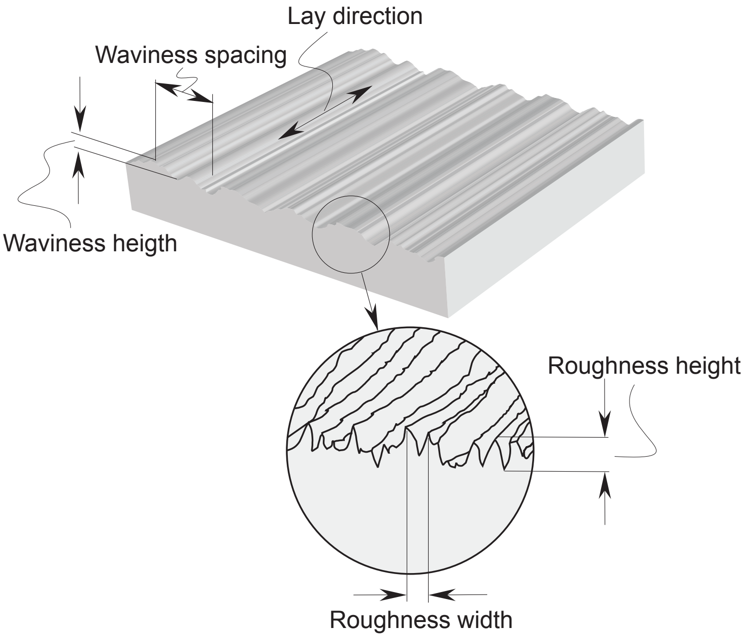
5.7 SURFACE FINISH

Introduction

The machining processes generate a wide variety of surface textures. Surface texture consists of the repetitive and/or random deviations from the ideal smooth surface. These deviations are

- *roughness*: small, finely spaced surface irregularities (micro irregularities)
- *waviness*: surface irregularities of grater spacing (macro irregularities)
- *lay*: predominant direction of surface texture



Elements of the machined surface texture

Three main factors make the surface roughness the most important of these parameters:

1. *Fatigue life*: the service life of a component under cyclic stress (fatigue life) is much shorter if the surface roughness is high
2. *Bearing properties*: a perfectly smooth surface is not a good bearing because it cannot maintain a lubricating film.
3. *Wear*: high surface roughness will result in more intensive surface wear in friction.

Surface finish is evaluated quantitatively by the average roughness height, R_a.

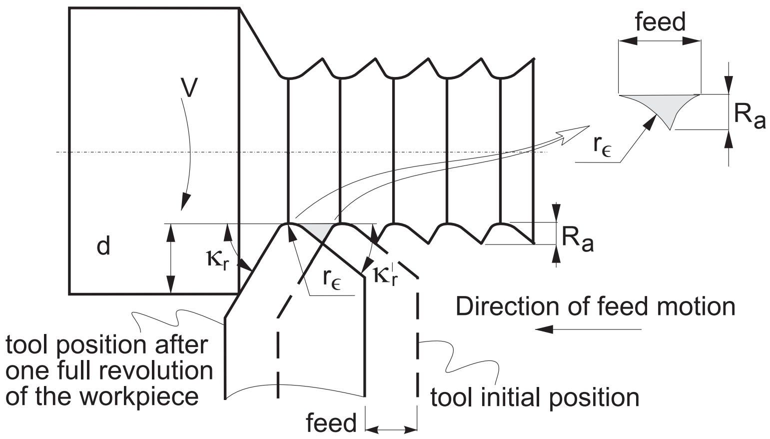
Roughness control

Factors, influencing surface roughness in machining are

- *tool geometry* (major cutting edge angle and tool corner radius),
- *cutting conditions* (cutting velocity and feed), and
- *work material properties* (hardness).

Feed marks

During cutting with a single point cutting tool (e.g. turning), the tool leaves a spiral profile on the machined surface as it moves across the workpiece, so called *feed marks*. The height of the feed marks is nothing but the surface roughness height and can be assumed equal to R_a. From the figure, it is evident that the feed and the geometry of the cutting tool determine the value of R_a:



Definition of the average surface roughness height R_a

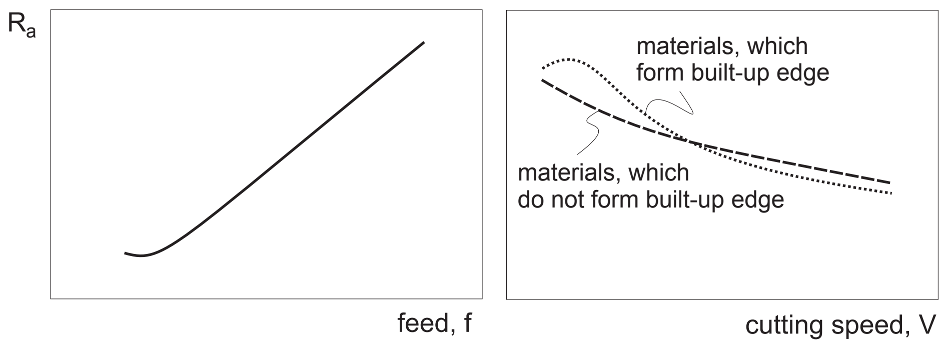
From geometrical considerations, the theoretical surface roughness $R`_a$ is approximately defined by

$$R`_a = f^2/32r_\epsilon$$

where f is the feed, and r_ϵ is the tool corner radius.

In case of machining with multi-point cutting tools or abrasive tools, the geometrical considerations are much more complex but the general tendency is the same.

From the above equation, it follows that feed is the primary machining parameter to change in order to control the surface roughness as far as changing the tool corner radius is much less convenient. The other process parameters - cutting speed, rake angle, and work material hardness, also influence the surface finish although not to the same extend as feed. The relationships between surface roughness and cutting conditions are shown in the figures:



Surface roughness versus cutting speed and feed

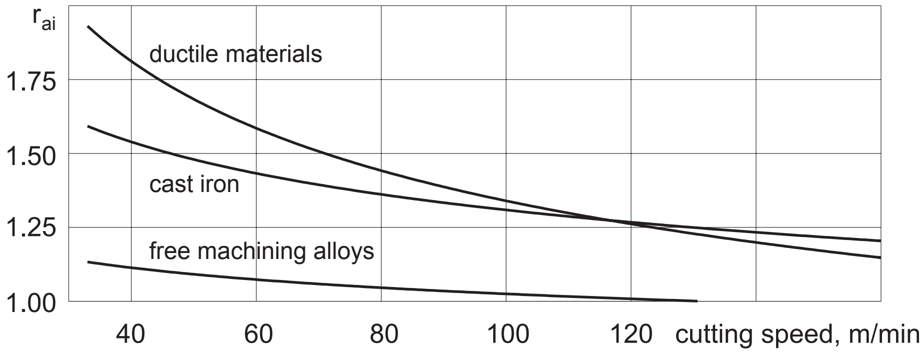
For very low feeds, surface roughness worsens. The reason is a change in the nature of metal cutting process. The influence of cutting speed is more complex for materials, which tend to form built-up edge at low speeds. The influence of built-up edge on surface finish is discussed in *Section 5.2 Mechanics of Machining*. Depth of cut has secondary effect on surface finish.

One major conclusion could be drawn from the above figures - best surface finish is achieved when cutting at high speed with low feed, a combination typical for finishing machining.

The influence of the other process parameters is outlined below:

- Increasing the *tool rake angle* generally improves surface finish
- Higher *work material hardness* results in better surface finish
- *Tool material* has minor effect on surface finish.
- *Cutting fluids* affect the surface finish changing cutting temperature and as a result the built-up edge formation.

The cumulative effect of these and other process parameters can be taken into account by an empirical correction coefficient r_{ai} defined from the next figure:



Correction coefficient to account for the influence of work material and cutting speed on surface finish

The corrected value of R_a is calculated as

$$R_a = r_{ai} R`_a$$

where the theoretical surface roughness $R`_a$ is defined as shown before.