Surface Finish

Introduction:

Since machining is often the manufacturing process that determines the final geometry and dimensions of the part, it’s also determines the part’s surface texture. Surface roughness of a machined surface depends on: (a) geometrical factors, (b) work material factors, and (c) vibrations and machine tool factors.

The two most important factors affecting the surface finish are tool geometry (nose radius) and the feed (Figure 5.1). The effect of nose radius and feed can be combined in an equation to predict the ideal average roughness for a surface produced by a single-point tool. The equation applies to operations like turning, shaping, and planning:

\[
R_i = \frac{f^2}{32R}
\]

Where \( R_i \) is theoretical arithmetic average surface roughness (in or mm), \( f \) is feed (in or mm), and \( R \) is nose radius on the tool point (in or mm).

![Figure 5.1. Effect of geometric factors on the theoretical surface finish: (a) nose radius, (b) feed, and (c) end cutting-edge angle (ECEA).](image)

Ideal surface roughness \( (R_i) \) represents the best possible surface finish that can be obtained with a given tool shape and feed, and can only be approached if built-up edge (BUE) formation, chatter, inaccuracies in the machine tool movement, etc., are eliminated. Quantitatively, it is useful to express the roughness in terms of a single parameter, i.e. the arithmetical mean value. Built-up edge is one of the main factors that contributes to surface roughness. Increasing speed, increasing rake angle, and adding a suitable machining lubricant would be expected to diminish the built-up edge effects. Other factors that affect surface roughness include chatter, inaccuracies in machine tool movements, work material defects, discontinuous-chip formation, and surface damage caused by chips.
Surface Finish

In most machining operations, ideal surface finish cannot be achieved because of factors related to the work material and its interaction with the tool. An empirical ratio ($r_{ai}$) can be developed to covert the ideal roughness value into an estimate of the actual surface roughness (Figure 5.2). This ratio takes into account BUE, tearing, and other factors. Actual surface roughness can be predicted by the following equation:

$$R_a = r_{ai} R_i$$

where $R_a$ is the estimated value of actual roughness; $r_{ai}$ is the ratio of actual to ideal surface finish; and $R_i$ ideal roughness value calculated. Ratio of

Figure 5.2. Ratio of actual surface roughness to ideal surface roughness.

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. Although roughness is usually undesirable, it is difficult and expensive to control in manufacturing. Decreasing the roughness of a surface will usually increase exponentially its manufacturing costs. This often results in a trade-off between the manufacturing cost of a component and its performance in application.
Objective:
The purpose of this investigation is to study the effects of cutting tool geometry and cutting conditions (speed and feed) on surface finish.

Equipment & Materials:
1. Engine Lathe (SUMMIT)
2. Mitutoyo Surftest
3. Carbide Turning Inserts with nose radii of .0157” and .0313”
4. Workpiece: 6061 Aluminum
5. Caliper or Micrometer

Procedure:
1. Machin use demonstration in lab.
2. Initially use the carbide insert with 1/64” nose radius
3. Adjust the speed (RPM) of the machine tool according to these specifications;
   a. Set RPM at 500, first cut 5 IPM, second cut 10 IPM
   b. Set RPM at 1000 and repeat with the same feed rates
4. Change the cutting tool to the carbide with the 1/32” nose radius and repeat the above steps.
5. Inspect the surface finish instrument and insure that it is set for µinch units and .03” measurement range.
6. Use the calibration standard supplied to check the instrument. It is OK if the reading is within ±2% of the standard. Turn the sample 90°, scan, record. Is it different? Why?
7. Hold the scanner with its length parallel to the axis of the bar. Scan each section at 4 positions around the circumference. Scan the eight sections of the sample bar and record. Explain the variation in values obtained from the eight sections.
8. The equations for $R_{\text{max}}$ and $R_a$ are provided below

$$R_{\text{max}} = \frac{f^2}{8R}$$

$$R_a = \frac{f^2}{32R}$$

where $R_{\text{max}}$ is the maximum peak-to-valley roughness (in.); $R_a$ is the theoretical center-line-average roughness (in.); $f$ is the feed (in/rev) and $R$ the nose radius in inches. Record on the data chart.

Compute and record in the sheet:
   a. Arithmetic Average
      $$R_{\text{ave}} = \frac{(a+b+c+d+......)/n}{n}$$
   b. Root-mean-square average
      $$R_{\text{rms}} = \sqrt{\frac{(a^2 + b^2 + c^2 + d^2 + ......)/n}{n}}$$

where all ordinates, a, b, c,......, are absolute values.

Lab Deliverables:
1. Prepare a report detailing the lab activity, observations, results and difficulties faced (follow the lab report instructions).
2. Discuss the effects of nose radius, speed and feed on surface roughness based on observations and recorded data.
3. Record all the values in the sheet provided. Compare recorded and calculated values of actual surface roughness.
4. Discuss the effect of using “RMS v/s. Arithmetic Average” to calculate averages (in general). What would be the effect on roughness values if \( R_i \) were computed using an RMS average?

References: