Efficient sawing of tubes and bars

Åke Strömhielm, Ovako Steel
Jan Tiberg, Erasteel

Metal cutting methods

Ovako is the steel maker within the SKF group. We make tubes and bars for manufacturing of bearings and components for the automotive industry. A considerable part of our steel is delivered as cut blanks. Ovako Steel has the capacity to cut more than 30.miljon blanks a year.

To day most of such cutting is done by using Band saws, Circular saws and parting off machines. Abrasive cutting is sometimes used for very special applications.

Saw cutting of bars and tubes has slowly changed over the years from old fashioned *Circular saw-machines* to *Band saws* for higher and higher output. Since the new CNC programs are implemented in the band saws during the last 6 - 7 years it seemed to be hard for circular saws to keep up, especially for tube cutting. However brand new concepts for circular-saw cutting are changing tube and bar cutting properties to a different level for tolerance and output.

The two methods both have their advantages depending on the material to be cut and the demands for surface, tolerance and output level.

Band-saws

Development of *Bi-metal* (HSS-tipped) band saw blades includes *improved geometry and new tooth material*s. In combination with modern machines the cutting rate could be *increased by 50 - 100%* above ordinary recommendations and sometimes much more. Cheap cutting when several pieces are cut together in one or more layers is a great advantage and hard to beat, Figure 1. Some machines have drive on both wheels for higher torque and even tension on the band. The life of the saw-band is not anymore the important parameter, it is the ***cost per cut.*** Higher cutting rate and output will lower the cost to a certain optimum. For cutting bearing steel (100Cr 6) the most economical bandspeed seem to be around *90 m / min,* Figure 2. The cut surface per band (7,5 m) achieved is as good as between 7 and 10 m². Former recommendations used to be ab. *45 m / min.*

Modern control systems allow either cutting for *maximum output* or *maximum tool life* when enough time is available.

Circular-saws

Modern circular saws are compact machines, and they use rather small diameter and thin blades, Figure 3. For us, cutting 30 10^6 pieces a year, every tens of a millimetre means 3 km tubes!

Tube sawing is a complicated process to optimise. Fully *CNC controlled* circular saw machines makes it possible to have total control of the cutting parameters. At any moment the program knows the actual cutting length and number of teeth in action. In this way the load on the saw-blade is optimised throughout the whole cutting cycle at a minimum of vibrations and a controlled wear. The machine works at a high feed when only few teeth are in action, and the feed is reduced when more teeth come in action. This means a dramatic increase in productivity.

For steel cutting, *carbide tipped* or *HSS* blades are used. Carbide is used for very abrasive solid material and heavy walled tubes. The higher number of teeth and *sharper edges* for HSS blades will give better surface and less burrs.

New high-speed *machines* are already on the market and have started to replace band sawing for *high output* in combination with *tight tolerances,* Figure 4. Higher speeds than in the old types of machines and the same or higher feed rates call for improved tool materials. Most HSS circular saw blades today are still made of the old M 2 steel, which is easy to find in steel-plates on the market. More modern HSS steel types normally used for drilling, turning and milling combined with new types of *multi-layer coating* used in these new machines will lower the cost also for saw cutting when available in the shape of circular saw blades. Present HSS types of saw-blades are used at cutting speeds up to 250 m / min (St 37 - 52) for thin-walled tubes. New HSS variants will increase tool life and keep the machines running more efficiently between blade change, Figure 5.

New tooth material for metal cutting saws

Erasteel make high-speed steel for bimetal saws and also bimetal strips with the HSS welded to a spring steel backing.

Saw testing is essential for us in our development of new tooth materials. In our band saw testing machine we measure the cutting forces, both the vertical forces by two transducers and the horizontal force with a transducer at the pulling wheel.

The cutting forces in a cut of a round bar are given in Figure 6. We start by clamping the side supports, which gives a certain friction, which will be our zero horizontal force in that cut. Then the forces gradually increase until we reach a maximum at the middle of the bar. We collect the maximum values from each cut for further treatment – both from the horizontal force and from the sum of the vertical cutting forces. We also evaluate maxima of the filtered curves. Thus we get four curves for the maximum forces in each cut, Figure 7. The curve for maximum (unfiltered) horizontal force has a rapid increase at the end of the tool life and is therefore a convenient criterion for tool life, which gives us a rather distinct value of the tool life. The out-of-square is also a very important quality of a saw cut, Figure 8. We evaluate it for each cut and use it as a second tool life criterion, Figure 9. We use 0.8 mm for all our types of sawing, and again we get usually very distinct tool life values. The two criteria are normally very close. We give the tool life as the shortest from the two criteria.

We have tested the new tooth grade ASP 2060 versus two conventional grades, M42 and M51, and found a tool life increase of almost 100%, Figure 10. Yet we used very tough cutting conditions 70 m/min band speed and 70 mm/min, which is 3 - 5 times the productivity normally recommended. I even found a recommendation to saw at 30 m/min and feed at 8 mm/min, which is nine times less than our productivity. Nevertheless our tool life is more than acceptable, 5 m^2 for ASP 2060. The results here are mean values of two saws.

The superiority of ASP 2060 over the conventional grade M42 has been confirmed several times and in different work materials, Figure 11.

The heat-treatment is of utmost importance for a good result as this diagram for drilling Inconel 718 shows, Figure 12. Here 69 HRC is here the optimum. The 67 HRC drills wear too fast and the 71 HRC drills are too brittle. ASP 2060 is in this application far better than the carbide drills. Of cause all drills are PVD coated.

The wear mechanism in band sawing is usually merely abrasive, as here when sawing stainless steel with ASP 2060 tooth material, Figure 13. The picture shows the clearance face of five teeth put side by side, and there is no chipping although the surfaces are quite rough.

Chipping occurs from time to time and therefore the tooth material must not be too brittle. In this M42 the brittle fracture has started from a groove in the rake face, when sawing stainless steel, Figure 14.

Why is ASP 2060 such an outstanding tooth material? – It has about 1.5 times as many carbides as M42, and the carbides are mainly of the MC type, which are very hard. Besides the carbides are small, which increases the toughness. ASP 2060 can therefore be heat-treated to 70 HRC, whereas M42 only with difficulty can exceed 68 HRC, Figure 15.

With these improvements in saw machines and with new tooth material sawing is today and in the future a very efficient way to cut tubes and bars.