polypropylene (PP) matrix composite.

VII. Conclusions

Based on the literature review, it is concluded that the various non destructive techniques have many advantages, but also some disadvantages. Many NDT techniques have the ability to detect and characterize defects in structures made entirely of composite materials. Based on the literature review, it was found that most of the NDT techniques are primarily being used in the aerospace industry, manufacturing industries and have the potential to be used for evaluating civil infrastructures. More research needs to be performed on these techniques to make them applicable for field use for civil infrastructure.

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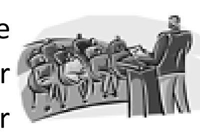

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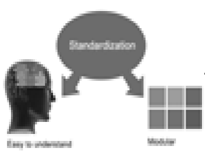

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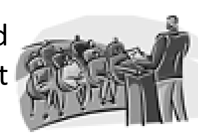

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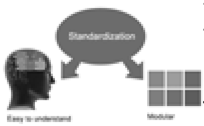

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5.STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.

6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

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The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

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Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

Index

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