Bharath
INSTITUTE OF HIGHER EDUCATION AND RESEARCH
Declared as **Deemed-to-be-University** u/s 3 of the UGC Act, 1956

B.Tech- Aerospace Engineering

U20ASSJ05 -Experimental Techniques in Structural Mechanics

Lab Manual

Vision of the institute

"Bharath Institute of Higher Education & Research (BIHER) envisions and constantly strives to provide an excellent academic and research ambience for students and members of the faculties to inherit professional competence along with human dignity and transformation of community to keep pace with the global challenges so as to achieve holistic development."

Mission of the institute

- To develop as a Premier University for Teaching, Learning, Research and Innovation on par with leading global universities.
- To impart education and training to students for creating a better society with ethics and morals.
- To foster an interdisciplinary approach in education, research and innovation by supporting lifelong professional development, enriching knowledge banks through scientific research, promoting best practices and innovation, industry driven and institute oriented cooperation, globalization and international initiatives.
- To develop as a multi-dimensional institution contributing immensely to the cause of societal advancement through spread of literacy, an ambience that provides the best of international exposures, provide health care, enrich rural development and most importantly impart value based education.
- To establish benchmark standards in professional practice in the fields of innovative and emerging areas in engineering, management, medicine, dentistry, nursing, physiotherapy and allied sciences.
- To imbibe human dignity and values through personality development and social service activities.

B.Tech- Aerospace Engineering

Vision of the Department

Department of Aeronautical Engineering will endeavor to accomplish worldwide recognition with a focal point of Excellence in the field of Aeronautics by providing quality Education through world class facilities, enabling graduates turning out to be Professional Experts with specific knowledge in Aeronautical & Aerospace engineering.

Mission of the Department

- To be the state of art Teaching and Learning center with excellent infrastructure and empowered Faculties in Aeronautical & Aerospace Engineering.
- To foster a culture of innovation among students in the field of Aeronautics and Aerospace with updated professional skills to enhance research potential for sponsored research and innovative projects.
- To Nurture young individuals to be knowledgeable, skilful, and ethical professionals in their pursuit of Aeronautical & Aerospace Engineering.

B.Tech- Aerospace Engineering

Program Educational Objectives Statements (PEO)

PEO 1: Demonstrate a solid grasp of fundamental concepts in Mathematics, Science, and Engineering, essential for effectively addressing engineering challenges within the Aerospace industry.

PEO 2: Involve in process of designing, simulating, fabricating, testing, and evaluating in the field of Aerospace.

PEO 3: Obtain advanced skills to actively engage in research and development endeavors within emerging domains, while also pursuing further education opportunities.

PEO 4: Demonstrate efficient performance both as independent contributors and as valuable team members in diverse multidisciplinary projects.

PEO 5: Embrace lifelong learning and career advancement while adapting to the evolving social demands and needs.

B.Tech- Aerospace Engineering

Programme Outcomes (PO's)

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and Engg. Specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, research literature, and analyze engineering problems to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

B.Tech- Aerospace Engineering

Program Specific Outcomes (PSO) - R2020

PSO1: Design and analyze aerospace components/systems for aerospace industries.

PSO2: Acquire the concepts of spacecraft attitude dynamics for the prediction of spacecraft motion.

Course Outcomes (COs)

CO1	**Describe** the performance of measuring instruments (**Understand**)
CO2	**Impart** knowledge of electrical resistance strain gauges (**Understand**)
CO3	**Explain** the concepts of strain gauge instrumentation (**Understand**)
CO4	**Acquire** knowledge of photoelastic methods for stress analysis. (**Understand**)
CO5	**Describe** the principles and applications of various non-destructive techniques (**Understand**)
CO6	**Carry out** mechanical measurements using extensometers (**Imitation**)
CO7	**Acquire** stress values using electrical resistance strain gauges techniques (**Manipulation**)
CO8	**Demonstrate** the Nondestructive testing methods for detecting cracks (**Precision**)

Mapping/Alignment of COs with PO & PSO

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M			M							H	H	
CO2	H	M			M					H		H	H	
CO3	H	M			M					H		H	H	
CO4	H	M			M							H	H	
CO5	H	M			M							H	H	
CO6	H	M		L				H	H	H		H	H	
CO7	H	M		L				H	H	H		H	H	
CO8	H	M		L				H	H	H		H	H	

(Tick mark or level of correlation: H-High, M-Medium, L-Low)

LIST OF EXPERIMENTS:

S.No	Name of Experiment	Course Outcome
1.	Measurement of displacements using mechanical extensometer	CO6,CO7,CO8
2.	Strain gauge installation &testing	CO6,CO7,CO8
3.	Measurement of strain using strain rosettes	CO6,CO7,CO8
4.	Calibration of strain gauges	CO6,CO7,CO8
5.	Strain measurements in beams.	CO6,CO7,CO8
6.	Detection of defects using Fluorescent Penetrant Testing	CO6,CO7,CO8
7.	Magnetic Particle Testing	CO6,CO7,CO8

EXP NO : 1 DATE :	MEASUREMENT OF DISPLACEMENTS USING MECHANICAL EXTENSOMETER

AIM:

To measure the deflection of the given beam

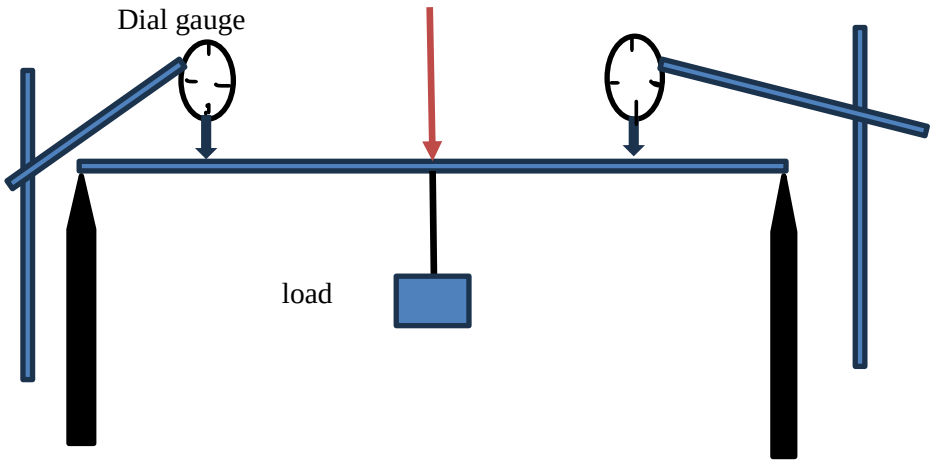
APPARATUS AND SPECIMENS REQUIRED:

1) Dial gauge
2) weights
3) vernier caliper
4) Metallic beam
5) Magnetic Stand
6) scale/ruler.

THEORY:

Mechanical Extensometer is an attachment to Universal Testing Machine and Tensile Testing Machines, used to find out the proof stress at the required elongation percentage. It measures the elongation of a test piece on load for the set gauge length.

DIAGRAM:



FORMULA USED :

$$Y_c = \frac{w^3}{48EI}$$ (Mid Span Deflection in the Simply supported beam)

$$\mathbf{I} = \frac{\mathbf{bh^3}}{\mathbf{12}}$$ (Moment of inertia)

Deflection equation at any section which is at a distance of x from right end is,

$$\mathbf{E.I_y} = \frac{\mathbf{wx^3}}{\mathbf{12}} - \frac{\mathbf{wl^2x}}{\mathbf{16}}$$

$$\textbf{\% Error} = \left[\frac{Y(c)Theoretical - Y(c)Experimental}{Y(c)Theoretical} \right] \times 100$$

where,

l = length of beam (mm).

I = Moment of inertia of beam (mm^4).

E = Young's modulus of the material of the beam.

Y_c= Vertical deflection at mid-span(mm).

PROCEDURE:

1) Make sure the apparatus are properly calibrated.
2) load the weights in the center of the beam and measure the deflection in D-1, D-2, D-3.
3) Add 3 or 4 weights and measure the deflection.
4) And also measure the deflection while unloading each weight.
5) Analyze the measurement.

CALCULATION :

RESULT:

Thus the deflection of the given beam was measured .

EXP NO : 2 DATE :	STRAIN GAUGE INSTALLATION AND TESTING

AIM:

To install Strain gauge in a given specimen.

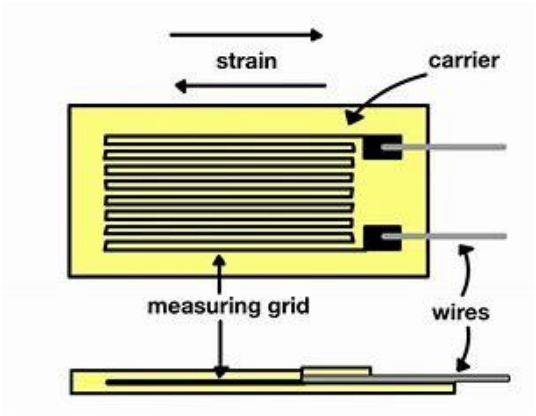
APPARATUS AND SPECIMENS REQUIRED:

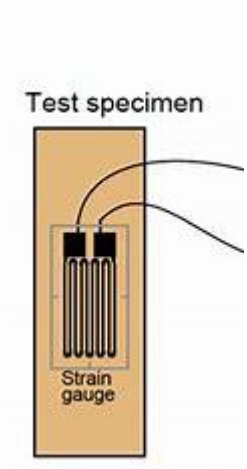
1) Strain gauges
2) Test specimen
3) Adhesive
4) Wiring to Connect DAS
5) Calibration equipment

THEORY

A strain gauge is a sensor used to measure the deformation or strain of an object subjected to an external force or load. It works on the principle that the electrical resistance of a wire changes when it is stretched or compressed

This information is crucial for understanding the mechanical behavior of materials and structures under different loading conditions. Strain gauges are widely used in various applications, including structural engineering, materials testing, biomechanics, and geotechnical monitoring.





PROCEDURE:

1) **SURFACE PREPARATION**

The surface where you'll attach the strain gauge should be clean, dry, and free from any contaminants. Use a solvent like alcohol to clean the surface thoroughly.

2) **SELECT LOCATION**

Choose the appropriate location on the structure or material where you want to measure strain. This should be a spot where strain is expected to be significant and representative of the overall behavior.

3) **SURFACE ROUGHENING**

Use a fine abrasive material or sandpaper to roughen the surface slightly. This helps the adhesive bond better with the surface.

4) **APPLY ADHESIVE**

Apply a thin layer of strain gauge adhesive to the prepared surface. Make sure to use an adhesive that is compatible with both the surface material and the strain gauge.

5) **ATTACH STRAIN GAUGE**

Carefully place the strain gauge on the adhesive-coated surface. Ensure that the gauge is aligned properly with the direction of strain and that it sits flat without any air bubbles trapped underneath.

6) **CURE ADHESIVE**

Allow the adhesive to cure according to the manufacturer's instructions. This usually involves applying pressure and letting it cure for a specific amount of time at a certain temperature.

7) WIRING

Once the adhesive has cured, carefully solder the lead wires of the strain gauge to the appropriate terminals. Be sure to follow the wiring diagram provided with the strain gauge and use proper soldering techniques to avoid damaging the gauge.

8) CALIBRATION

Before conducting experiments, it's essential to calibrate the strain gauge setup to ensure accurate measurements. This involves applying known loads or strains to the structure and comparing the gauge output to the expected values.

9) ANALYSIS AND REPORT

Collect the data from the strain gauge to DAS the analyze and prepare the report.

RESULT:

Thus the procedure for the strain gauge installation is studied and performed.

EXP NO : 3 DATE :	**MEASUREMENTS OF STRAIN USING STRAIN ROSETTES**

Aim:

To measure the value of strain at a point in the given specimen using strain rosette

APPARATUS REQUIRED

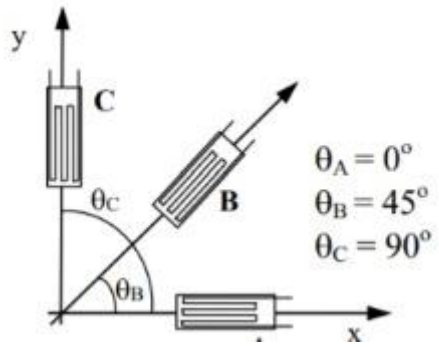
1) Strain gauge
2) Structural specimen
3) Strain indicator
4) Power supply
5) Multimeter

THEORY

Strain rosettes are specialized sensors that provide comprehensive understanding of the strain state at a specific Point on a structure.

The experiment aims to demonstrate the use of strain rosette in capturing both magnitude and directionality of strain.

DIAGRAM:



PROCEDURE

- Clean the surface thoroughly to ensure proper adhesion of the rosette and attach the strain rosette according to the manufacturer's Instructions ensuring Proper alignment with the principal strain direction.

- Use a single element strain gauge to calibrate the strain rosette and apply known strain to the specimen and measure the corresponding changes in resistance using a multimeter.
- Apply a known load or deformation to the structural specimen to induce strain, then use the strain rosette to measure the strain at the desired Point.

- Repeat the experiment with varying loads or deformation to attain the repeatability of values.

- Compare the results obtained from the strain rosette with those from single element Strain gauge to validate the accuracy of the rosette measurements.
- Analyze the strain data to determine the Principal strain and the orientations of principal strain axes.
- Compare the experimental results with theoretical results.

RESULT:

Thus, the measurements of strain in the given specimen were studied using strain rosettes.

EXP NO: 4 DATE:	CALIBRATION OF STRAIN GAUGES

AIM:

To do calibration of the Strain gauge

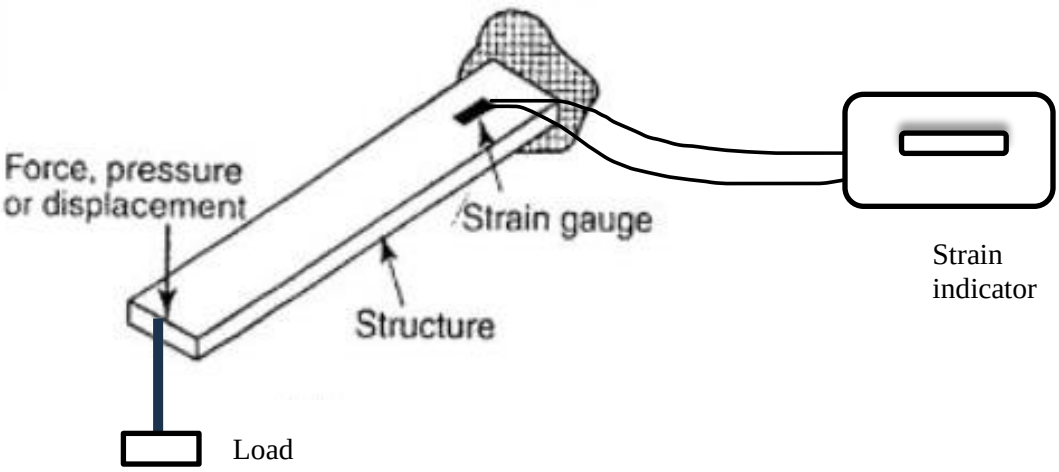
APPARATUS REQUIRED

- Strain gauge
- Strain indicator
- Loads
- Wirings to connect
- Data acquisition system (DAS)

PRACTICAL USES

Strain gauge calibration is a crucial step in ensuring the accuracy and reliability of strain measurements.

DIAGRAM



PROCEDURE

1. Ensure all apparatus are in working condition and free from any damage**.**
2. Set up the strain gauge, strain indicator, loads, wiring, and data acquisition system (DAS) in a controlled laboratory environment.
3. Apply no load to the strain gauge and adjust the strain indicator to zero.
4. Ensure that the strain gauge readings are stable and consistent at zero load.
5. Apply known loads incrementally to the specimen.
6. Record the readings displayed on the strain indicator for each applied load.
7. Compare the stress values with the theoretical values.
8. Ensure that the data acquisition settings are configured appropriately for accurate data collection and storage.

OBSERVATION

Location of the strain gauge attached in the test specimen =

TABULATION

SI.NO	Load (kg)	Strain	Stress

CALCULATION

RESULT :

Thus ,the strain gauge is calibrated successfully .

EXP NO: 5 DATE:	STRAIN MEASUREMENTS IN BEAMS

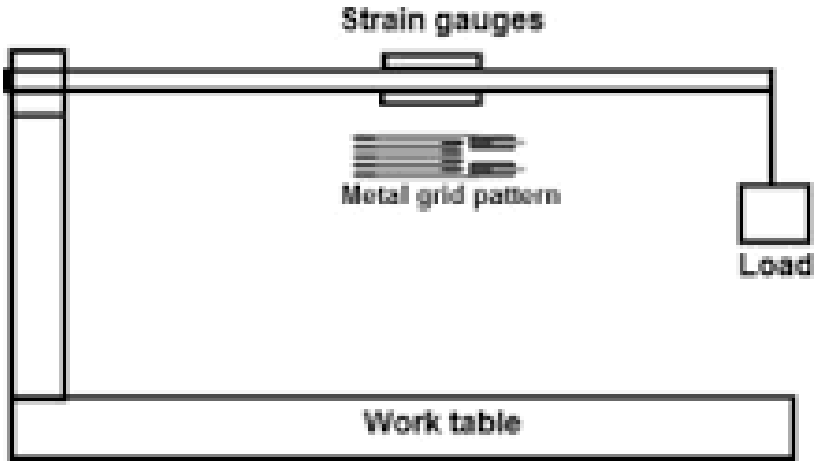
Aim:

To measure the strain in the given Beam.

Apparatus Required

1) Beam Specimen.
2) Strain gauge.
3) Data acquisition system.
4) Load application system.
5) Supports and fixtures.
6) weights or load cells.
7) Measuring instruments.

Diagram:



Procedure

- Measure the dimensions of the beam specimen and attach strain gauges to predetermined location on the beam.
- Calibrate the strain gauge and apply known Strain to the gauges and record the corresponding electrical readings using a data acquisition system.
- Apply load at different positions along the beam length and record the applied loads and measure the corresponding strain using strain gauges.
- Compare the measured strain with theoretical predication based on beam theory.

Observation

Length of the beam =
Width of the beam =
Thickness of the beam =

Tabulation

SI.NO	Load (kg)	Strain	Stress

Calculation

Result:

Thus the strain measurement on the beam are done by using the strain gauges.

EXP NO: 6 DATE:	DETECTION OF DEFECTS USING FLUORESCENT PENETRANT TESTING

AIM

To detect the defects using Fluorescent Penetrant testing method.

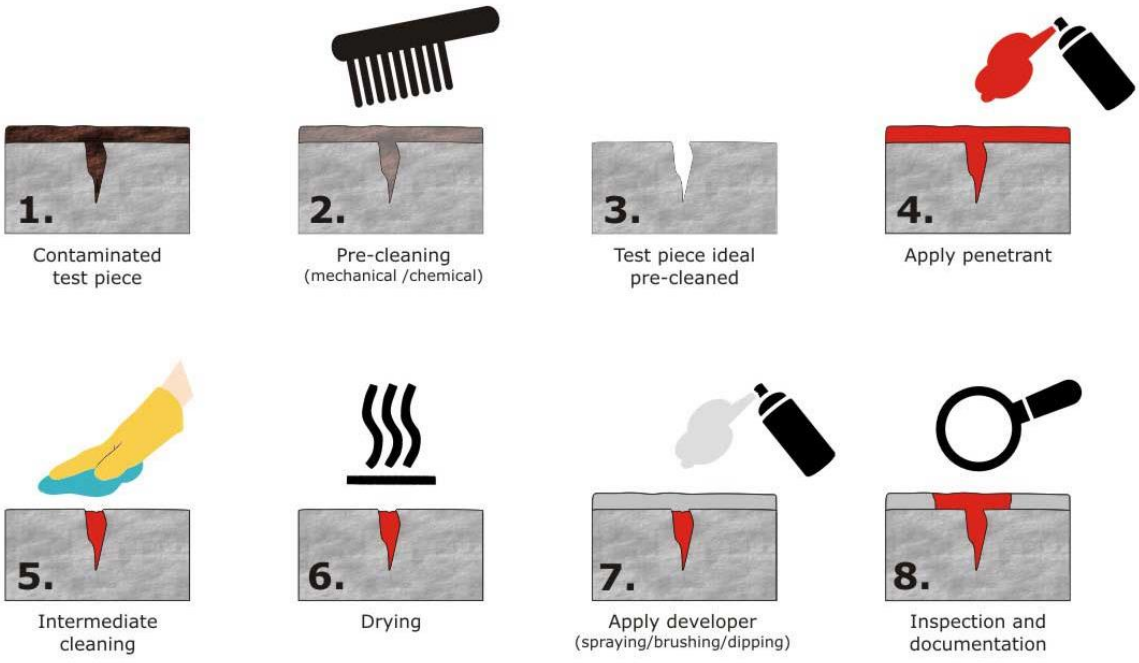
PARATUS REQUIRED

- Brush,
- Fluorescent penetrant,
- Excess penetrant removal emulsifier or water,
- Developer.

THEORY

Fluorescent penetrant testing (FPT), also known as dye penetrant inspection (DPI) or liquid penetrant inspection (LPI), is a non-destructive testing (NDT) method used to detect surface-breaking defects in non-porous materials. It's commonly employed in industries like aerospace, automotive, and manufacturing where the detection of defects is crucial for safety and quality assurance.

DIAGRAM:



PROCEDURE

1) **Initial cleaning:**

The specimen part must be free of dirt, rust, reals, oil, grease to perform a reliable Inspection.

The cleaning process must remove contaminants from the surface of the part and defects and must not plug any of the defects.

2) **Penetrant application:**

Many methods of application are possible such as brushing, spraying, flow and more.

The Penetrant reduction must be allowed to 'dwell' on the surface of the part to allow the penetrant, time to fill any defects present.

3) **Excess penetrant removal:**

The removal technique depends upon the type of

Penetrant used like,

- solvent removal.
- water washable.
- Post emulsifiable.

4) **Developer application.**

The method of developer application is in dependent on the type of developer used. The Primary method for the following main developer types are:

- Dry
- wet
- Non-aqueous lost.

5) **Inspection / Evaluation:**

The inspector Evaluates the penetrant indications against specified accept or reject criteria and attempt to determine the origin of the Indications.

6) **Post clean:**

The final step should clean the parts, the residual material should possibly affect the performance of the part or affect the visual appeal.

RESULT :

Thus, the process of detection of defects using fluorescent penetrant testing (FPT) were performed.

EXP NO: 7 DATE:	MAGNETIC PARTICLE TESTING

AIM

To detect the process of detection of defects using magnetic particle testing method.

PARATUS REQUIRED

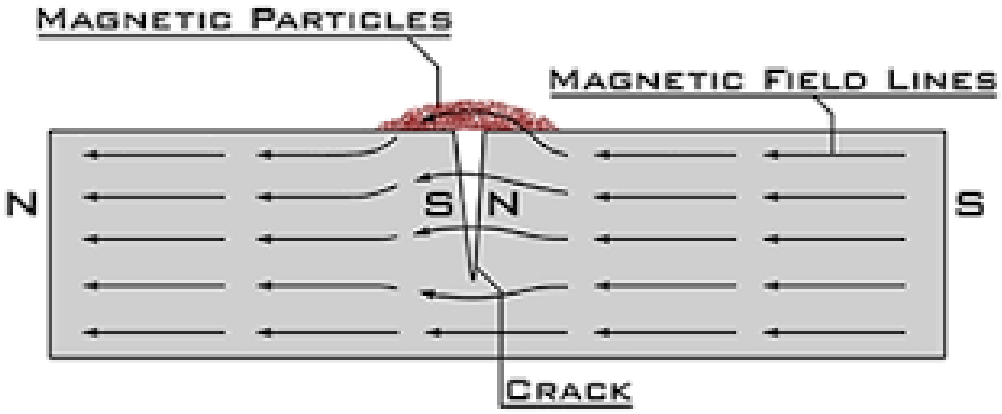
- Brush(Cleaning Equipment),
- Magnetic particles,
- Magnetic Particle Inspection Equipment,
- Magnetic Field Indicator.

THEORY

Magnetic particle testing (MPT), also known as magnetic particle inspection (MPI), is a non-destructive testing (NDT) technique used to detect surface and near-surface flaws in ferromagnetic materials. These materials include iron, nickel, cobalt, and some of their alloys.

A ferromagnetic test specimen is magnetized with a strong magnetic field created by a magnet on specified equipment. If the specimen has a discontinuity, it will be indicated by the magnetic field flowing through the specimen and leakage field will occur.

DIAGRAM:



PROCEDURE

1) **Components Pre-cleaning**

when inspecting a test part with the magnetic particle method it is essential for the Particle to have an un impacted path for migration to both strong and weak leakage field alike. The Part surface should be clean and dry before inspection.

contaminants such as oil, grease, prevent particle from being attracted to leakage fields, they may also interfere with interpretation of indications.

2) Introduction of magnetic field.

The required magnetic field can be introduced into a component in a number of different ways

- Using a permanent magnet or an electromagnet that contact the test pieces.
- Flowing an electrical current through the Specimen.
- Flowing an electrical current through a coil of wire around the part through a central conductor running near the part.

3) Application of magnetic media

MPI can be performed either dry particle or particle suspended in a liquid with dry method ,the Particle are lightly dusted on the surface with wet method, the part is flooded with a solution carrying the particle.

4) Interpretation of indication:

After applying the magnetic field, indications that form must interpreted.

This process requires that the inspector distinguish between relevant and non-relevant Indications

RESULT :

Thus, the process of detection of defects using Magnetic particle testing (MPT) were performed.