ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

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DEPARTMENT OF MECHANICAL ENGINEERING

ME 3592 – METROLOGY AND MEASUREMENTS

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UNIT I BASICS OF METROLOGY

Measurement – Need, Process, Role in quality control; Factors affecting measurement - SWIPE; Errors in Measurements – Types – Control – Measurement uncertainty – Types, Estimation, Problems on Estimation of Uncertainty, Statistical analysis of measurement data, Measurement system analysis, Calibration of measuring instruments, Principle of air gauging- ISO standards.

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1.1 Introduction to Metrology:

Metrology word is derived from two Greek words such as metro which means measurement and logy which means science. Metrology is the science of precision measurement. The engineer can say it is the science of measurement of lengths and angles and all related quantities like width, depth, diameter and straightness with high accuracy. Metrology demands pure knowledge of certain basic mathematical and physical principles. The development of the industry largely depends on the engineering metrology. Metrology is concerned with the establishment, reproduction and conservation and transfer of units of measurements and their standards. Irrespective of the branch of engineering, all engineers should know about various instruments and techniques.

1.1.1 Types of Metrology

a) **Legal Metrology**. 'Legal metrology' is that part of metrology which treats units of measurements, methods of measurements and the measuring instruments, in relation to the technical and legal requirements.

The activities of the service of 'Legal Metrology' are:

(i)Control of measuring instruments;

(ii)Testing of prototypes/models of measuring instruments;

(iii)Examination of a measuring instrument to verify its conformity to the statutory requirements etc.

b) **Dynamic Metrology.** 'Dynamic metrology' is the technique of measuring small variations of a continuous nature. The technique has proved very valuable, and a record of continuous measurement, over a surface, for instance, has obvious advantages over individual Measurements of an isolated character.

c) **Deterministic metrology.** Deterministic metrology is a new philosophy in which part measurement is replaced by process measurement. The new techniques such as 3D error compensation by CNC (Computer Numerical Control) systems and expert systems are applied, leading to fully adaptive control. This technology is used for very high precision manufacturing machinery and control systems to achieve micro technology and nanotechnology accuracies.

1.1.2 Objectives of Metrology

Although the basic objective of a measurement is to provide the required accuracy at a minimum cost, metrology has further objectives in a modern engineering plant with different shapes which are:

1.Complete evaluation of newly developed products.

2.Determination of the process capabilities and ensure that these are Better than the relevant component tolerances.

3.Determination of the measuring instrument capabilities and ensure that they are quite sufficient for their respective measurements.

4.Minimizing the cost of inspection by effective and efficient use of available facilities.

5.Reducing the cost of rejects and rework through application of Statistical Quality Control Techniques.

6.To standardize the measuring methods:

7.To maintain the accuracies of measurement.

8.To prepare designs for all gauges and special inspection fixtures.

1.1.3 Necessity and Importance of Metrology

1.The importance of the science of measurement as a tool for scientific research (by which accurate and reliable information can be obtained) was emphasized by Ga1ileo and Goethe. This is essential for solving almost all technical problems in the field of engineering in general, and in production engineering and experimental design in particular. The design engineer should not only check his design from the point of view of strength or economical production, but he should also keep in mind how the dimensions specified can be checked or measured. Unfortunately, a considerable amount of engineering work is still being executed Without realizing the importance of inspection and quality control for improving the function of product and achieving the economical production.

2. Higher productivity and accuracy is called for by the present manufacturing techniques. This cannot be achieved unless the science of metrology is understood, introduced and applied in industries. Improving the quality of production necessitates proportional improvement of the measuring accuracy, and marking out of components before machining and the in-process.

And post process control of the dimensional and geometrical accuracies of the product. Proper gauges should be designed and used for rapid and effective inspection. Also, automation and Automatic control, which are the modem trends for future developments, are based on measurement. Means for automatic gauging as well as for position and displacement measurement with feedback control have to be provided.

1.1.4 NEED FOR INSPECTION

Industrial inspection has acquired significance in recent times and has a systematic and scientific approach. Prior to the industrial revolution, craftsmen used to assemble the

different parts by hand and, in the process, consumed a lot of time. They were entirely responsible for the quality of their products. Inspection was an integral function of production. Since the industrial revolution, many new manufacturing techniques have been developed to facilitate mass production of components.

In modern manufacturing techniques, a product has to be disintegrated into different components. Manufacture of each of these components is then treated as an independent process.

Inspection is defined as a procedure in which a part or product characteristic, such as a dimension, is examined to determine whether it conforms to the design specification. Industrial inspection has become a very important aspect of quality control.

Inspection essentially encompasses the following:

1. Ascertain that the part, material, or component conforms to the established or desired standard.

2. Accomplish interchangeability of manufacture.

3. Sustain customer goodwill by ensuring that no defective product reaches the customers.

4. Provide the means of finding out inadequacies in manufacture. The results of inspection are recorded and reported to the manufacturing department for further action to ensure production of acceptable parts and reduction in scrap.

5.Purchase good-quality raw materials, tools, and equipment that govern the quality of the finished products.

6. Coordinate the functions of quality control, production, purchasing, and other department of the organizations.

7. Take the decision to perform rework on defective parts, that is, to assess the possibility of making some of these parts acceptable after minor repairs.

8. Promote the spirit of competition, which leads to the manufacture of quality products in bulk by eliminating bottlenecks and adopting better production techniques.

1.2 Methods of Measurement:

1) **Method of direct measurement**: The value of the quantity to be measured is obtained directly without the necessity of carrying out supplementary calculations based on a functional dependence of the quantity to be measured in relation to the quantities actually measured.

Example: Weight of a substance is measured directly using a physical balance.

2) **Method of indirect measurement**: The value of the quantity is obtained from measurements carried out by direct method of measurement of other quantities, connected with the quantity to be measured by a known relationship. *Example:* Weight of a substance is measured by measuring the length, breadth & height of the substance directly and then by using the relation

Weight = Length x Breadth x Height x Density

3) **Method of measurement without contact**: The sensor is not placed in contact with the object whose characteristics are being measured.

4) **Method of combination measurement closed series**: The results of direct or indirect measurement or different combinations of those values are made use of & the corresponding system of equations is solved.

5) **Method of fundamental measurement**: Based on the measurements of base quantities entering into the definition of the quantity.

6) **Method of measurement by comparison**: Based on the comparison of the value of a quantity to be measured with a known value of the same quantity (direct comparison), or a known value of another quantity which is a function of the quantity to be measured (indirect comparison).

7) **Method of measurement by substitution**: The value of a quantity to be measured is replaced by a known value of the same quantity, so selected that the effects produced in the indicating device by these two values are the same (a type of direct comparison).

8) **Method of measurement by transposition:** The value of the quantity to be measured is in the beginning, balanced by a first known value A of the same quantity, then the value of the quantity to be measured is put in place of this known value and is again balanced by another known value B. If the position of the element indicating equilibrium is the same in both the cases, the value of the quantity measured is equal to A & B.

9) **Method of differential measurement**: Based on the comparison of the quantity to be measured with a quantity of the same kind, with a value known to be slightly difference from that of the quantity to be measured, and the measurement of the difference between the values of these two quantities.

10) **Method of measurement by complement**: The value of the quantity to be measured