5.9 MACHINABILITY

Introduction

Machinability is a term indicating how the work material responds to the cutting process. In the most general case good machinability means that material is cut with good surface finish, long tool life, low force and power requirements, and low cost.

A closer definition of machinability requires that some quantitative judgements be made. Several possibilities are available, but in practice so called machinability index is often quoted. The machinability index K_M is defined by

$$K_M = V_{60}/V_{60R}$$

where V_{60} is the cutting speed for the target material that ensures tool life of 60 min, V_{60R} is the same for the reference material. Reference materials are selected for each group of work materials (ferrous and non-ferrous) among the most popular and widely used brands.

If $K_M > 1$, the machinability of the target material is better that this of the reference material, and vice versa. Note that this system can be misleading because the index is different for different machining processes.

Example: Machinability rating

The reference material for steels, AISI 1112 steel has an index of 1. Machining of this steel at cutting speed of 0.5 m/s gives tool life of 60 min. Therefore, $V_{60R} = 0.5$ m/s.

For the austenitic 302 SS steel, the machinability index is $K_M = 0.23/0.5 = 0.46$ (tool life of 60 min for 302 SS is reached for cutting at 0.23 m/s).

For a tool life of 60 min, the AISI 1045 steel should be machined at 0.36 m/s. Hence, the machinability index for this steel is $K_M = 0.36/0.5 = 0.72$. This index is smaller than 1, therefore, AISI 1045 steel has a worse workability than AISI 1112, but better than 302 SS.

So, we can rate these steels in a descending order of machinability: AISI 1112→AISI 1045→302 SS

Machinability of different materials

Steels

- *Leaded steels*: lead acts as a solid lubricant in cutting to improve considerably machina bility.
- *Resulphurized steels*: sulphur forms inclusions that act as stress raisers in the chip formation zone thus increasing machinability.
- *Difficult-to-cut steels*: a group of steels of low machinability, such as stainless steels, high manganese steels, precipitation-hardening steels.

Other metals

- *Aluminum*: easy-to-cut material except for some cast aluminum alloys with silicon content that may be abrasive.
- *Cast iron*: gray cast iron is generally easy-to-cut material, but some modifications and alloys are abrasive or very hard and may cause various problems in cutting.
- *Cooper-based alloys*: easy to machine metals. Bronzes are more difficult to machine than brass.

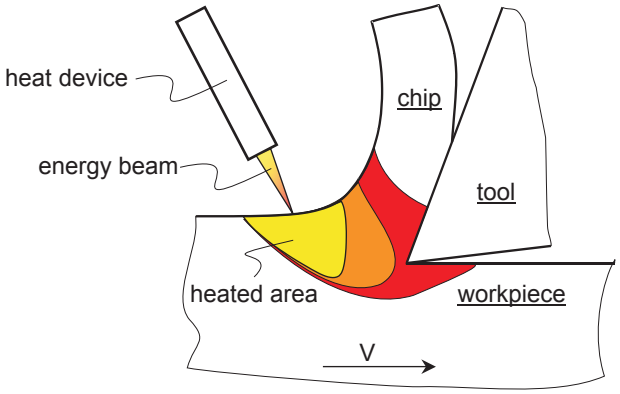
Methods for improvement of machinability

Adding some elements

Adding lead and sulphur to obtain so-called *free-machining steels*.

Thermally assisted machining

To relieve machining of *difficult-to-cut materials,* some heat can be added to the cutting zone to lower shear strength of work material. The heat source is a oxyfuel torch, laser beam or plasma arc, focused on an area just ahead of the cutting tool:



Oxyfuel torch used for thermally-assisted machining

Although effective, thermally-assisted machining has a limited practical application because of the high cost and difficult process control.