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Department of Mechanical Engineering

ME 222A

Nature and Properties of Material

Lab Report

Experiment No. : 7

Study of Surface Roughness

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Objective:-

To study and record the surface roughness of three given samples i.e. Mild Steel, Aluminium and Brass.

Importance of Experiment:-

The shape and size of irregularities on a machined surface have a major impact on the quality and performance of that surface, and on the performance of the end product. The quantification and management of fine irregularities on the surface, which is to say, measurement of surface roughness, is necessary to maintain high product performance. Quantifying surface irregularities means assessing them by categorizing them by height, depth, and interval. They are then analyzed by a predetermined method and calculated per industrial quantities standards.

Theory:-

Surface roughness often shortened to roughness, is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. Roughness is typically considered to be the high-frequency, short-wavelength component of a measured surface. Roughness plays an important role in determining how a real object will interact with its environment. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces. Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion. On the other hand, roughness may promote adhesion.

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However, controlled roughness can often be desirable. For example, a gloss surface can be too shiny to the eye and too slippery to the finger (a touchpad is a good example) so a controlled roughness is required. This is a case where both amplitude and frequency are very important.

Hence, it is quite useful to measure and have an idea of the roughness value of the sample we are dealing with to have a better idea of its performance.

A roughness tester is used to quickly and accurately determine the surface texture or surface roughness of a material. A roughness tester shows the measured roughness depth (Rz) as well as the mean roughness value (Ra) in micrometers or microns (µm). Measuring the roughness of a surface involves applying a roughness filter. Different international standards and surface texture or surface finish specifications recommend the use of different roughness filters.

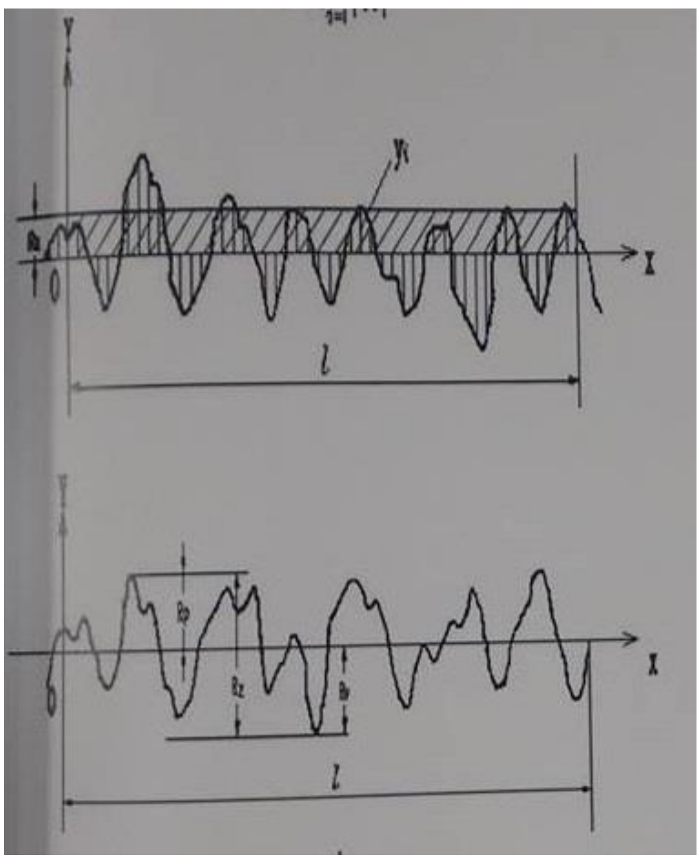

Figure 1 – Surface texture (Marked with surface parameters)

In this experiment we will use QUALISURF Surface Roughness Tester which have high accuracy, wide range of application, simple operation and stable performance. It is widely applicable in testing surfaces of all kind of metals and non-metals. It uses the principle of Cantilever in order to measure the roughness of the surface.When the pickup driven by a driver is making a linear uniform motion along the test surface, the contact stylus in perpendicular with the work surface is moving up and down on the work surface. Its motion is converted into electric signals, which are amplified, filtered and transformed into digital signals through A/D. The signals are then processed by the DSP into Ra and Rz values before displayed on the screen.

$$R_{\mathrm{a}} = \frac{1}{n}\sum_{i=1}^{n} |y_i|$$ [3]

$$R_{\mathrm{q}} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^2}$$ [3]

$$R_{\mathrm{t}} = R_{\mathrm{p}} + R_{\mathrm{v}}$$

$$R_{\mathrm{v}} = \min_i y_i$$

$$R_{\mathrm{p}} = \max_i y_i$$

Some terminology related to this experiment:-

Measurement unit: Micrometre (µm)

- **<u>Ra</u>**: Arithmetical Mean Deviation of the profile within the sampling length
- **<u>Rz</u>**: The maximum height of irregularities given by the distance between maximum height of the profile peaks and maximum depth of the profile valley within the sampling length

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- **<u>Rq</u>**: Root-Mean-Square Deviation of the profile. Rq is the square root of the arithmetic means of the squares the profile deviation (Yi) from mean within the sampling length
- **<u>Rt</u>**: Total Peak-to-Crest Height

<u>Device and its Specifications</u>:-

Figure 2 - Qualisurf (Front View)

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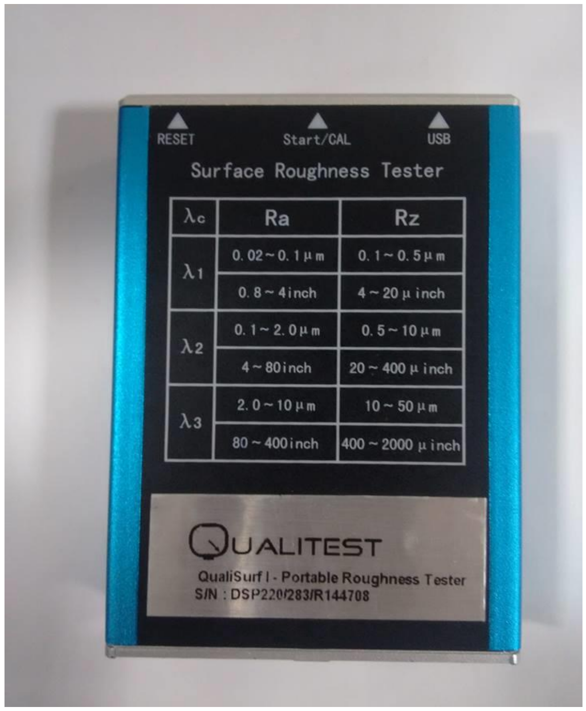

Figure 3 – Qualisurf (Back view)

Figure 4 – Qualisurf (Bottom view)

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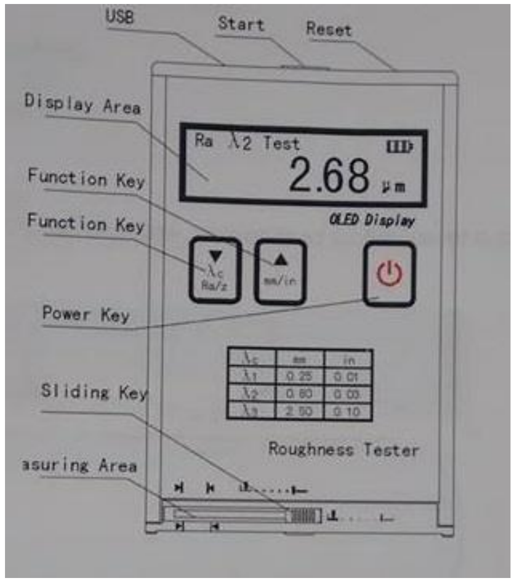

Figure 5 – Device Specification

Sample sused for experiment:-

Figure 6 – Aluminium sample

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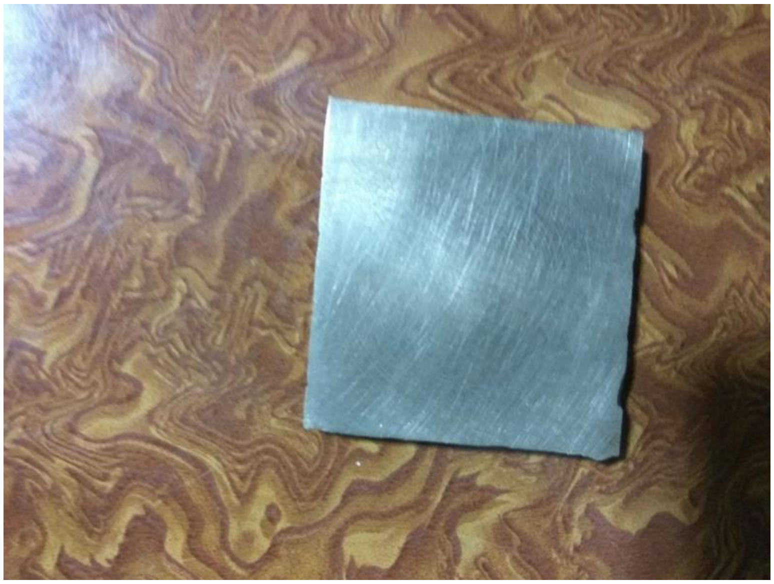

Figure 7 – Mild Steel Sample

Figure 8 – Brass sample (right most)

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Experimental condition:-

- Travelling length = 6mm
- Measurement range(µm)
  R_a: 0.05- 10
  R_z: 0.1- 50
- Tolerance: ±15%
- Variation of indication < 12%
- Touch needle tip arc radius and angle of sensor
  Tip arc radius: 10µm ± 1µm
  Angle: 90^{+5}_{-10}

- The sensor touch needle static force measurement and its rate
  Touch needle static force measurement: ≤ 0.016N
  Force measurement rate: ≤ 800N/m

Sensor guide head pressure: < 0.05N

Procedure:-

- Take the sample material and calibrate the machine using this sample and its indicated value
- Verify this callibration by putting this device over the specified region on the sample.
- Take 3 readings and verify thai it is properly calibrated
- Now, take first sample and specify the region whose roughness is to be measured
- Put the device over specified region and take the reading
- Repeat this until we get the four readings whose difference of maxima and minima doesn’t go beyond 0.05 µm

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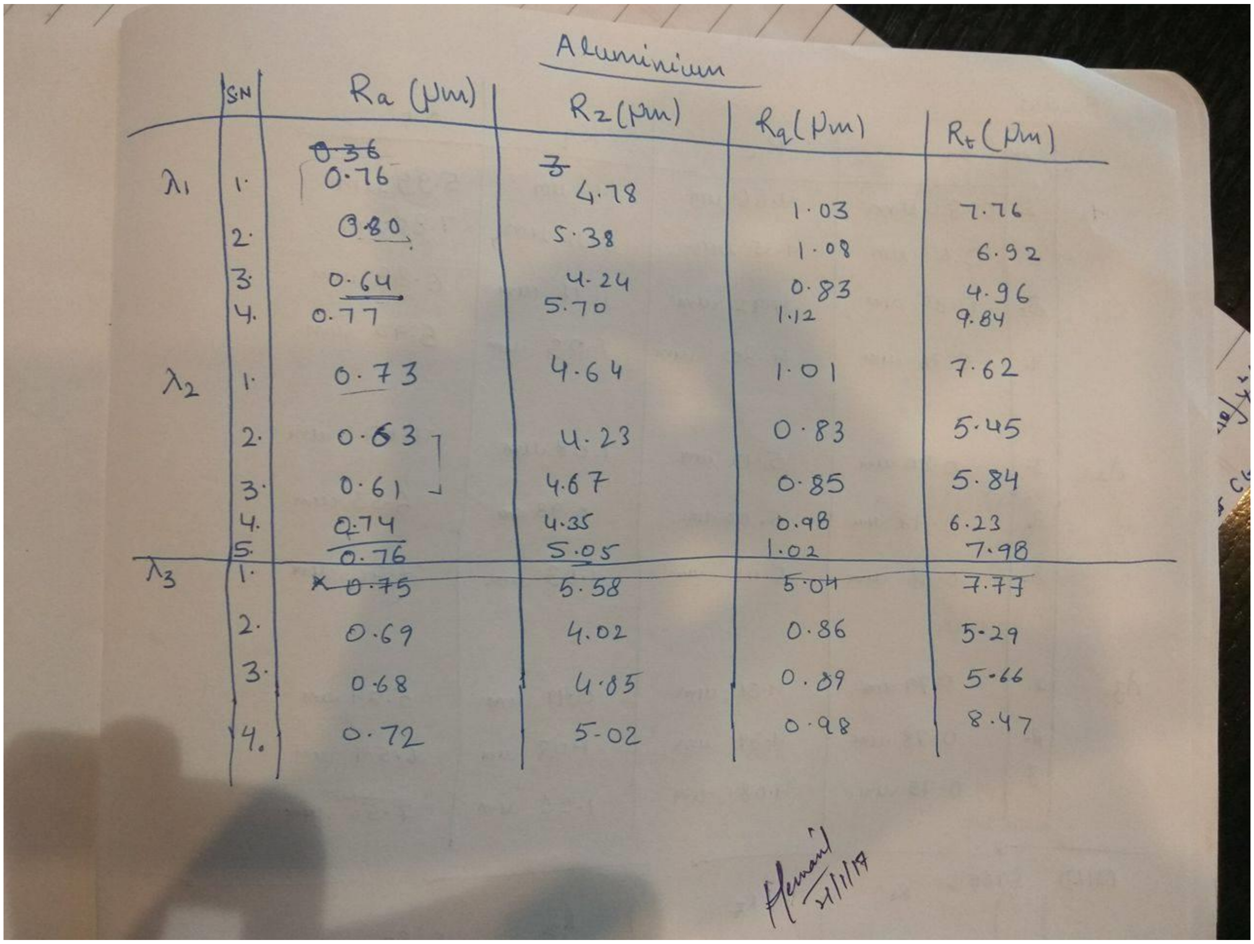
- Repeat this process over other two samples and note down their reading.

Observation:-

Material	S. No.	Ra(µm)	Rz(µm)	Rq(µm)	Rt(µm)	λ(µm)
Brass	1	0.67	4.35	0.92	7.85	$\lambda 2$
	2	0.89	4.92	1.16	6.89	
	3	0.76	4.80	1.03	6.90	
	1	0.80	5.12	1.08	7.07	$\lambda 1$
	2	0.72	5.00	0.98	6.53	
	3	0.76	5.05	1.03	7.76	
	1	0.79	4.31	0.99	5.24	$\lambda 3$
	2	0.78	4.39	1.02	6.54	
	3	0.75	4.08	1.06	7.50	
Mild Steel	1	0.33	2.38	0.46	4.49	$\lambda 1$
	2	0.32	2.31	0.42	3.02	
	3	0.35	2.81	0.49	3.50	
	1	0.37	2.34	0.47	2.99	$\lambda 2$
	2	0.32	2.32	0.41	3.28	
	3	0.42	2.65	0.53	3.95	
	1	0.39	2.49	0.49	3.31	$\lambda 3$
	2	0.34	2.34	0.43	3.10	
	3	0.42	2.92	0.58	4.21	
Aluminium	1	0.76	4.78	1.03	7.76	$\lambda 1$
	2	0.80	5.38	1.08	6.92	
	3	0.77	5.70	1.12	9.84	
	1	0.73	4.64	1.01	7.62	$\lambda 2$
	2	0.74	4.35	0.98	6.23	
	3	0.76	5.05	1.02	7.98	
	1	0.69	4.02	0.86	5.29	$\lambda 3$
	2	0.68	4.05	0.89	5.66	
	3	0.72	5.02	0.98	8.47	



Aluminium

	SN	R_a (μm)	R_z (μm)	R_q (μm)	R_t (μm)
λ_1	1.	~~0.36~~ 0.76	~~3~~ 4.78	1.03	7.76
	2.	0.80	5.38	1.08	6.92
	3.	0.64	4.24	0.83	4.96
	4.	0.77	5.70	1.12	9.84
λ_2	1.	0.73	4.64	1.01	7.62
	2.	0.63	4.23	0.83	5.45
	3.	0.61	4.67	0.85	5.84
	4.	0.74	4.35	0.98	6.23
	5.	0.76	5.05	1.02	7.98
λ_3	1.	× ~~0.75~~	5.58	5.04	7.77
	2.	0.69	4.02	0.86	5.29
	3.	0.68	4.85	0.89	5.66
	4.	0.72	5.02	0.98	8.47

Figure – Observation table of Aluminium

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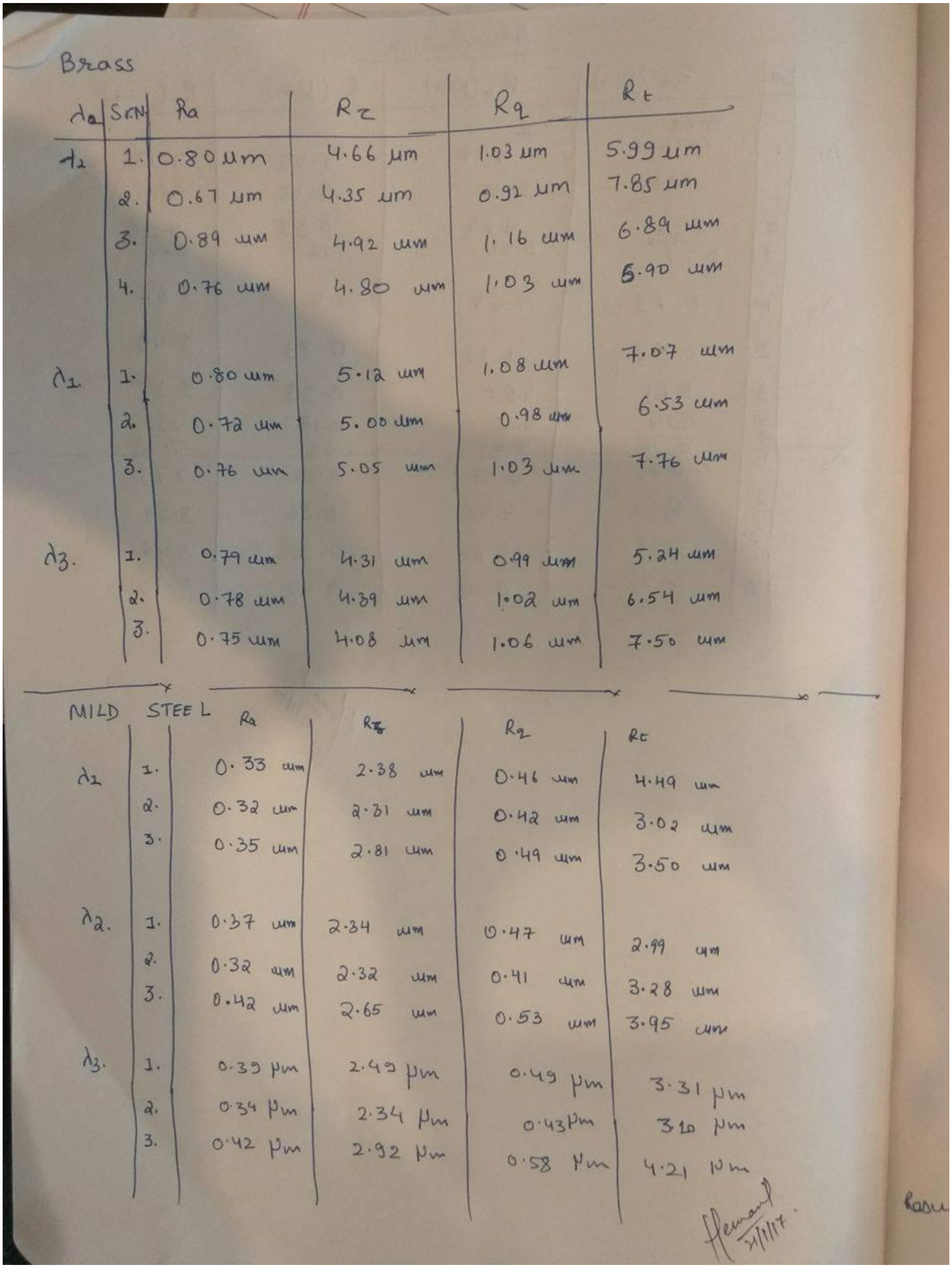

Brass

λ	S.N.	Ra	Rz	Rq	Rt
λ_2	1.	0.80 μm	4.66 μm	1.03 μm	5.99 μm
	2.	0.67 μm	4.35 μm	0.92 μm	7.85 μm
	3.	0.89 μm	4.92 μm	1.16 μm	6.89 μm
	4.	0.76 μm	4.80 μm	1.03 μm	5.90 μm
λ_1	1.	0.80 μm	5.12 μm	1.08 μm	7.07 μm
	2.	0.72 μm	5.00 μm	0.98 μm	6.53 μm
	3.	0.76 μm	5.05 μm	1.03 μm	7.76 μm
λ_3	1.	0.79 μm	4.31 μm	0.99 μm	5.24 μm
	2.	0.78 μm	4.39 μm	1.02 μm	6.54 μm
	3.	0.75 μm	4.08 μm	1.06 μm	7.50 μm

MILD STEEL

λ	S.N.	Ra	Rz	Rq	Rt
λ_1	1.	0.33 μm	2.38 μm	0.46 μm	4.49 μm
	2.	0.32 μm	2.31 μm	0.42 μm	3.02 μm
	3.	0.35 μm	2.81 μm	0.49 μm	3.50 μm
λ_2	1.	0.37 μm	2.34 μm	0.47 μm	2.99 μm
	2.	0.32 μm	2.32 μm	0.41 μm	3.28 μm
	3.	0.42 μm	2.65 μm	0.53 μm	3.95 μm
λ_3	1.	0.39 μm	2.49 μm	0.49 μm	3.31 μm
	2.	0.34 μm	2.34 μm	0.43 μm	3.10 μm
	3.	0.42 μm	2.92 μm	0.58 μm	4.21 μm

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Figure – Observation table of brass and Mild steel

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Calculation:-

For $\lambda 2$

Brass

Ra(1)= 0.67 µm

Ra(2)=0.89 µm

Ra(3)=0.76 µm

$$Ra(average) = \frac{Ra(1)+ Ra(2)+ Ra(3)}{3}$$

$$= 0.773µm$$

Aluminium

Ra(1)= 0.73 µm

Ra(2)=0.74 µm

Ra(3)=0.76 µm

$$Ra(average) = \frac{Ra(1)+ Ra(2)+ Ra(3)}{3}$$

$$= 0.743µm$$

Mild Steel

Ra(1)= 0.37 µm

Ra(2)=0.32 µm

Ra(3)=0.42 µm

$$Ra(average) = \frac{Ra(1)+ Ra(2)+ Ra(3)}{3}$$

$$= 0.37µm$$

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Discussion:-

Through this experiment we measured the surface roughness of few samples provided to us using the instrument 'Qualisurf'. The instrument works on the principle of cantilever and has a movable cantilever head which helps measure the roughness value. Using the instrument we measured the various parameters as average, root mean square etc. values related to surface roughness. During the experiment many errors happened, so we take more than three readings, if the results of a particular reading are more deviated then the results of other two readings.

Conclusion:-

- Roughness of Aluminium Sample = (0.743) µm

  Roughness of Mild Steel Sample = (0.37) µm

  Roughness of Brass Sample = (0.773) µm
- Order of roughness of material Brass > Aluminium > Mild Steel
- Most rough material is Brass
- Least rough material is Mild steel

Precautions:-

- The device should be calibrated before testing the samples
- Reading should be taken from the same spot on the sample to avoid deviations in results

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- The moving head of the cantilever should make perfect contact with the sample
- The set of readings taken must be convergent

Reference:-

- William D. Callister, Jr., and David G. Rethwisch, Material Science and Engineering an Introduction, 8th Ed.
- Fundamentals of material science and engineering by William D. Callister, Jr. 4th edition.
- Wikipedia