Lathe speeds and

Have you ever been bewildered by the vast array of buttons and levers on your department's centre lathe headstock? Ever thought, "Why bother to change anything, as it looks so complicated?" Back in Bulletin 233 [1], we highlighted the importance of changing pillar drill speeds in relation to the size of holes being drilled, the type of drill bits used and the material being drilled. Well, machining safely and correctly on the centre lathe commands the same degree of importance and the machine should have its speed set appropriately. Having said that, it can look pretty complicated, with each centre lathe having different arrangements to select and change speeds.

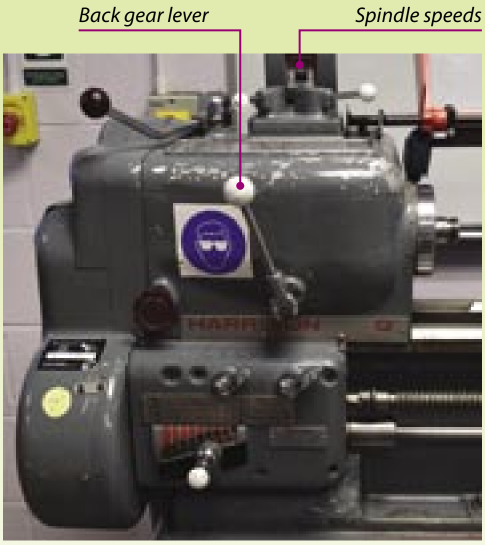

Figure 1 *- Headstock gear arrangement.*

Figures 1 and 2 show some common centre lathe headstocks. The arrangement of small levers in Figure 1 at the top of the machine controls the spindle speeds of the lathe i.e. the speed at which the chuck rotates. By moving these levers into the positions indicated on the diagram fixed to the machine, a number of speeds can be selected. Further reductions in speed can be obtained by moving the 'back gear' lever directly on the front of the machine. This not only provides reduced speed but also greatly increases the lathes turning power. In Figure 2, the spindle speeds are controlled by the large rotating dial type lever. All other levers on each of these machine relate to screw cutting operations. Generally speaking, the larger and harder the material being turned then the slower the speed. Larger materials are often heavy and thus the use of the back gear to provide more torque will be required.

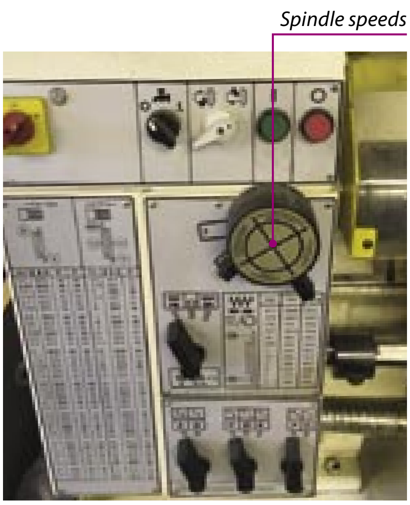

Figure 2 *- Headstock gear arrangement.*

$$\text{Spindle Speed} = \frac{\text{cutting speed (c.s)}}{\text{Circumference of workpiece}} = \frac{C.S}{\pi d}$$

e.g. for a cutting speed of 25 m/min; bar diameter 20 mm

$$\text{Spindle Speed} = \frac{25 \times 1000}{\pi \times 20} = 398 \text{ rev/min (approx.)}$$

Figure 6 *- The Formula.*

Most centre lathes typically have a number of selectable speeds ranging from 45 rpm up to 3000 rpm. These speeds ranges cover a wide range of machining operations, such as facing off, taper turning, parallel turning, parting off, knurling and screwcutting. They also adequately cover a wide range of materials that are usually found in schools such as ferrous, non-ferrous metals and some forms of plastic. In order to select the most appropriate spindle speed, we must consider the cutting speed of the material being turned.

Cutting speeds

Cutting speeds, which have a constant value for a given material, are unusually expressed in metres per minute and they indicate the optimum speeds required in order to achieve a quality finish (see Table 1).

To achieve and maintain these cutting speeds, smaller diameter work has to turn much faster than larger diameter work and, depending on the given cutting speed and diameter (*d*) of material being turned, the approximate lathe spindle speed can be calculated from the formula shown above.

tool angles

Spindle speeds

Table 2 shows a quick 'handy reckoner' guide of preferred spindle speeds for a range of materials of varying diameters. It is assumed that these cutting speeds are for moderate depths of cut and feeds; the feed being the distance the cutting tool moves along the lathe bed in one revolution.

For a smoother finish, longer tool life and faster cutting speeds a lubricant (cutting fluid or coolant) must be used. A common cutting fluid is soluble oil and water, although light machine oil is sometimes used.

Material	Spindle speeds (rev/min) for given diameters			
	Ø9 mm	Ø12 mm	Ø18 mm	Ø25 mm
Mild Steel	880	660	440	320
Plastics (e.g. Nylon)	1400	1050	700	500
Brass	2650	1990	1330	960
Aluminium	3000	2200	1400	1000

***Table 2** - Spindle speeds.*

***Figure 3** - Brazed carbide tip tool.*

***Figure 4** - H.S.S tool and holder.*

Lathe tools

The tooling used in turning also plays an important role in selecting the correct speed. Typically the most common type of cutting tool used in school workshops are made from high speed steel (H.S.S). Other types are available such as carbide tipped tools (Figure 3). These types of tools offer faster material removal in most cases and as the carbide is more expensive and more brittle than steel it is brazed onto a steel shank. Almost all high-performance cutting tools use indexable inserts. This type of tooling allows for the cutting edge to be rotated when dull, to a fresh edge. This can be done a number of times before the insert needs replacing. However, these types of tools are more expensive than the traditional high speed steel tools.

H.S.S cutting tools come in the form of a square section that is held in a tool holder (Figure 4). It is important that when selecting the correct speed for the material being turned that the cutting edge of tool is also properly ground. This edge is formed by grinding a clearance angle, below the cutting edge, known as front clearance, and a slope on the top side, away from the cutting edge, known as the top and side rakes respectively.

***Figure 5** - Index tooling.*

During machining, the cutting edge must retain maximum strength and cut with minimum friction. Generally, when cutting soft metals like aluminium and copper, the tool angle can be relatively small but when cutting hard and brittle metals like brass and cast iron the tool angle must be large (for maximum strength) to avoid breakage.

Material	Meters per min (MPM)
Steel (tough)	15 - 18
Mild Steel	30 - 38
Cast Iron (medium)	18 - 24
Alloy Steels	20 - 37
Carbon Steels	21 - 40
Bronzes	24 - 45
Aluminium	75 - 105
Brass	90 - 210

***Table 1** - Cutting speeds, using H.S.S tool bit.*

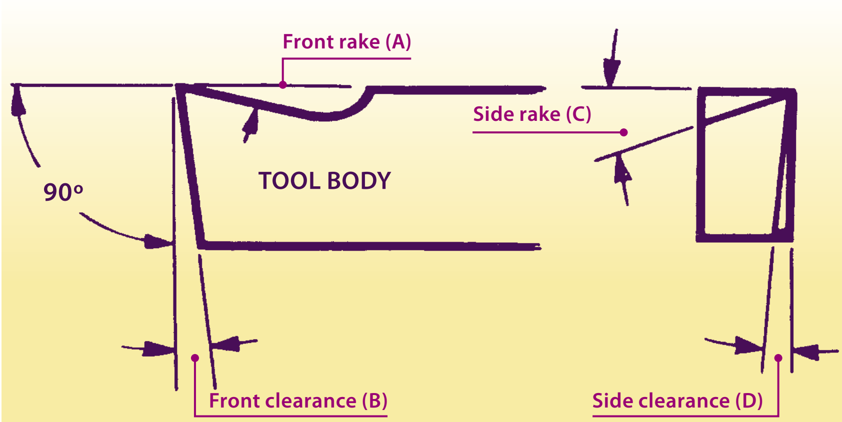

***Figure 6** - Grinding clearance.*

Material	Front Rake (A)	Front Clearance (B)	Side Rake (C)	Side Clearance (D)
Soft Steel	15°	8°	15° - 20°	6°
Medium Steels	8° - 10°	8°	12° - 15°	6°
Hard Steels	5°	6°	6° - 10°	6°
Cast Iron	8°	8°	10° - 15°	6°
Brass & Bronze	1°	6°	0° - 3°	6°
Copper	20° - 25°	10° -15°	20° - 30°	2° - 5°
Aluminium	35° - 55°	6°	10° - 20°	1° - 3°

***Table 3** - Rake and clearance angles.*

For various materials, the rake and clearance angles are listed in Table 3.

It should be noted that from the chart the top rake angle varies the most and generally increases as the material being turned get softer. The front clearance angle varies least and should be no more than necessary. If excessive clearance is ground then the point of the tool becomes too sharp, losing necessary strength and heat dissipating area.

Conclusion

In order to operate and machine safely on a centre lathe, produce accurate and quality work, spindle speeds and cutting tool angles must be changed and ground accordingly. Spindle speeds which are set too fast and cutting tools that have too little clearance can cause tool breakage, poor surface finishes, overheating and chatter (vibrating noise while cutting). So next time you use the lathe check the tables and change the speed to match what you are turning.

Reference

[1] SSERC Bulletin (2010), The 'hole truth and nothing but....', **233**, 2-4.

Chemistry probationers - A professional development opportunity

SSERC is pleased to announce that it will be working in partnership with The Royal Society of Chemistry (RSC) during 2017/18 on a new initiative to support probationer teachers of chemistry in Scotland.

The scheme offers the opportunity to take part in a free 2-part professional development course combined with a personal chemistry specialist mentor during your probationer year.

The RSC has set up this initiative to try and help with the decreasing number of chemistry specialist teachers in Scotland, and ensure that students are getting the highest quality chemistry education possible. If the initiative is successful, there will be scope to continue and expand the programme in future years.

This programme will start with a two-day residential course in SSERC. As well as running CPD training, we will use part of this meeting to link the probationer teachers with a chemistry specialist mentor who will have been trained by the RSC.

The course dates are 29-30th September 2017 with a follow-up day on 11th May 2018. Further details are on the SSERC website [1]. **The closing date for applications is 1st September 2017.**

Reference

[1] http://www.sserc.org.uk/cpd-sserc/probationers/4231-rsc-chemistry-probationers-29th-30th-sept-2017-and-11th-may-2018.