측정 및 시험시스템(M&TS)
(Measurement and Testing System)

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Abstract

This paper has briefly explained the various measurement and testing system which is an important component of modern quality and process improvement activities. This paper deals with precision and force measurement , NDT, and MSA.

Keywords: Measurement, Testing, MSA

1. Introduction

1.1 Precision Measurement : Direct, Comparative, Limit Measurement

1.2 Nondestructive Testing(NDT): Electromagnetic, Image Generation, Optical,Radiation,Thermal,Ultrasonic Technique

1.3 Force Measurement: Hardness, Tensile, Compressive, Impact, Fatigue, Creep Test

1.4Measurement System Analysis(MSA): Bias(Accuracy, Offer), Linearit, Stability(Drift), Precision, Gage R&R

2. Precision Measurement [1, 3]

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Type of Gage	Accuracy	Application
Adjustable snap gages	Usually accurate within 10% of the tolerance.	Measures diameters on a production basis where an exact measurement is needed
Air gages	Accuacy depends supon the design. Measurements of less than 50 millionths of an inch are possible.	Primary application is measuring the diameter of a bore or hole. However, numerous other measurements are possible.
Automatic sorting gages	Accurate within 0.0001 inch.	Used to sort parts by dimension
Combination square	Accurate within one degree.	Used to make angular checks.
Coordinate measuring machines	Accuracy depends upon the part. Axis accuracies are within 35 millionths and T.I.R. within 5 millionths of an inch.	Can be used to measure a variety of characteristics, such as contour, taper, radii, roundness, squareness, etc.
Dial bore gages	Accurate within 0.0001 inch, using great care.	Used to measure bore diameters and out-of-roundness or taper within a bore
Dial indicator	Accuracy depends upon the type of indicator used. Some measure within 0.0001 inch	Measures a variety applications such as: flatness, taper, concentricity, diameter, height, etc.
Electronic comparator	Accurate from 0.00001 inch to 0.000001 inch.	Used for applications where the allowable tolerance is 0.0001 inch or less.
Fixed snap gages	No set accuracy: determines if the part is in or out of specification.	Normally used to determine if diameters are within specification.
Flush pin gages	Accuracy of about 0.002 inch	Can check most

		charateristics, but used for high volume single purpose applications.
Gage blocks	Accuracy of the gage block gage depends upon the grade used. Normally the accuracy is 0.000008 inch or better.	Gages blocks are best adapted for precision machining and as a comparison master.
Height verniers	Mechanical models measure to 0.0001 inch. Some digital models attain 0.00005 inch.	Used to check dimensional tolerances on a surface plate.
Inrernal and external thread gages	No exact reading. Will discriminate to a given specification limit.	Used for measuring inside and outside pitch thread diameters.
Micrometer (inside)	Mechanical accuracy is about 0.001 inch. Some digital models are accurate to 0.00005 inch.	Used for checking large hole diameters.
Micrometer (outside)	Mechanical accuracy is about 0.001 inch. Some digital models are accurate to 0.00005 inch.	Normally used to check diameter or thickness. Special models can check thread diameters.
Optical comparator	The accuracy can be within 0.0002 inch.	Used for measuring difficult contours and part configurations.
Optical flat	Accurate to within a few millionths of an inch, depending on operator skill.	Used only for very precise tool room work. Best used for checking flatness.
Plug gages	Accuracy very good for checking the largest or smallest hole diameter.	Checking the diameter of drilled or reamed holes. Will not check for out of roundness.
Precision straight edge	Visual 0.10 inch with a feeler gage 0.003 inch	Used to check flatness, waviness or squareness of a face to a reference plane.
Radius & template gages	Accuracy is no better than 0.015 inch.	Used to check small radii, and contours.

Ring gages	Will only discriminate against diameters large or smaller than print specification.	Best application is to approximate a mating part in assembly. Will not check for out of roundness.
Split sphere & telescope	No better than 0.0005 inch using an accurate micrometer graduated in 0.0001 inch.	Used for measuring small hole diameters.
Steel ruler or scale	No better than 0.015 inch.	Used to measure heights, depths, diameters, etc.
Surface plates	Flatness expected to be no better than 0.0005 inch between any 2 points.	Used to measure the overall flatness of a piece.
Tapered parallels	When used with an accurate micrometer, the accuracy is about 0.0005 inch.	Used to measure bore sizes in low volume applications.
Tool maker's flat	Accuracy is no better than 0.0005 inch and depends upon the instrument used to measure the height.	Used with a surface plate and gage blocks(plus an indicator or micrometer) to measure height.
Vernier calipers	About 0.001 inch. Some digital models are accurate to 0.00005 inch.	Used to check diameters and thickness.
Vernier depth gage	About 0.001 inch. Some digital models are accurate to 0.00005 inch.	Used to check depths.

3. NDT [1, 3]

Test Type	Application Advantages	Limitations
Eddy Current	Can check material thickness, conductivity, coating thickness and physical properties. Adaptable to 100% high speed applications where	Only useful for conductive materials. Reliable standards and frequent calibration are required. Part thickness and penetration depth can pose

	no probe contact is desired. The costs can be relatively low.	problems. Results are normally comparative.
Liquid Penetrant	A simple accurate, inexpensive technique to locate surface defects. The penetrant / developer contrast makes visual inspection easy. Works on nonmetallic and nonmagnetic materials.	Does not work for porous materials. The process requires cleaning operations. Works on surface defects only. Not as fast as eddy current methods.
Magnetic Particle	Can detect surface and subsurface defects in ferromagnetic parts. Portable equipment may be used. This technique is quick and economical.	Used for ferromagnetic parts only. Surfaces must be clean and dry. Magnetism may have to be two directional to find all discontinuities. Parts may require demagnetizing.
Microwave	Used for thickness measurement. Can also monitor moisture content and chemical composition of both liquids and solids.	Can not detect subsurface defects in metals.
Ultrasonic Transmission Pulse echo or Resonance	Can locate and determine the relative size and orientation of internal defects. Can measure thicknesses difficult to reach with mechanical methods. Inspection units can be portable.	Complex part geometries present difficulties. Requires skilled operators and good test srandards. Coupling materials such as water, glycerine or petroleum jelly must be used.
X-Ray Fluoroscopy Gamma Ray TVX	Useful in detecting internal defects in metals. Some techniques provide a permanent record of	Relatively high initial. Trained technicians are required. Not applicable to extremely thin products.

	defects. Provides continual product movement and rapid decisions.	The results may not be immediately known. Inherent safety risks.

4. Force Measurement [3]

4.1 Hardness Testing

Type	Technique	Penetrator	Loading	Scale
Brinell	Area of Penetration	10 mm Ball	500-3000 kg.	HBW, HBS, BHN
File	Appearance of Scratch	File	Manual	None
Knoop	Area of Penetration	Pyramidal Diamond	25-3600 g	HK
Mohs	Presence of Scratch	10 Stones	Manual	Units Mohs
Rockwell	Depth of Penetration	Diamond Point or 1/16-1/8 Ball	60-100-150 kg.	R_c
Rockwell Superficial	Depth of Penetration	Diamond Point or 1/16-1/8 Ball	15-30-45 kg.	15N, 30T, 45X, etc.
Shore	Height of Bounce	40 Grain Weight	Gravity	Units Shore
Sonodur	Vibration Frequency	Vibrating Rod	N.A	BHN
Vickers	Area of Penetration	Pyramidal Diampnd	25 g to 120 kg	HV, DPH

5. MSA [2, 3]

5.1 Repeatability & Reproducibility

5.1.1 Range Method

5.1.2 Average and Range Method

5.1.3 Analysis of Variance Method

(1) Choose five parts at random and select a quality characteristic to measure.
(2) Identify the parts by numbering them 1 through 5.
(3) Pick three technicians / inspectors.
(4) Have them randomly measure the parts using the same measuring instrument.
(5) Repeat 4 so that there are two replications for each technician / part combination.

6. Summary

- Precision Measurement: Instrument Selection, Accuracy, Application
- Nondestructive Testing: Application Advantages, Limitations
- Force Measurement: vs Material Science
- Measurement System Analysis: vs Uncertainty in Measurement
- Electric and Electronic Measurement: vs Certified Calibrated Technician

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