Circular Metal Cutting Saw Blade

Wear Characteristics & Failure Mechanisms

Demands

Choosing the right steel for the application becomes more and more important as the demands on the saw blade increase. What are these demands?

- the saw blade must have sufficient wear resistance.
- the saw blade must perform reliably. It should not fail due to premature cracking or dulling.

Optimal tooling economy is the lowest possible tooling costs per part produced. It may only be achieved if the correct steel for the application in question is used.

Performance

The performance of a saw blade depends on many factors. Many of these are shown in Figure 1. The performance of a saw blade is often monitored by examining the quality of the parts it produces. In most applications, there are special requirements on surface finish and dimensional tolerances etc., for the parts being produced. A worn or damaged saw blade usually results in rejection of the parts produced and the saw blade must be reconditioned or replaced.

Failure Mechanisms

Failure investigations on numerous worn-out saw blades from many different applications have shown that five main failure mechanisms are encountered. These are illustrated in Figure 2 and include the following:

- wear
- chipping
- plastic deformation
- cracking/total failure
- galling

All of these mechanisms have mechanical origins. They are due to high pressures and sliding contact between the working surfaces of the saw blade and the work material. Wear will always occur to a greater or lesser extent in every application. However, depending on the application, working conditions and work material, one or more of the above mechanisms can be present at the same time. The work material itself has a fundamental influence on the failure mechanisms.

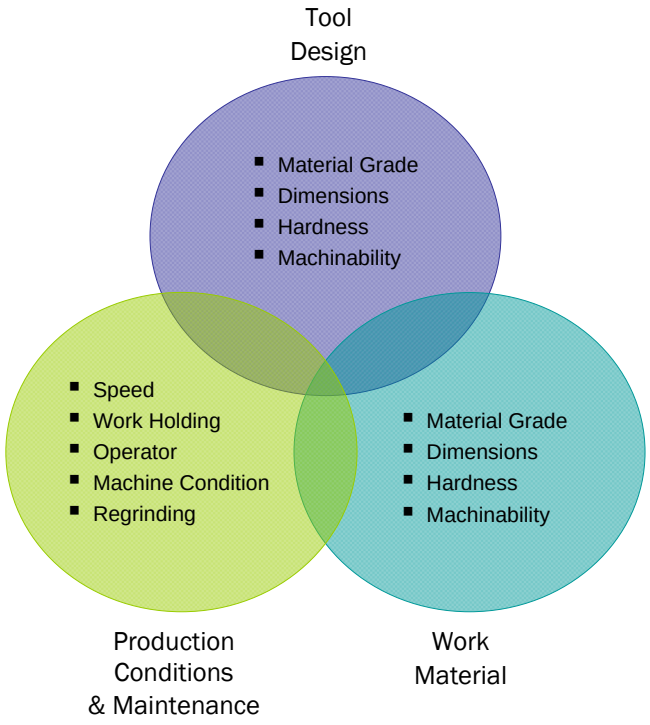

Figure 1. Common factors influencing tool life.

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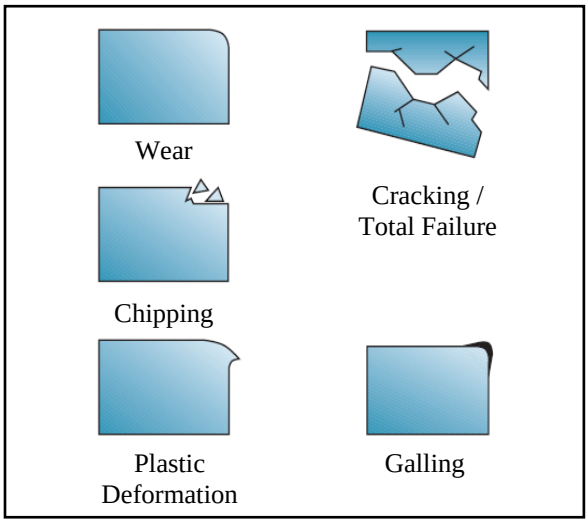

Figure 2. Common failure mechanisms of saw blades

Wear Types and Influences

There are three primary categories of wear in sawing applications. By understanding these types, we can efficiently manage the relationship between wear, tool failure and tool design.

Abrasive Wear

This type of wear dominates when the work material is hard and/or when the material has very high strength. These characteristics scour the tool surface. An example of abrasive wear is shown in Figure 3. Abrasive wear is common in many materials. The tool properties that are important for good resistance to abrasive wear include:

- correct saw blade hardness
- chemical composition (alloy)
- grain microstructure

Adhesive Wear

The origin of adhesive wear is the occurrence of local micro-welding between the surface of the saw blade and the work material. The relative motion between the saw blade and work material will cause the micro-welds to be torn apart and small fragments of saw blade material may be pulled out of the surface. Such a loss of tool material can result in significant wear of the saw blade surface.

However, the torn off fragments can also stick to the work material and cause abrasive wear on the saw blade surface. Adhesive wear may also be the origin of chipping. A fatigue mechanism gradually takes over from the adhesive wear dominant in the early stages. Micro-cracks are initiated and these will start to deepen and widen. The cracks can then cause a large scale spalling (chipping) or even lead to a catastrophic failure. An example of adhesive wear is shown in Figure 4. Fatigue cracks can be clearly seen. Adhesive wear will occur with soft, adhesive metallic work materials such as aluminum, copper, stainless steel, nickel-base alloys and low carbon steels.

The adhesive type of wear can be decreased by making the micro-welding and/or tearing off mechanisms more difficult. The saw blade properties that are critical for good resistance to adhesive wear are:

- correct saw blade hardness
- low coefficient of friction between the tool and work material
- good ductility

Mixed Wear

It should be noted that not all metallic work materials cause purely abrasive or purely adhesive wear. Some will cause partly adhesive and partly abrasive wear. This type of wear is designated as “mixed wear”.

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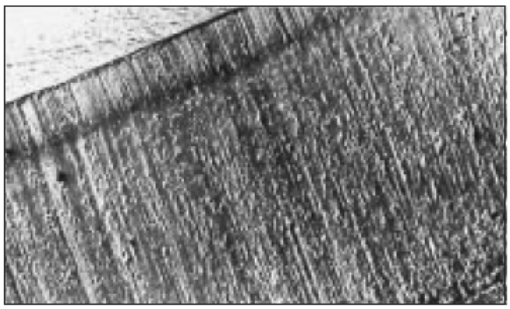

Figure 3. Photograph of tool worn by abrasive wear.

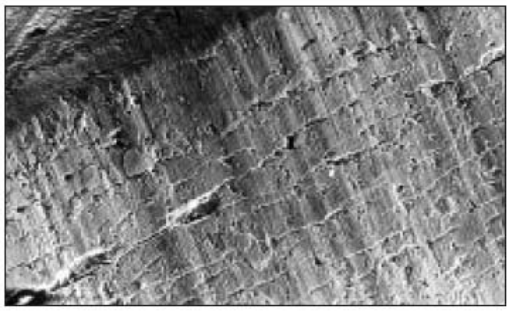

Figure 4. Photograph of tool worn by adhesive wear.

Figure 5. Photograph of tool worn by galling.

Chipping

Chipping often occurs after the saw blade has been in service for a relatively short time. This failure mechanism is one of low cycle fatigue. Small cracks are initiated in the working surface of the saw blade and further growth finally results in pieces chipping out. To obtain good resistance to chipping it is important to make crack initiation and growth more difficult. One property that gives a good resistance to chipping is high ductility.

Plastic Deformation

Plastic deformation occurs when the yield strength of the saw blade has been exceeded. Plastic deformation causes damage to or shape changes on the working surfaces of the saw blade. The property that is important for good resistance to plastic deformation is correct hardness.

Note: Appropriate consideration of toughness and ductility must be made when selecting the hardness level to be used.

Cracking

Cracking is a failure mechanism which tends to occur spontaneously and means that the saw blade has to be replaced. Unstable crack propagation is the mechanism causing this type of failure. The formation of cracks is often caused by the presence of stress concentrators, e.g. grinding and/or machining marks or design features such as sharp corners or radii. The properties that give a good resistance to cracking are:

- correct saw blade hardness
- grain microstructure

Note: Low hardness will have a detrimental effect on the resistance to the other failure mechanisms. Thus working with a low hardness is normally not a good solution. It is better to use a material with a good microstructural toughness.

Galling

Galling is a problem associated with soft, adhesive metallic work materials. It normally appears as a gradual build up of small fragments of the work material which are torn off and adhere to the working surfaces of the tool. A low coefficient of friction between the saw blade surface and the work material will help to prevent galling. Figure 5 shows an example of material galling.

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Summary

Tool wear and failure may come from many areas and is usually identifiable from the symptoms. Eliminating variables in the application and optimizing the tool to fit the application will result in good long-term use of the tool and the lowest cost per part produced.

Choosing the correct type of steel for the cutting application is as important as choosing the correct parameters under which the tool should be run. We give very careful consideration to the hardening, quenching and annealing processes. Additionally, all grinding processes are done to ensure consistency from blade to blade and batch to batch. Quality and innovation in every manufacturing step are the rule not the exception.