Practical Workbook

MM-303: Inspection and Testing of Materials

Name________________________

Roll No______________________

Batch________________________

Year ________________________

Department of Metallurgical Engineering
NED University of Engineering and Technology
Karachi-75270, Pakistan

Practical Workbook

MM-303: Inspection and Testing of Materials

Prepared by

Dr. Aqeel Ahmed Shah
(Assistant Professor)

This is to certify that this practical book contains __________ pages.

Approved by

Prof. Dr. Ali Dad Chandio
Chairman, MYD

Department of Metallurgical Engineering
NED University of Engineering and Technology
Karachi-75270, Pakistan

CERTIFICATE

It is certified that Mr. / Ms. ____ student of class ______________ Batch ____________, bearing Roll No. MY ________ has completed his / her coursework in **Inspection and Testing of Materials (MM-303)** as prescribed and approved by the Board of Review of the Metallurgical Engineering Department.

His/her performance is reflected by the performance rubrics of his/her practical workbook. The student's overall performance will address the assigned learning attribute.

____

Course Teacher

TABLE OF CONTENT

MM-303: INSPECTION AND TESTING OF MATERIALS

Experiment No. 1

Aim of the Experiment

To **practice** on the hardness tester for the determination of hardness.

Material /Apparatus

Rockwell, Vickers, Micro Hardness Tester, Standard Calibration Block

Procedure

The Rockwell tests constitute the most common method used to measure hardness because they are so simple to perform and require no special skills. Several different scales may be utilized from possible combinations of various indenters and different loads, which permit the testing of virtually all metal alloys (as well as some polymers). Indenters include spherical and hardened steel balls having diameters of 1/16,1/8, 1/4, and 1/2 in. (1.588, 3.175, 6.350, and 12.70 mm), and a conical diamond (Brale) indenter, which is used for the hardest materials. With this system, a hardness number is determined by the difference in depth of penetration resulting from the application of an initial minor load followed by a larger major load; utilization of a minor load enhances test accuracy. On the basis of the magnitude of both major and minor loads, there are two types of tests: Rockwell and superficial Rockwell. For Rockwell, the minor load is 10 kg, whereas major loads are 60, 100, and 150 kg. Each scale is represented by a letter of the alphabet; several are listed with the corresponding indenter and load in Tables 1 For superficial tests, 3 kg is the minor load; 15, 30, and 45 kg are the possible major load values. These scales are identified by a 15, 30, or 45 (according to load), followed by N, T, W, X, or Y, depending on indenter. Superficial tests are frequently performed on thin specimens. Table 2 presents several superficial scales. When specifying Rockwell and superficial hardnesses, both hardness number and scale symbol must be indicated. The scale is designated by the symbol HR.

Two other hardness-testing techniques are Knoop (pronounced) and Vickers (sometimes also called diamond pyramid). For each test a very small diamond indenter having pyramidal geometry is forced into the surface of the specimen. Applied loads are much smaller than for Rockwell and Brinell, ranging between 1 and 1000 g. The resulting impression is observed under a microscope and measured; this measurement is then converted into a hardness number. Careful specimen surface preparation (grinding and polishing) may be necessary to ensure a well-defined indentation that may be accurately measured. The Knoop and Vickers hardness numbers are designated by HK and HV, respectively, 16 and hardness scales for both techniques are approximately equivalent. Knoop and Vickers are referred to as micro-indentation-testing methods on the basis of indenter size. Both are well suited for measuring the hardness of small, selected specimen regions; furthermore, Knoop is used for testing brittle materials such as ceramics. The modern micro-indentation hardness-testing equipment has been automated by coupling the indenter apparatus to an image analyzer that incorporates a computer and software package. The software controls important system functions to include indent location indent spacing, computation of hardness values, and plotting of data.

Table 1 Rockwell Hardness Scales

Scale Symbol	*Indenter*	*Major Load (kg)*
A	Diamond	60
B	$\frac{1}{16}$-in. ball	100
C	Diamond	150
D	Diamond	100
E	$\frac{1}{8}$-in. ball	100
F	$\frac{1}{16}$-in. ball	60
G	$\frac{1}{16}$-in. ball	150
H	$\frac{1}{8}$-in. ball	60
K	$\frac{1}{8}$-in. ball	150

Table 2 Superficial Rockwell Hardness Scale

Scale Symbol	*Indenter*	*Major Load (kg)*
15N	Diamond	15
30N	Diamond	30
45N	Diamond	45
15T	$\frac{1}{16}$-in. ball	15
30T	$\frac{1}{16}$-in. ball	30
45T	$\frac{1}{16}$-in. ball	45
15W	$\frac{1}{8}$-in. ball	15
30W	$\frac{1}{8}$-in. ball	30
45W	$\frac{1}{8}$-in. ball	45

followed by the appropriate scale identification.12 For example, 80 HRB represents a Rockwell hardness of 80 on the B scale, and 60 HR30W indicates a superficial hardness of 60 on the 30W scale.

For each scale, hardnesses may range up to 130; however, as hardness values rise above 100 or drop below 20 on any scale, they become inaccurate; and because the scales have some overlap, in such a situation it is best to utilize the next harder or softer scale.

Observations

____
____
____
____
____
____
____
____
____

Questions

1: What is superficial hardness? How it differs from normal surface hardness testing?

____
____
____
____

2: How should be thickness of the specimen be for hardness testing?

____
____
____
____

3: Can hardness estimate the tensile strength of the material? If yes, give the correlation for ferrous and non-ferrous materials.

____
____
____
____

4: How would you take the hardness of diamonds and minerals?

____
____
____
____

NED University of Engineering & Technology
Department of_____________________________Engineering
Course Code and Title: ______________________________

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensory skill to ***identify*** equipment and/or its component for a lab work.	Not able to identify the equipment.	--	--	--	Able to identify equipment as well as its components.
Equipment Use Sensory skills to ***demonstrate*** the use of the equipment for the lab work.	Doesn't demonstrate the use of equipment.	Slightly demonstrates the use of equipment.	Somewhat demonstrates the use of equipment.	Moderately demonstrates the use of equipment.	Fully demonstrates the use of equipment.
Procedural Skills ***Displays*** skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedure and perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to ***imitate*** the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use ***Displays*** skills to use the observations from lab work for experimental verifications and illustrations.	Not able to use the observations from lab work for experimental verifications and illustrations.	Slightly able to use the observations from lab work for experimental verifications and illustrations.	Somewhat able to use the observations from lab work for experimental verifications and illustrations.	Moderately able to use the observations from lab work for experimental verifications and illustrations.	Fully able to use the observations from lab work for experimental verifications and illustrations.
Safety Adherence Adherence to ***safety*** procedures.	Doesn't adhere to safety procedures.	Slightly adheres to safety procedures.	Somewhat adheres to safety procedures.	Moderately adheres to safety procedures.	Fully adheres to safety procedures.
Equipment Handling ***Equipment care*** during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care.	Often handles equipment with required care.	Handles equipment with required care.
Group Work ***Contributes*** in a group based lab work.	Doesn't participate and contribute.	Slightly participates and contributes.	Somewhat participates and contributes.	Moderately participates and contributes.	Fully participates and contributes.

Laboratory Session No.________________ Date: _____________

Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

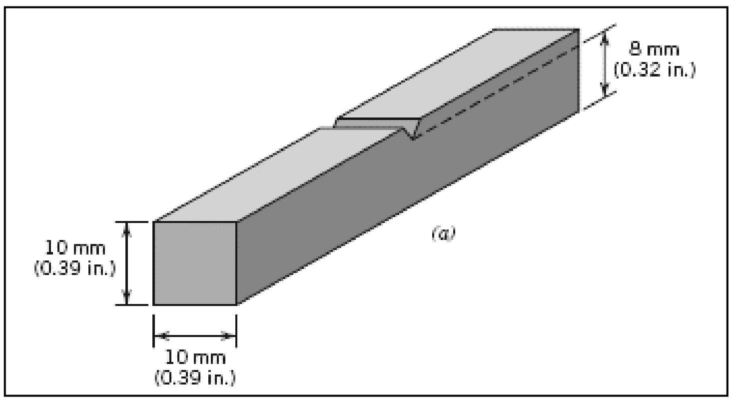
Experiment No. 2

Aim of the Experiment
To perform Impact testing on various steel grades in different conditions and observe the toughness.

Material /Apparatus
Impact testing machine, varnier caliper, and shaper machine for sample preparation.

Sample Preparation (Dimensions)

1-Length of Specimen	(mm)	=	55
2-Cross Section	(mm^2)	=	10
3- Notch Depth	(mm)	=	2
4- Notch Angle	(Degree)	=	45
5- Notch Radius		=	0.25



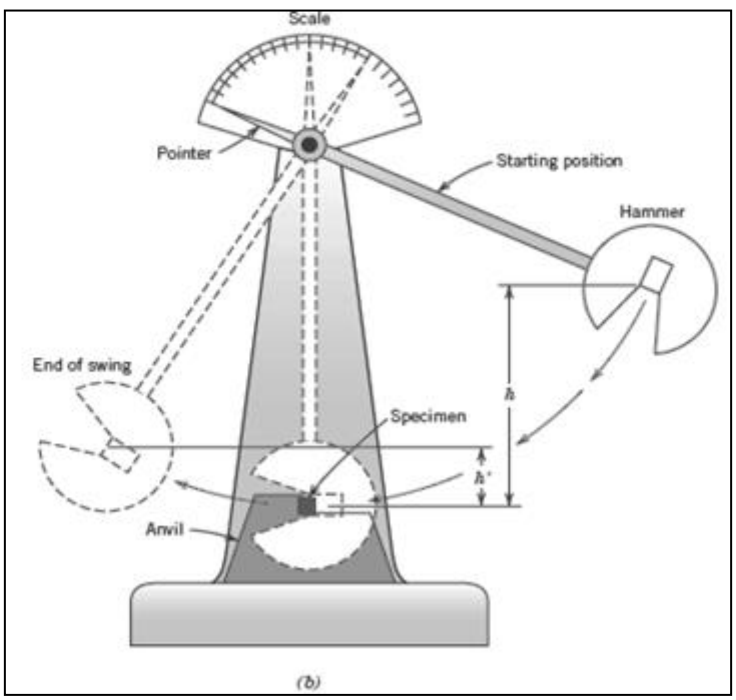


Figure 1: Impact test machine

The Charpy V-notch (CVN) technique is most commonly used, the specimen is in the shape of a bar of square cross section, into which a V-notch is machined (Figure *a*). The apparatus for making V-notch impact tests is illustrated schematically in Figure *b*. The load is applied as an

impact blow from a weighted pendulum hammer that is released from a cocked position at a fixed height *h*. The specimen is positioned at the base as shown. Upon release, a knife edge mounted on the pendulum strikes and fractures the specimen at the notch, which acts as a point of stress concentration for this high-velocity
impact blow. The pendulum continues its swing, rising to a maximum height, which is lower than *h*. The energy absorption computed from the difference between *h* and is a measure of the impact energy in Figure *b*. Furthermore, these are termed impact tests in light of the manner of load application. Variables including specimen size and shape as well as notch configuration and depth influence the test results.

One of the primary functions of Charpy tests is to determine whether or not a material experiences a **ductile-to-brittle transition** with decreasing temperature and, if so, the range of temperatures over which it occurs. The ductile-to-brittle transition is related to the temperature dependence of the measured impact energy absorption. This transition is represented for a steel by curve *A* in Figure C. At higher temperatures the CVN energy is relatively large, in correlation with a ductile mode of fracture. As the temperature is lowered, the impact energy drops suddenly over a relatively narrow temperature range, below which the energy has a constant but small value; that is, the mode of fracture is brittle.

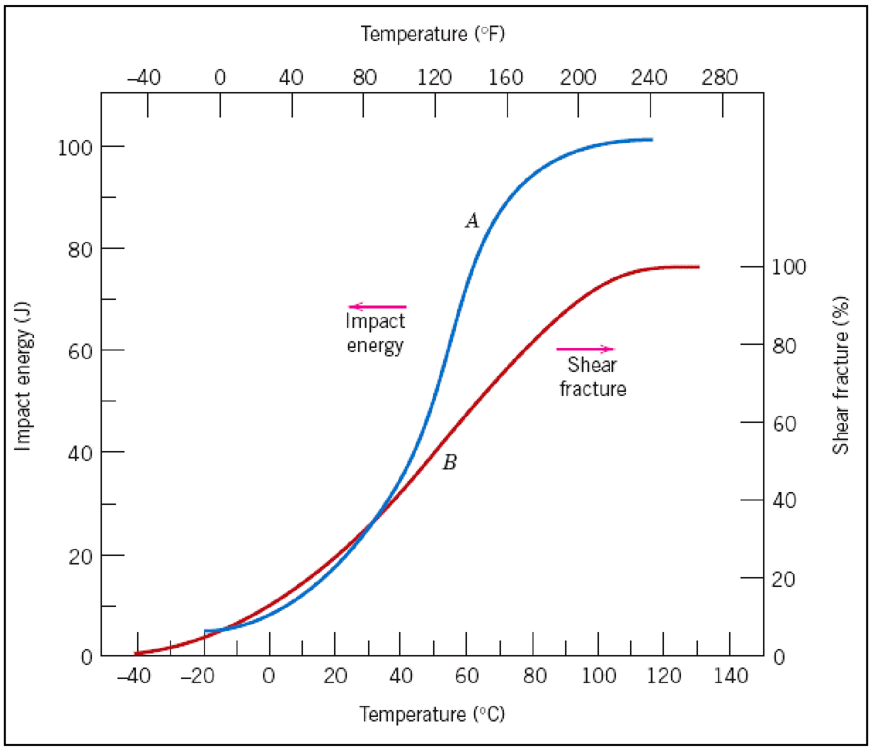


Figure 2: Impact energy VS temperature curve

Observations

____
____
____
____
____

Questions

1 what is the difference between impact strength and impact energy?

2: what are the dimensions of Izod impact specimens?

3 Define why DBTT curve is prevalent in impact testing.

4: What effect of fibres/grains orientation on DBTT for impact values?

5: Give any two factors which tend to improve the impact energy for DBTT

Experiment No. 3

Aim of the Experiment

Operate tensile testing machine to identify the behaviour of metallic material by the examination of mechanical properties on tensile testing machine for circular & flat specimens according to ASTM A-370.

Material /Apparatus
UTS machine, Lathe machine for specimen preparation, Vernier, Micrometer, File of various grids.

Procedure
One of the most common mechanical stress–strain tests are performed in *tension*. As will be seen, the tension test can be used to ascertain several mechanical properties of materials that are important in design. A specimen is deformed, usually to fracture, with a gradually increasing tensile load that is applied uniaxially along the long axis of a specimen. A standard tensile specimen is shown in Figure. Normally, the cross-section is circular, but rectangular specimens are also used. This "dog bone" specimen configuration was chosen so that, during testing, deformation is confined to the narrow centre region (which has a uniform cross-section along its length), and, also, to reduce the likelihood of fracture at the ends of the specimen.

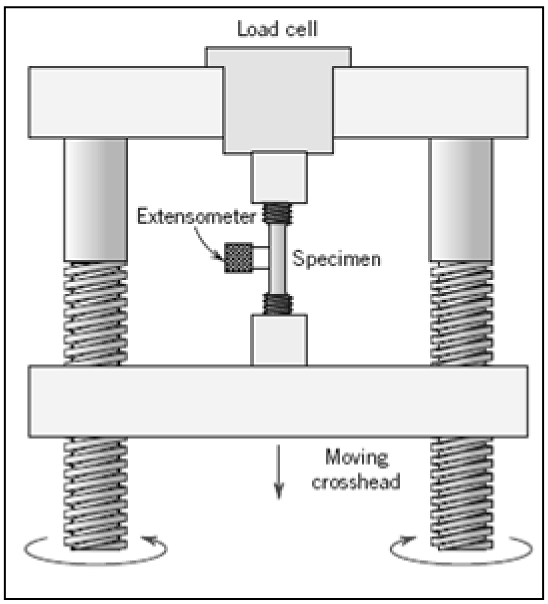


Figure 1: Universal Tensile Testing Machine

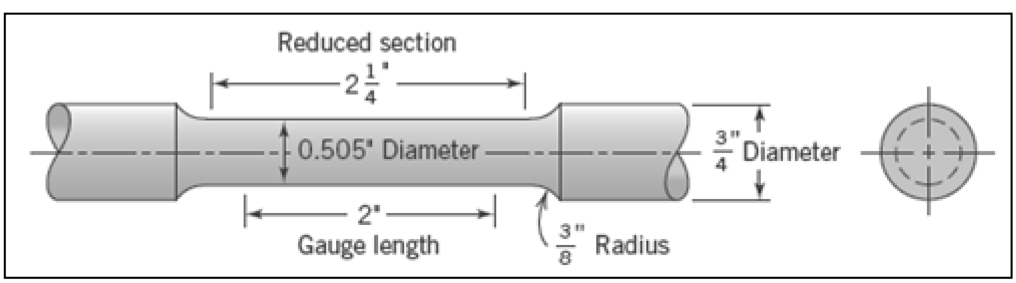


Figure 2: Standard tensile test specimen

The standard diameter is approximately 12.8 mm (0.5 in.), whereas the reduced section length should be at least four times this diameter; 60 mm (in.) is common. Gauge length is used in ductility computations; the standard value is 50 mm (2.0 in.).The specimen is mounted by its ends into the holding grips of the testing apparatus (above Figure). The tensile testing machine is designed to elongate the specimen at a constant rate, and to continuously and simultaneously measure the instantaneous applied load (with a load cell) and the resulting elongations (using an extensometer). A stress–strain test typically takes several minutes to perform and is destructive; that is, the test specimen is permanently deformed and usually fractured. in which *F* is the instantaneous load applied perpendicular to the specimen cross section, in units of newtons (N) or pounds force (lbs) , and Ao is the original cross-sectional area before any load is applied (m2 or in.2). The units of engineering stress (referred to subsequently as just stress) are megapascals, MPa (SI) (where1 MPa = 10^6N/m2), and pounds force per square inch, psi and strain is defined according to eq. below in which l_o is the original length before any load is applied, and l_i is the instantaneous

length. Sometimes the quantity is denoted as and is the deformation elongation or change in length at some instant, as referenced to the original length. Engineering strain (subsequently called just strain) is unit less, but meters per meter or inches per inch are often used; the value of strain is obviously independent of the unit system. Sometimes strain is also expressed as a percentage, in which the strain value is multiplied by 100.

$$\epsilon = \frac{l_i - l_0}{l_0} = \frac{\Delta l}{l_0}$$

Observations

____

____

____

____

____

____

____

____

____

____

____

____

Questions

1: What is offset method?

2: Calculate the % EL (Elongation) on 50, 80 and 200 G.L for any specimen and write down the values.

3: What is the use of Extensometer?

4: Why direction is critically chosen to draw the specimen for tensile testing in rolled plate and sheet?

5: Why double yield point phenomenon occur in carbon low carbon steel?

NED University of Engineering & Technology
Department of____________________________Engineering
Course Code and Title __________________________________

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensory skill to ***identify*** equipment and/or its component for a lab work.	Not able to identify the equipment.	--	--	--	Able to identify equipment as well as its components.
Equipment Use Sensory skills to ***demonstrate*** the use of the equipment for the lab work.	Doesn't demonstrate the use of equipment.	Slightly demonstrates the use of equipment.	Somewhat demonstrates the use of equipment.	Moderately demonstrates the use of equipment.	Fully demonstrates the use of equipment.
Procedural Skills ***Displays*** skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedureand perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to ***imitate*** the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use ***Displays*** skills to use the observations from lab work for experimental verifications and illustrations.	Not able to use the observations from lab work for experimental verifications and illustrations.	Slightly able to use the observations from lab work for experimental verifications and illustrations.	Somewhat able touse the observations fromlab work for experimental verifications and illustrations.	Moderately able touse the observations from lab work for experimental verifications and illustrations.	Fully able to use the observations from lab work for experimental verifications and illustrations.
Safety Adherence Adherence to ***safety*** procedures.	Doesn't adhere to safety procedures.	Slightly adheresto safety procedures.	Somewhat adheres to safety procedures.	Moderately adheresto safety procedures.	Fully adheres to safety procedures.
Equipment Handling ***Equipment care*** during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care.	Often handles equipment withrequired care.	Handles equipment with required care.
Group Work ***Contributes*** in a group based lab work.	Doesn't participate and contribute.	Slightly participates and contributes.	Somewhat participates and contributes.	Moderately participates and contributes.	Fully participates and contributes.

Laboratory Session No.__________________ Date:______________

Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

Experiment No. 4

Aim of the Experiment
Operate bending machine under supervision to determine the soundness and measures of the ductility of rolled plate or bars, welded plates with root bend and face band.

Material /Apparatus
Bending machine, mandrel of various sizes, sample cutting machine.

Procedure
All specimens to be removed and prepared without causing significant distortion or heating. The specimen is bent by the movement of a former of prescribed diameter, the relevant side of the specimen to be placed in tension. Angle of bend and diameter of former should be as specified in the appropriate standard Sample.

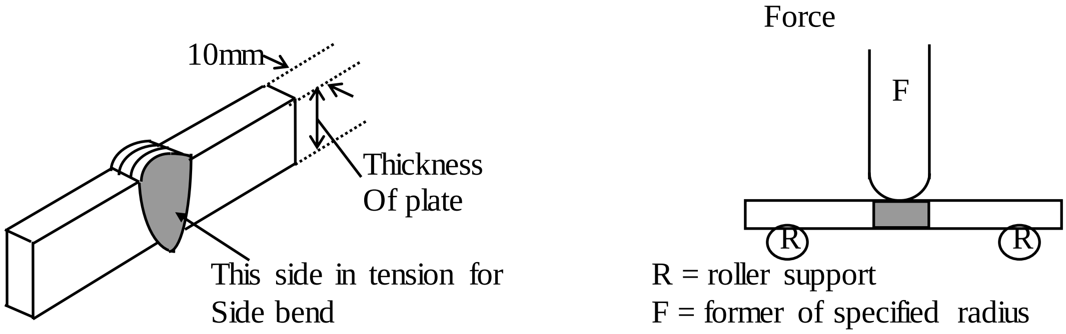


Figure 1: Welded specimens for side bend and root. Face bend

Bend test Shall be made on specimen of sufficient length to ensure free bending and with apparatus which provides continuous and uniform application of force throughout the duration of the operation, Unrestricted movement of the specimen at the point of contact with the apparatus and bending around a pin free to rotate, and close wrapping of the specimen around the pin during the bending operation. Other acceptable more sever methods of bend testing, such as placing a specimen across two pins free to rotate and applying the bending force with a fix pin may be used. When re-testing is permitted by the product specification, the following shall apply. a-Sections of the bar containing identifying roll marking shall not be used. Bars shall be so placed that longitudinal ribs lie in a plane at right angles to the plane of bending.

Observations

____
____
____
____
____
____
____

Questions

1: What is mandrel?

2: Why side bend test is recommended

3: How is the criterion for selection of mandrel size for bend test & define the severity of mandrel for test specimen?

4: Why bend test is recommended?

5: What are root bend & face bend and give the dimensions for the sheet specimen as per ASTM-A370.

NED University of Engineering & Technology
Department of____________________________Engineering
Course Code and Title __________________________________

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensory skill to ***identify*** equipment and/or its component for a lab work.	Not able to identify the equipment.	--	--	--	Able to identify equipment as well as its components.
Equipment Use Sensory skills to ***demonstrate*** the use of the equipment for the lab work.	Doesn't demonstrate the use of equipment.	Slightly demonstrates the use of equipment.	Somewhat demonstrates the use of equipment.	Moderately demonstrates the use of equipment.	Fully demonstrates the use of equipment.
Procedural Skills ***Displays*** skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedureand perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to ***imitate*** the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use ***Displays*** skills to use the observations from lab work for experimental verifications and illustrations.	Not able to use the observations from lab work for experimental verifications and illustrations.	Slightly able to use the observations from lab work for experimental verifications and illustrations.	Somewhat able to use the observations fromlab work for experimental verifications and illustrations.	Moderately able touse the observations from lab work for experimental verifications and illustrations.	Fully able to use the observations from lab work for experimental verifications and illustrations.
Safety Adherence Adherence to ***safety*** procedures.	Doesn't adhere to safety procedures.	Slightly adheresto safety procedures.	Somewhat adheres to safety procedures.	Moderately adheresto safety procedures.	Fully adheres to safety procedures.
Equipment Handling ***Equipment care*** during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care.	Often handles equipment withrequired care.	Handles equipment with required care.
Group Work ***Contributes*** in a group based lab work.	Doesn't participate and contribute.	Slightly participates and contributes.	Somewhat participates and contributes.	Moderately participates and contributes.	Fully participates and contributes.

Laboratory Session No.__________________ Date:_______________

Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

Experiment No. 5

Aim of the Experiment

Operate the ultrasonic flaw detector to determine the defects in a given material and **practice** the calibration of the ultrasonic flaw detector with normal probes.

Material /Apparatus
Digital ultrasonic machine, calibration Block, various probes,

Theory

The ultrasonic testing is based on vibrations in materials which is generally referred to as "acoustics". Ultrasonic testing uses high-frequency sound waves (typically in the range between 0.5 and 15 MHz) to conduct examinations and make measurements. Besides its wide use in engineering applications (such as flaw detection/ evaluation, dimensional measurements, material characterization, etc.), ultrasonics are also used in the medical field (such as sonography, therapeutic ultrasound, etc.). In general, ultrasonic testing is based on the capture and quantification of either the reflected waves (pulse echo) or the transmitted waves (through transmission). Each of the two types is used in certain applications, but generally, pulse echo systems are more useful since they require one-sided access to the object being inspected.

Basic Principles

A typical pulse-echo UT inspection system consists of several functional units, such as the pulser/receiver, transducer, and display device. A pulser/ receiver is an electronic device that can produce high-voltage electrical pulses. Driven by the pulser, the transducer generates high-frequency ultrasonic energy. The sound energy is introduced and propagates through the material in the form of waves. When there is a discontinuity (such as a crack) in the wave path, part of the energy will be reflected from the flaw surface. The reflected wave signal is transformed into an electrical signal by the transducer and is displayed on the screen. Knowing the velocity of the waves, travel time can be directly related to the distance that the signal traveled. From the signal, information about the reflector location, size, orientation and other features can sometimes be gained.

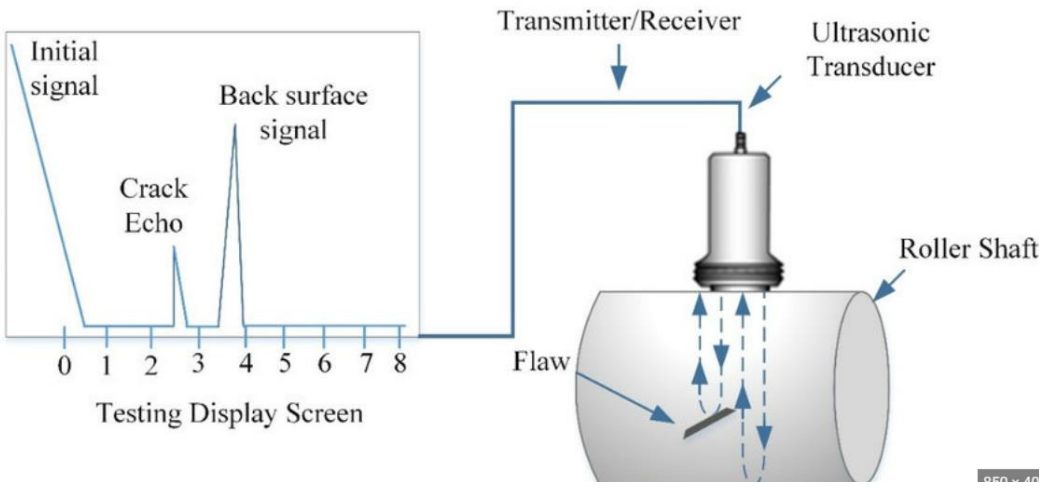


Figure 1: Working principle of ultrasonic flaw detector.

Calibration and Test Method

- Switch on the instrument.
- Couple a normal probe to the 25mm thick side of the test blocks V1.
- Adjust the delay and depth range controls so that four back wall echoes appear on the screen.
- Adjust the delay (or zero) control to accurately locate the leading edge of the first back wall echo at the 25-scale division if the total screen has 100 large divisions. Adjust the fourth echo to the 100 division using the range control.
- Repeat steps 4 and 5 until the 1st and 4th echoes are located accurately at 25 scale division and the 100 scale division respectively.
- Observe the 2nd and 3rd echoes. They should be located accurately at 50 scale division and 75 scale division respectively as shown in Fig.2.

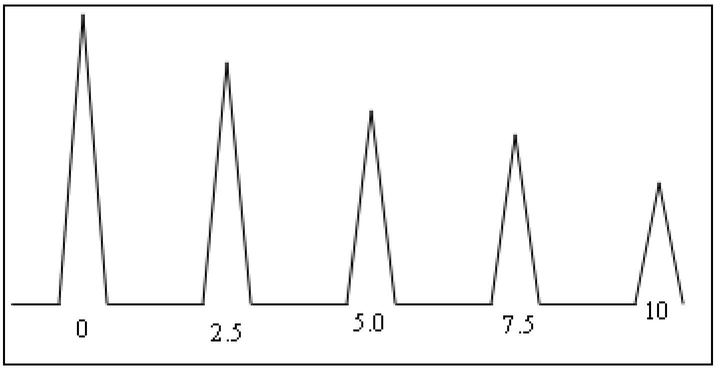


Figure 2: Diagram for ultrasonic test

- The base is now calibrated for a test range of 100 mm
- Place the probe at position ‘a’ on the block as shown in Fig.3. Only one peak should appear on the screen and it should be located at 10.
- Similarly place the probe at position ‘b’ on the test block. A single peak should now appear at 9.1

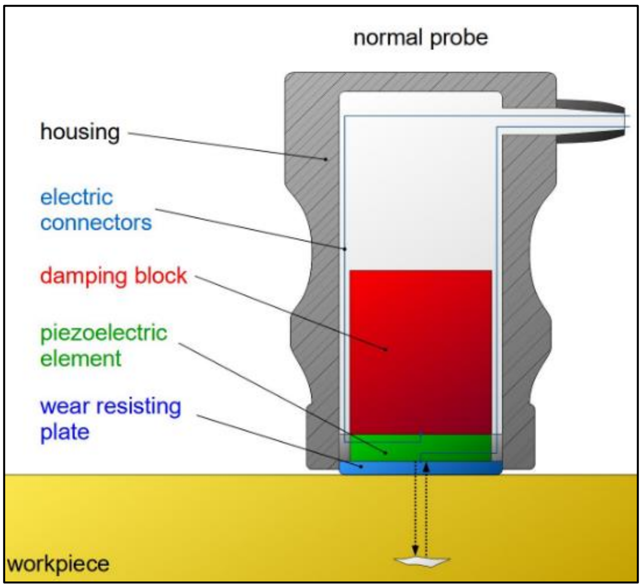


Figure 3: Ultrasonic test probe

- The corresponding screen appearance for the position ‘a’ and ‘b’ of Fig.4.

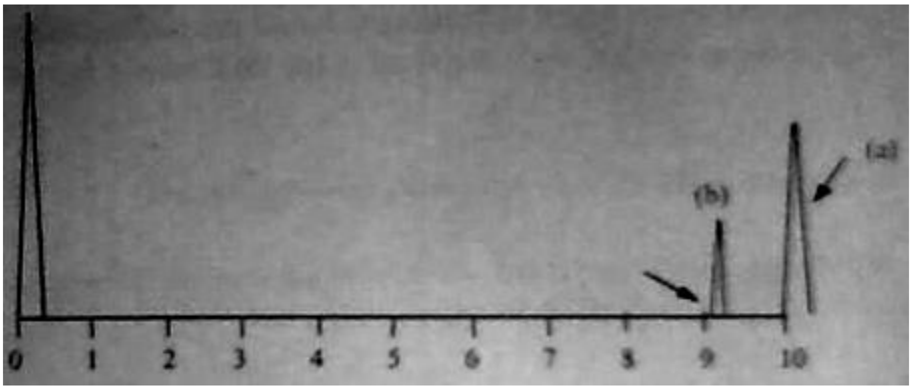


Figure 4: Ultrasonic echo test

- Set the flaw detector to give a test range of 400 and 800 mm.

Caution: Always calibrate the screen with at least two back wall echoes to ensure proper linearity of the time base.

Observations

Questions

1: List down the probe crystals for Ultrasonic Testing

2: Calculate the thickness of the Lead Zirconate Titanate crystal with a velocity of 4000m/s

3: List down the Ultrasonic techniques.

4: List down the zones in ultrasonic testing.

5: Define what is acoustic impedance and its formula.

6: Define ultrasonic waves and give name of two waves.

7: How many type of probes are used in ultrasonic testing. Define their application

8: Define zones of the sound beam and list down the name

9: How to calculate the near zone of 10mm probe for 5MHz in steel?

10: What is beam spread?

F/OBEM 01/05

NED University of Engineering & Technology
Department of___________________________Engineering
Course Code and Title _________________________________

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensory skill to ***identify*** equipment and/or its component for a lab work.	Not able to identify the equipment.	--	--	--	Able to identify equipment as well as its components.
Equipment Use Sensory skills to ***demonstrate*** the use of the equipment for the lab work.	Doesn't demonstrate the use of equipment.	Slightly demonstrates the use of equipment.	Somewhat demonstrates the use of equipment.	Moderately demonstrates the use of equipment.	Fully demonstrates the use of equipment.
Procedural Skills ***Displays*** skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedureand perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to ***imitate*** the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use ***Displays*** skills to use the observations from lab work for experimental verifications and illustrations.	Not able to use the observations from lab work for experimental verifications and illustrations.	Slightly able to use the observations from lab work for experimental verifications and illustrations.	Somewhat able to use the observations fromlab work for experimental verifications and illustrations.	Moderately able touse the observations from lab work for experimental verifications and illustrations.	Fully able to use the observations from lab work for experimental verifications and illustrations.
Safety Adherence Adherence to ***safety*** procedures.	Doesn't adhere to safety procedures.	Slightly adheresto safety procedures.	Somewhat adheres to safety procedures.	Moderately adheresto safety procedures.	Fully adheres to safety procedures.
Equipment Handling ***Equipment care*** during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care.	Often handles equipment withrequired care.	Handles equipment with required care.
Group Work ***Contributes*** in a group based lab work.	Doesn't participate and contribute.	Slightly participates and contributes.	Somewhat participates and contributes.	Moderately participates and contributes.	Fully participates and contributes.

Laboratory Session No.__________________ Date:______________

Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

Experiment No. 6

Aim of the Experiment

Operate the Eddy Current Tester for the determination of the defects in a given material.

Material /Apparatus

Eddy Current Equipment, Reference Standard, Probes with cable cord

Procedure

Eddy currents are created through a process called electromagnetic induction. When alternating current is applied to the conductor, such as copper wire, a magnetic field develops in and around the conductor. This magnetic field expands as the alternating current rises to maximum and collapses as the current is reduced to zero. If another electrical conductor is brought into the close proximity to this changing magnetic field, current will be induced in this second conductor. Eddy currents are induced electrical currents that flow in a circular path. They get their name from "eddies"

Figure 1: Eddy current Test Set up

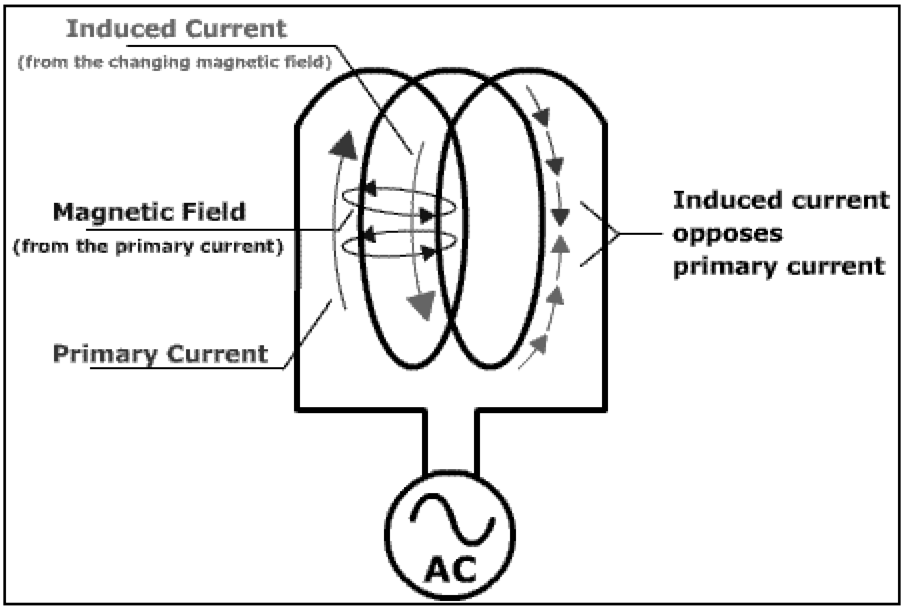


Figure 2: Eddy current Test Mechanism

Conventional eddy current inspection techniques use sinusoidal alternating electrical current of a particular frequency to excite the probe. The pulsed eddy current technique uses a step function voltage to excite the probe. The advantage of using a step function voltage is that it

contains a continuum of frequencies. As a result, the electromagnetic response to several different frequencies can be measured with just a single step. Since the depth of penetration is dependent on the frequency of excitation, information from a range of depths can be obtained all at once. If measurements are made in the time domain (that is by looking at signal strength as a function of time), indications produced by flaws or other features near the inspection coil will be seen first and more distant features will be seen later in time.
To improve the strength and ease interpretation of the signal, a reference signal is usually collected, to which all other signals are compared (just like nulling the probe in conventional eddy current inspection). Flaws, conductivity, and dimensional changes produce a change in the signal and a difference between the reference signal and the measurement signal that is displayed. The distance of the flaw and other features relative to the probe will cause the signal to shift in time. Therefore, time gating techniques (like in ultrasonic inspection) can be used to gain information about the depth of a feature of interest.

Observations

____
____
____
____
____
____
____
____
____
____

Result

____
____
____
____
____
____

Questions

1: List down the type of probes used in Eddy current techniques.

2: Give the limitations of Eddy's current testing

3: Give advantages of Eddy Current

NED University of Engineering & Technology
Department of_____________________________Engineering
Course Code and Title __________________________________

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensory skill to ***identify*** equipment and/or its component for a lab work.	Not able to identify the equipment.	--	--	--	Able to identify equipment as well as its components.
Equipment Use Sensory skills to ***demonstrate*** the use of the equipment for the lab work.	Doesn't demonstrate the use of equipment.	Slightly demonstrates the use of equipment.	Somewhat demonstrates the use of equipment.	Moderately demonstrates the use of equipment.	Fully demonstrates the use of equipment.
Procedural Skills ***Displays*** skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedureand perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to ***imitate*** the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use ***Displays*** skills to use the observations from lab work for experimental verifications and illustrations.	Not able to use the observations from lab work for experimental verifications and illustrations.	Slightly able to use the observations from lab work for experimental verifications and illustrations.	Somewhat able to use the observations fromlab work for experimental verifications and illustrations.	Moderately able touse the observations from lab work for experimental verifications and illustrations.	Fully able to use the observations from lab work for experimental verifications and illustrations.
Safety Adherence Adherence to ***safety*** procedures.	Doesn't adhere to safety procedures.	Slightly adheresto safety procedures.	Somewhat adheres to safety procedures.	Moderately adheresto safety procedures.	Fully adheres to safety procedures.
Equipment Handling ***Equipment care*** during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care.	Often handles equipment withrequired care.	Handles equipment with required care.
Group Work ***Contributes*** in a group based lab work.	Doesn't participate and contribute.	Slightly participates and contributes.	Somewhat participates and contributes.	Moderately participates and contributes.	Fully participates and contributes.

Laboratory Session No.__________________ Date:______________

Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

Experiment No. 7

Aim of the Experiment
To **manipulate** and identify the cracked / defective surface by Dye penetrant testing.

Material /Apparatus
Abrasive paper, penetrant, developers (depends upon the type of test)

Procedure
Liquid penetrant inspection is a method that is used to reveal surface-breaking flaws by bleeding out of a colored or fluorescent dye from the flaw. The technique is based on the ability of a liquid to be drawn into a "clean" surface-breaking flaw by capillary action After a period called the "dwell," excess surface penetrant is removed and a developer applied. This acts as a blotter. It draws the penetrant from the flaw to reveal its presence. Colored (contrast) penetrants require good white light while fluorescent penetrants need to be used in darkened conditions with an ultraviolet "black light".
A very early surface inspection technique involved the rubbing of carbon black on glazed pottery, whereby the carbon black would settle in surface cracks rendering them visible
The penetrant material can be applied in several different ways, including spraying, brushing, or immersing the parts in a penetrant bath. The method of penetrant application has little effect on the inspection sensitivity but an electrostatic spraying method is reported to produce slightly better results than other methods. Once the part is covered in penetrant it must be allowed to dwell so the penetrant has time to enter any defect present
Penetrant dwell time is the total time that the penetrant is in contact with the part surface. The dwell time is important because it allows the penetrant the time necessary to seep or be drawn into a defect. Dwell times are usually recommended by the penetrant producers or required by the specification
The next step after penetrant is the function of the developer, which is very important in a penetrant inspection. It must draw out of the discontinuity a sufficient amount of penetrant to form an indication, and it must spread the penetrant out on the surface to produce a visible indication part should be allowed to develop for a minimum of 10 minutes and no more than 2 hours before inspecting.
Inspection is then performed under appropriate lighting to detect indications from any flaws, which may be present. The final step in the process is to thoroughly clean the part surface to remove the developer from the parts that were found to be acceptable.

Observations
____
____
____
____
____
____
____
____
____
____
____
____

Questions

1: Classify the method of penetrants

2: Classify the forms of developers.

3: What are the advantages of liquid penetrant testing?

4: What are the disadvantages of liquid penetrant testing?

5: What is dwell time?

NED University of Engineering & Technology
Department of_____________________________Engineering
Course Code and Title __________________________________

Psychomotor Domain Assessment Rubric-Level P3					
Skill Sets	Extent of Achievement				
	0	1	2	3	4
Equipment Identification Sensory skill to ***identify*** equipment and/or its component for a lab work.	Not able to identify the equipment.	--	--	--	Able to identify equipment as well as its components.
Equipment Use Sensory skills to ***demonstrate*** the use of the equipment for the lab work.	Doesn't demonstrate the use of equipment.	Slightly demonstrates the use of equipment.	Somewhat demonstrates the use of equipment.	Moderately demonstrates the use of equipment.	Fully demonstrates the use of equipment.
Procedural Skills ***Displays*** skills to act upon sequence of steps in lab work.	Not able to either learn or perform lab work procedure.	Able to slightly understand lab work procedureand perform lab work.	Able to somewhat understand lab work procedure and perform lab work.	Able to moderately understand lab work procedure and perform lab work.	Able to fully understand lab work procedure and perform lab work.
Response Ability to ***imitate*** the lab work on his/her own.	Not able to imitate the lab work.	Able to slightly imitate the lab work.	Able to somewhat imitate the lab work.	Able to moderately imitate the lab work.	Able to fully imitate the lab work.
Observation's Use ***Displays*** skills to use the observations from lab work for experimental verifications and illustrations.	Not able to use the observations from lab work for experimental verifications and illustrations.	Slightly able to use the observations from lab work for experimental verifications and illustrations.	Somewhat able to use the observations fromlab work for experimental verifications and illustrations.	Moderately able touse the observations from lab work for experimental verifications and illustrations.	Fully able to use the observations from lab work for experimental verifications and illustrations.
Safety Adherence Adherence to ***safety*** procedures.	Doesn't adhere to safety procedures.	Slightly adheresto safety procedures.	Somewhat adheres to safety procedures.	Moderately adheresto safety procedures.	Fully adheres to safety procedures.
Equipment Handling ***Equipment care*** during the use.	Doesn't handle equipment with required care.	Rarely handles equipment with required care.	Occasionally handles equipment with required care.	Often handles equipment with required care.	Handles equipment with required care.
Group Work ***Contributes*** in a group based lab work.	Doesn't participate and contribute.	Slightly participates and contributes.	Somewhat participates and contributes.	Moderately participates and contributes.	Fully participates and contributes.

Laboratory Session No.__________________ Date:______________

Weighted CLO (Psychomotor Score)	
Remarks	
Instructor's Signature with Date:	

Experiment No. 8

Aim of the Experiment
To determine the cracks in the material using magnetic particle inspection

Material /Apparatus
Magnetic yoke, Iron particles, power supply, work piece.

Introduction
Magnetic particle inspection (MPI) is a nondestructive testing method used for defect detection. MPI is fast and relatively easy to apply, and part surface preparation is not as critical as it is for some other NDT methods. These characteristics make MPI one of the most widely utilized nondestructive testing methods. MPI uses magnetic fields and small magnetic particles (i.e.iron filings) to detect flaws in components. The only requirement from an inspectability standpoint is that the component being inspected must be made of a ferromagnetic material such as iron, nickel, cobalt, or some of their alloys. Ferromagnetic materials are materials that can be magnetized to a level that will allow the inspection to be effective.

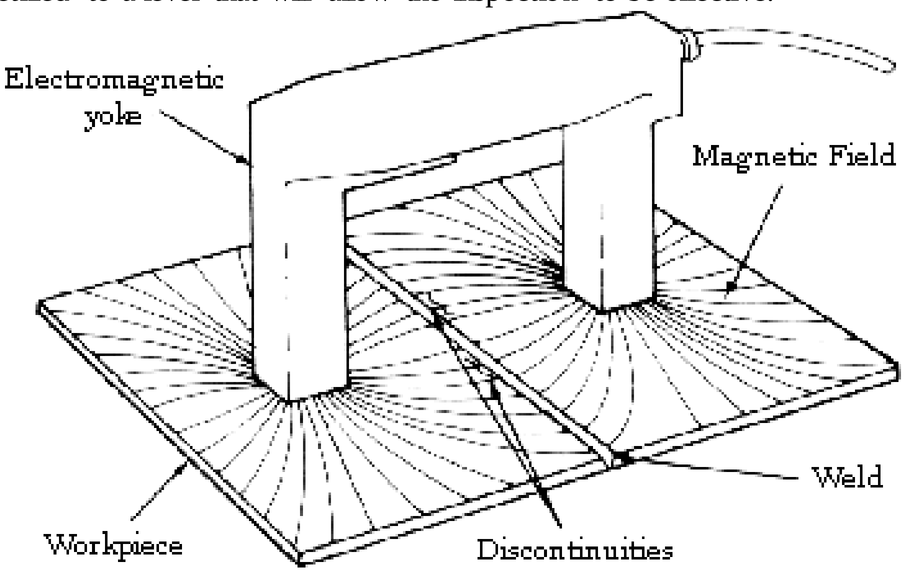


Figure 1: Magnetic Particle Inspection of a work piece.

Experimental procedure
The part to be inspected should be clean to avoid any debris and oil on the surface. After that the yoke is placed on the surface of the test piece and induce magnetism in it. Next step is to provide the part with magnetic particles. These particles can be in the form of dry powder or wet suspension. Suspension is more favorable as it allows free moment of particles near the cracks. Apply the suspension to the part by spraying it on the part. In the entire process the part should be magnetized in order to have an idea about cracks. The cracks present in the part will leak the flux and act like poles in the magnet which attracts the particles present in its periphery. These clusters of particle can be viewed under normal light to identify the crack present on the material surface.

Observation

____

____

____

____

____

Precautions

1. Don’t eat anything in lab and don’t make panic in case of accident.
2. Always operate the instrument under supervision of your supervisor
3. Don’t try to smell any chemical or powder
4. Always wash hands after experiment.

Questions

1.What type of magnetic field is used for magnetization?

2. Is demagnetization necessary after magnetic particle inspection, if yes then why?

3. Write down the process of demagnetization?

4. What is the effect of magnetization on domains?

5. For which materials magnetic particle is suitable?

Experiment No. 9

Aim of the Experiment
Find out the Shear strength of a given specimen using UTM.

Material /Apparatus
A UTM, Specimen, shearing attachment, vernier caliper etc.

Theory
A type of force which causes or tends to cause two contiguous parts of the body to slide relative to each other in a direction parallel to their plane of contact is called the shear force. The stress required to produce fracture in the plane of cross-section, acted on by the shear force is Called shear strength.

Figure 1: Shear test set up

Procedure
1. Insert the specimen in position and grip one end of the attachment in the upper portion and one end in the lower position
2. Switch on the UTM
3. Bring the drag indicator in contact with the main indicator.
4. Select the suitable range of loads and space the corresponding weight in the Pendulum and balance it if necessary with the help of small balancing weights
5. Operate (push) the button for driving the motor to drive the pump.
6. Gradually move the head control ever in left hand direction till the specimen shears.
7. Note down the load at which the specimen shears.
8. Stop the machine and remove the specimen.
9. Repeat the experiment with other specimens

Observation

1. Applied compressive force (F) = ---------kgf.
2. Diameter of specimen = ---------mm.

3. Cross-sectional area of the pin (in double shear) = $\frac{2\times\pi\times d^2}{4}$ mm^2

4. Load taken by the specimen at the time of failure = ___________N)

5. Strength of the pin against shearing (τ) = $\frac{4\times W}{2\times\pi\times d^2}$

Precautions

1. The measuring range should not be changed at any stage during the test.
2. The inner diameter of the hole in the shear stress attachment should be slightly greater than the specimen.
3. Measure the diameter of the specimen accurately.
4. The method for determining the shear strength consists of subjecting a suitable Length of steel specimen in full cross-section to double shear, using a suitable test rig, in a testing m/c under a compressive load or tensile pull and recording the maximum load 'F' to fracture.

Result

Shear strength of specimen = --------

Questions

1. What is bulging? Why does it occur?

____
____
____
____

2. What are single and double shear?

____
____
____
____
____

3. Does shear failure in wood occur along a 45° shear plane?

____
____
____
____

Experiment No. 10

Aim of the Experiment

To conduct a torsion test on mild steel specimens to find modulus of rigidity or to find angle of twist of the materials.

Material /Apparatus

1. A torsion test machine along with the angle of twist measuring attachment.
2. Standard specimen of mild steel or cast iron.
3. Steel rule.
4. Vernier caliper or a micrometre.

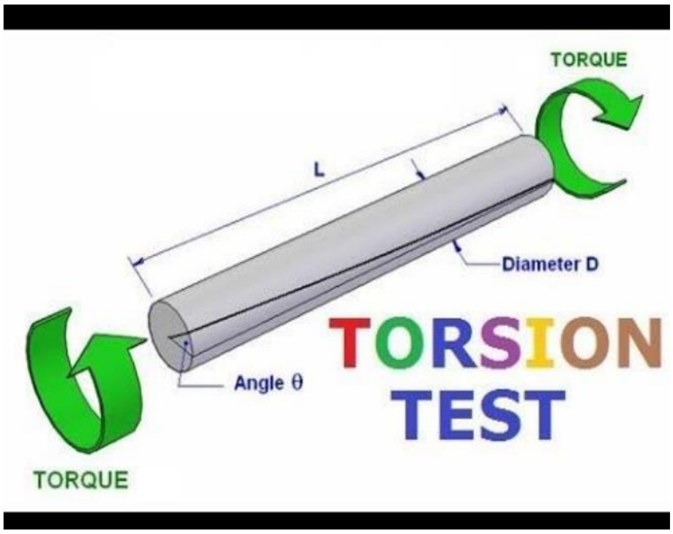


Figure 1: Torsion Test Set up

Theory

For transmitting power through a rotating shaft it is necessary to apply a turning force. The force is applied tangentially and in the plane of the transverse cross-section. The torque or twisting moment may be calculated by multiplying two opposite turning moments. It is said to be in pure torsion and it will exhibit the tendency of shearing off at every cross section which is perpendicular to the longitudinal axis.

Torsion equation

$$\frac{T}{I_p} = \frac{C\theta}{L} = \frac{\tau}{R}$$

T = maximum twisting torque (N.mm)
Ip = Polar moment of inertia (mm^4)
τ = Shear stress (N/mm^2)
C = Modulus of rigidity (N/mm^2)
Θ = angle of twist in radians
L = Length of shaft under torsion (mm)

Procedure

1. Select the suitable grips to suit the size of the specimen and clamp it in the machine by adjusting the sliding jaw.
2. Measure the diameter at about the three places and take the average value.
3. Choose the appropriate loading range depending on the specimen.
4. Set the maximum load pointer to zero.
5. Carry out straining by rotating the hand wheel or by switching on the motor.
6. Load the members in suitable increments, and observe and record strain readings.
7. Continue till failure of the specimen.
8. Calculate the modulus of rigidity C by using the torsion equation.
9. Plot the torque–twist graph (T vs θ)

Observations

Gauge length L =

Polar moment of inertia I_p =

Modulus of rigidity C = $\frac{TL}{I_p\theta}$

Result

The modulus of rigidity of the given test specimen material is_____________.

Questions

1. Is there any relationship between the modulus of rigidity and the modulus of elasticity of a material?

____

____

____

____

2. Which material, either brass or steel would you expect to have a high modulus of rigidity?

____

____

____

____

3. If testing steel and aluminium, which material fails at a high angle of twist?

____

____

____

____