ME 372 : Heat Transfer and Metrology Lab

Exp No - 2B (Flatness Study using Optical Flat)

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Introduction

- An optical flat is a contact optical measurement device used in conjunction with a monochromatic light source to measure precision flat surfaces.
- An optical flat utilizes the property of interference to exhibit the flatness on a desired surface.
- They are mainly used to measure the flatness of precisely lapped and polished surface flat surfaces.
- Here we are going to perform the qualitative flatness test for slip gauges with the help of optical flat and monochromatic light source.

Monochromatic light source

- A monochromatic light, consisting of only a single wavelength, is used to illuminate the flats.
- Here, we are using sodium vapor lamp for producing monochromatic light of yellowish orange color with wavelength of 590 nm.
- To show the fringes properly, several factors need to be taken into account when setting up the light source, such as the angle of incidence between the light and the observer, the angular size of the light source in relation to the pupil of the eye, and the homogeneity of the light source when reflected off of the glass.

Optical flat

- Optical flat are circular piece of optical glass or quartz having both the faces flat and parallel and finished to the optical degree of flatness.
- Therefore, they are assumed as perfectly flat surface for performing flatness test.
- When an optical flat is laid over a flat reflecting surface, it orients at a small angle θ, because of the presence of air damper between the two surfaces.
- Optical flats are versatile optical components used in many applications, such as: inspection of gauge blocks for wear and accuracy, as well as the testing of various components including windows, prisms, filters, mirrors, etc.

Slip gauges

- Slip gauges (also known as **Gauge blocks**) are generally made up of hardened alloy steels that has been precision ground and lapped to a specific thickness.
- Slip gauges come in sets of blocks with a range of standard lengths and they are stacked to make up a desired length (or height).
- An important feature of gauge blocks is that they can be joined together with very little dimensional uncertainty.
- Slip gauges are mainly used for producing precision lengths. The blocks are joined by a sliding process called wringing, which causes their ultra-flat surfaces to cling together.

Working principle

- When an optical flat is placed upon another flat reflecting surface (without pressure), it will not form an intimate contact but will lie at some angle making an inclined plane.
- When an optical flat is placed upon another flat reflecting surface (without pressure), it will not form an intimate contact but will lie at some angle making an inclined plane.
- If the optical flat is illuminated by a monochromatic light source, and the eye is placed in proper position, a number of bands will be observed

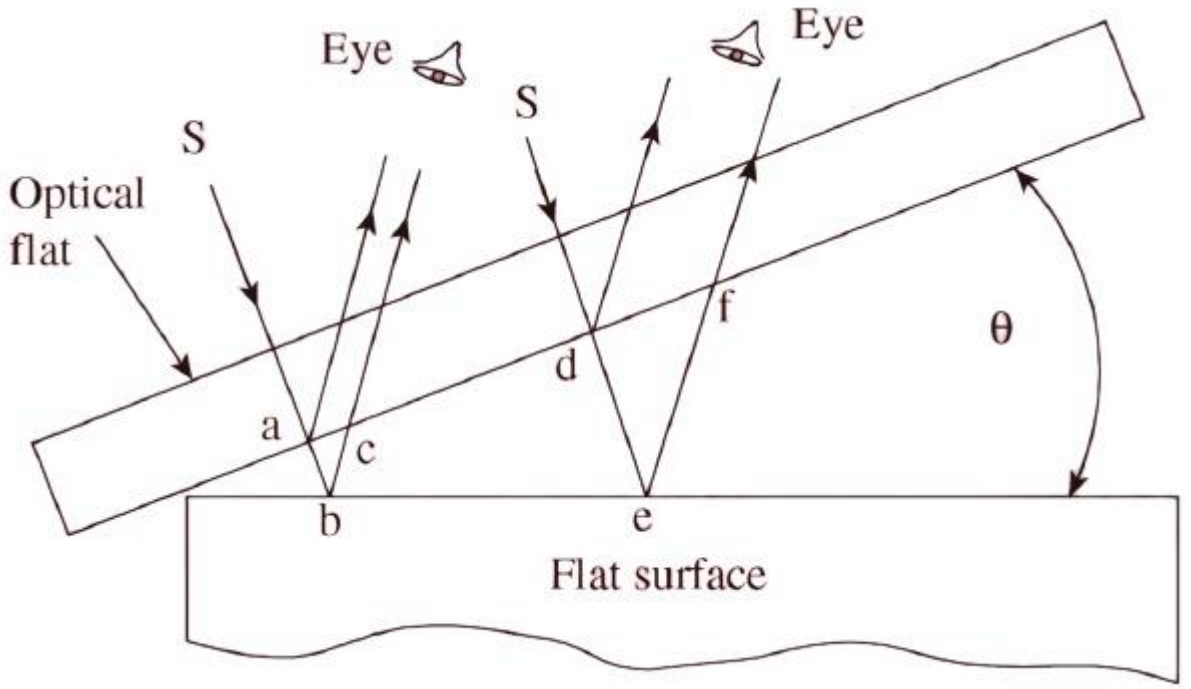


Figure: Principle of interferometry

Working principle

- These bands are produced by the interference of light rays reflected from the top surface of the surface being inspected and lower surface of the optical flat.
- It the path length of these two rays differ by an odd number of half wavelength, then the condition of complete interference is achieved and a straight dark fringe is observed.
- If the path difference is even multiple of half wavelength, then the component of light rays will be in phase producing a light band.
- Thus for perfectly flat surface, alternate bright and dark bands will be seen.
- Any deviation from this will be a measure of the error in the flatness of the surface.

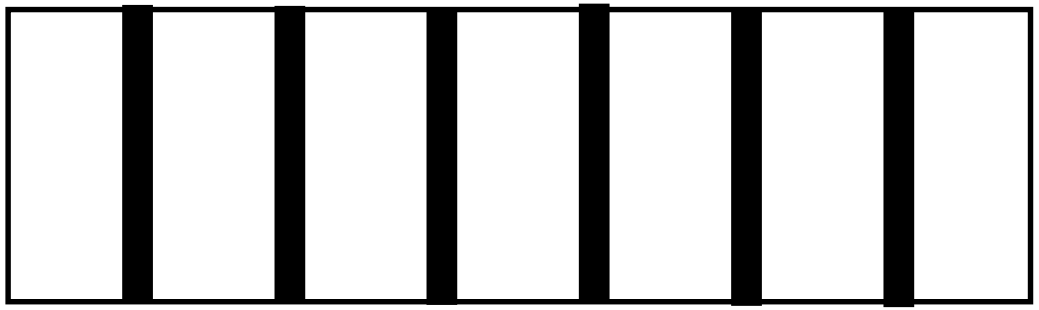
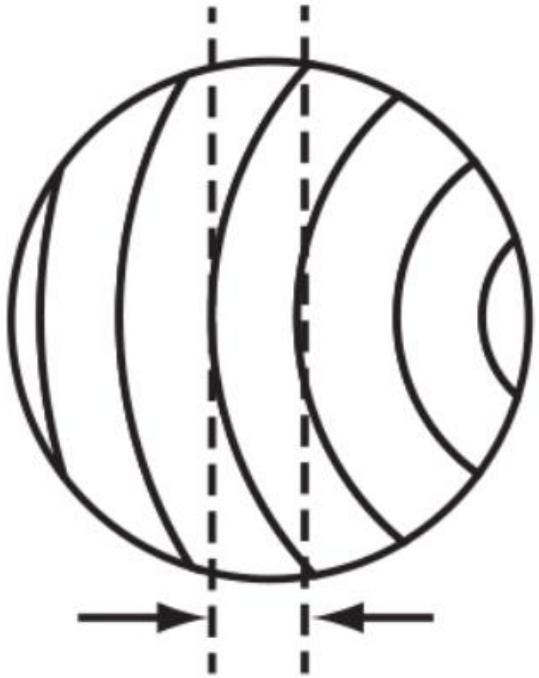


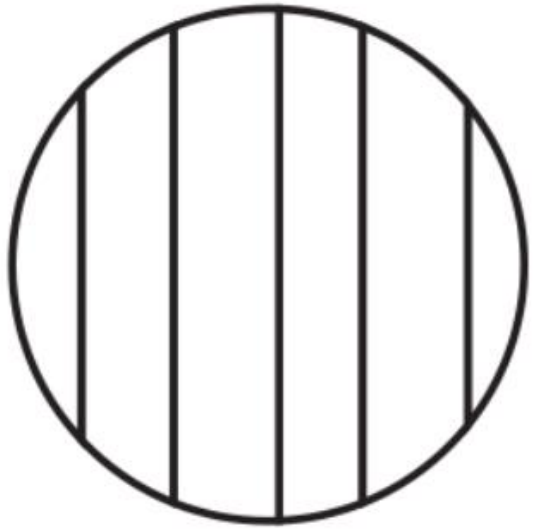
Figure: Interference fringes on a flat surface viewed under an optical flat in a parallel beam of monochromatic light

Working principle

- The number of bands which appear is not an indication of the flatness of the surface but relates only to the steepness of the wedge.
- The amount that the bands curve, with reference to the distance between them, indicates the amount of flatness error.
- In judging the amount of curvature, imagine a line drawn across the surface from one end of any band to the other end of that same band.
- If this line just touches the previous band the flatness error is 1 band. If it comes half way between the two bands the error is 1/2 band



Flatness error of one fringe (λ/2)



Test piece perfectly flat

Procedure

1. **Preparation**:
   - Both the optical flat and the surface to be tested need to be extremely clean. The tiniest bit of dust settling between the surfaces can ruin the results.
   - Most commonly, acetone is used as the cleaning agent, because it dissolves most oils and it evaporates completely, leaving no residue. Lint-free cloth is also used for cleaning purpose.
2. **Lighting:** Switch on the monochromatic light source and wait till light become saturated.
3. Place the cleaned sample (slip gauge) for which flatness test has to be performed and then optical flat above it under the monochromatic light source.
4. Observe the fringes pattern and make conclusion of surface flatness.

Results and Conclusions

1. Observed different fringe patterns for five different sample will be provided.
2. Sketch the fringes and draw the conclusion of surface shape.
3. Compare the flatness error for all the samples.

Additional Questions:

Ques 1: What is the phenomena of wringing ?

Ques 2: How the amount of flatness error can be measured using optical flats?

Ques 3: What kind of fringes are obtained if test surface is convex? And how will you confirm that surface is convex?

Ques 4: When vapor lamp is switched on, initially it emits light yellow light and after saturation, light changes to yellowish orange. What variation is there in the fringes if we observe the fringes initially and after light saturation for same sample?

Report requirements

- Introduction
- Objective
- Experimental setup
- Principle of working (Interference effect)
- Procedure
- Sketch different type of patterns possible using optical flat along with their interpretation
- Attach answer of question given additionally (provided on the day of experiment)
- Results and conclusions (for five fringes pattern provided)
- Sources of error