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Benchmarking accuracy

Matthew Platt takes a look at the tools required to benchmark accuracy in the workshop and how to get the best out of them

There are plenty of terms that contribute to the vocabulary of woodwork that predate contemporary understanding. Take for example the try plane; it gets its name from the word 'trying', which is also the root of the modern verb 'trueing' as in 'to make something true'. In this case, truth refers to flatness and although 'true' can also be applied to something being straight, square – hence, try square – it can also be applied to describe spherical, cylindrical, or any other condition come to think of it.

These absolute conditions can only ever really exist as mathematical concepts that are easy to define but impossible to achieve in practice, even in the most sophisticated environment. So as we attempt to prepare stock as accurately as we can with equipment ranging from simple hand tools to fully automated machines, how can we make the most of the tools available to us and what, exactly, does flat really mean? The best that we can do is to approach the shape or surface required to within a tolerance, an allowable deviation defined by relevance for the job at hand.

Squares or straightedges, should always have a stated tolerance, which is usually expressed by means of a standard marked on the body of the tool. These are the origin surfaces from which all of the accuracy in your workshop is inherited, so they are not a place to skimp. Sticking with good quality brands like Starret, Kinex or Moore & Wright and treating them with due care and respect are the best ways of ensuring that they will remain accurate over time.

PHOTOGRAPH BY MATTHEW PLATT

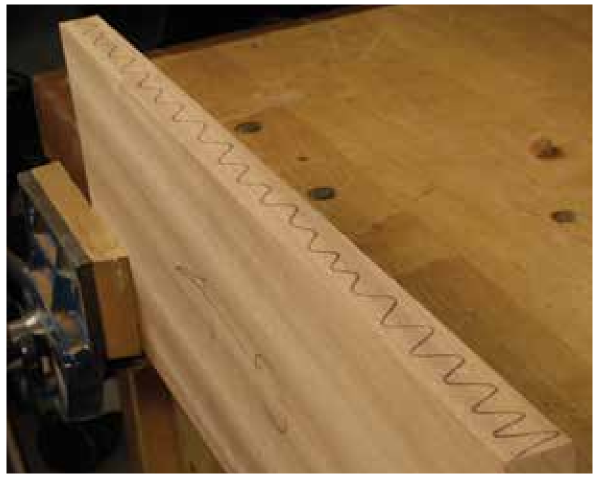
The DIN or BS mark on a measuring tool identifies the standard to which it was manufactured

Flavours of flatness

Tolerances are usually expressed as 'maximum total deviation on centreline'; this means that the surface can be concave, convex or both, as long as the highest and lowest points are less than half the tolerance above or below the mean. By contrast, a unilateral tolerance is one that only allows for a specified concavity – or a specified convexity.

Preparing timber components to tolerances more suited to metalwork will obviously give you the best chance of success when it comes to making a piston fit drawer for example. It will also tie you up in knots if you try to work at this level for every single component. In practical terms it makes sense to adopt a workshop tolerance for all your reference tools.

In practical terms



Mark the edge of the board with a continuous pencil line

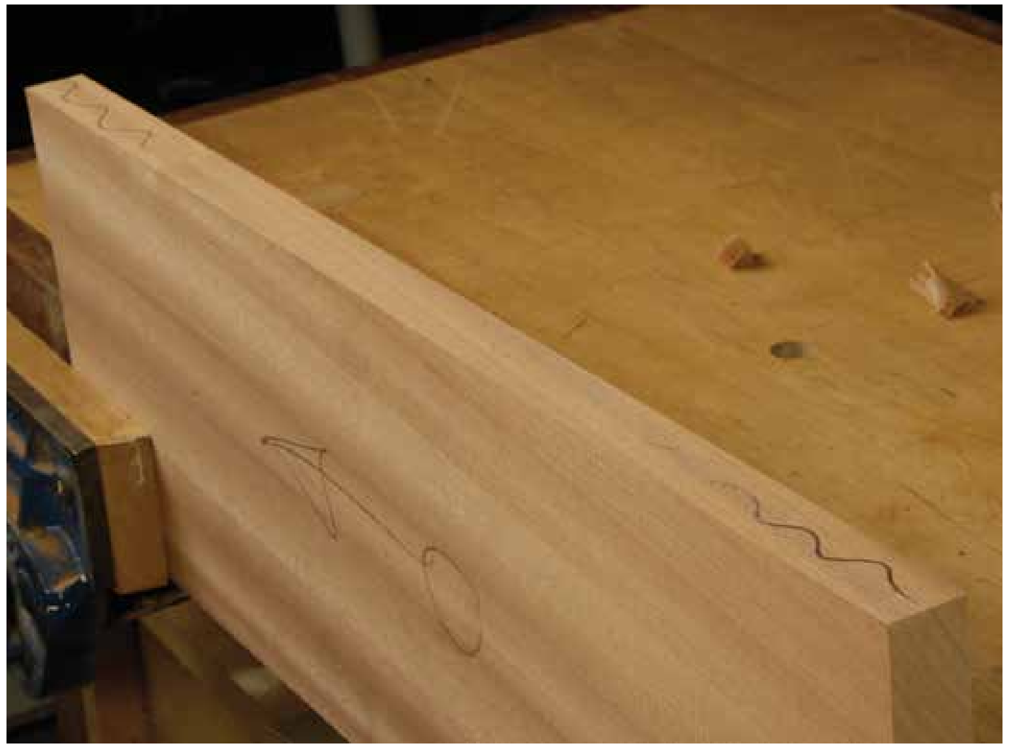
Taking a series of progressively longer stopped shavings, starting from the arrows, will generate concavity in the length of the edge

> "When working by hand, we can steer towards flatness by adjusting the way in which material is removed"

When working by hand, we can steer towards flatness by adjusting the way in which material is removed. Take edge jointing for example. Removing material through the boundaries of the item generates convexity whereas removing material within the boundaries of the item generates concavity.

Because a concave surface referenced against something flatter is self-jigging, it is preferable to approach flatness from the direction of a pre-existing concavity. The same principles apply whether you are working wood or metal.

When hand planing, for example, if you plane the edge of a board repeatedly using stopped shavings that start and finish within the length of the board – removing material within the end boundaries – then you will make it concave until eventually the plane ceases to cut: toe and heel in contact, mouth in fresh air, cutting edge just touching the surface. Switch to through shavings, with the blade starting and finishing off the surface – removing material through the boundaries – and you will begin to move the surface back in the direction of convexity. If you scribble pencil lines along the surface, you can watch the concavity disappearing. Stop at the first continuous through shaving and it will be as flat as you can get it; if you continued beyond this point with through shavings, you would eventually make the timber convex over its length.



At this point the board is concave the plane will cease to cut, time to replace your pencil line and switch to through shavings

Starting and finishing with the blade off the timber, we are now moving back in the direction of convexity. Keep checking for squareness with the face side

With each through shaving the board becomes progressively less concave. When the last remaining bit of pencil mark is on the top of the full length full width shaving you have just taken – stop

Hold a straightedge at one end of the board and see if it pivots at that end when moved across the surface of the edge. If so, you have left a barely perceptible almost immeasurable concavity – perfect! Now all you need to practice is hitting the middle of a gauge line with that last shaving

[redacted]

Hard plane tolerances

The sole of a bench plane should be flat to a maximum total deviation on centreline not exceeding 3 thou – 76.2 microns. The sides of the plane should be square to the sole to within 30 arcminutes, or half a degree. In practical terms, this means that you shouldn't be able to get a 3 thou feeler gauge to pass under a straightedge on the sole and you shouldn't be able to pass an 8 thou feeler under a square 25mm from the corner.

I often hear of people trying to improve upon these tolerances. In the case of manufacturers, this is to give themselves a bit of leeway for movement of the materials. The tool might end up being used in Australia or Alaska, so in order to guard against the possibility of differential thermal expansion of uneven sections, they make sure that the plane is significantly within tolerance at the time of manufacture.

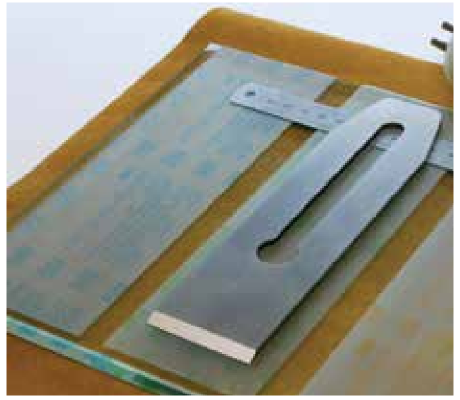
In the case of end users, it is usually a misapprehension that the plane will function better the further within tolerance it is – it won't. In this case, the tolerances define the point beyond which improvement ceases to yield additional benefit. When you think about how a bench plane is used, most of the referencing is between either toe and mouth or heel and mouth. At the beginning of the cut we apply pressure over the front to keep the toe engaged and the weight of the plane keeps the mouth in contact. Once the cut is established, we transfer weight to the back so that the heel and mouth are in contact and jig the blade relative to the cut surface. The only point at which heel and toe are both referencing at the same time is when we are hollowing within a stopped cut, at which point the mouth is suspended in fresh air. Whether it's 1 thou of air or 3 thou of air makes no difference.

Lapping bench planes should only be a last resort and should never be necessary on a new tool. As with wood, removing material from a single surface is the best way to release any remaining tension within the material and set it moving. Although manufacturers do all they can to eliminate internal stresses, tempting fate when there is nothing to be gained is surely bad practice. A slight concavity in the middle of the front or rear beds is tolerable, as is a fractionally proud area in front of the mouth. Convexity in either bed or behind the mouth can often be remedied or improved by adjusting the tension of the handle screws or frog retaining screws – equal and opposite reaction. The worst case is the area directly in front of the mouth being shy of the rest of the surface – hence the big reinforcing rib in the casting above the front of the mouth.

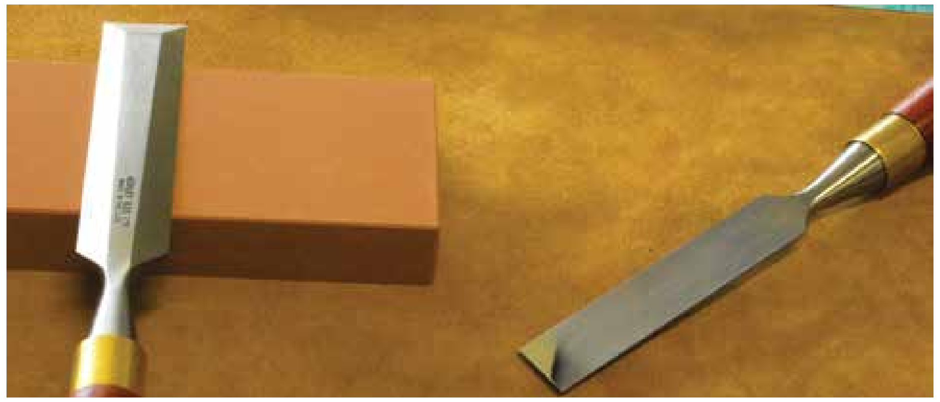
There is a difference between lapping for flatness and either very fine polishing or applying wax to reduce friction, either of which will deliver improvements by reducing the effort required to push the plane.

The sole of a bench plane can be distorted – or corrected – by a thou or so just by altering the tension on the knob, frog and handle screws. The big casting rib in front of the mouth ensures maximum sole stability at the most critical spot

Using convexity and concavity in sharpening



The ruler trick isolates a small area adjacent to the cutting edge, so that a finer polish can be achieved



A fractionally hollow chisel back achieves the same advantage, but by different means

Flattening and polishing large areas on the back of a plane's cutting iron is another frequently encountered fool's errand. Beyond the first millimetre, the flat side of a plane iron isn't a reference or registration surface. In use, it will be screwed to the cap iron, which in most cases will bend it. The quality of polish that can be achieved on a surface for a given effort is inversely proportional to its area, so flattening and polishing a large area yields no benefit and deprives users from experiencing the true potential of the steel. I am a huge fan of David Charlesworth's ruler trick for plane irons, which saves considerable time and effort and improves the quality of cutting edge that can be achieved by orders of magnitude. I have yet to hear a single compelling argument against it.

Using convexity and concavity in sharpening – *cont'd*

The ruler trick is a good example of a carefully managed convexity, the other obvious one being secondary bevels. In both cases, we could have chosen to use managed concavity – hollow backs and hollow ground bevels – to achieve the same objective of isolating a small area to polish.

In the case of chisel backs – the non-bevelled side – we can't use convexity because it is a registration surface, so a managed concavity is the only option. A well-prepared chisel back will have a polished patch at the ends of the blade and another somewhere up near the bolster. With continued polishing on a flat surface, the polished patches would grow, merge and the surface would start to become convex, just like the planed timber surface earlier on. In this instance, though, you are not aiming for true flatness. Like the ruler trick, we want to keep the polished area small so that we can achieve a high quality edge with minimum effort. Periodically reinstating the hollow by working the blade across a medium stone will keep the blade in good order, and as long as the hollow is controlled to within a couple of thou, you will find that there will be no discernible loss of accuracy.

Inspection

Tolerances for squares, squareness between blade and stock in microns (and thou)					
Blade length	**DIN875/00**	**DIN875/0**	**DIN875/1**	**DIN875/2**	**BS939B**
75mm	3 (0.12)	7 (0.28)	14 (0.55)	28 (1.10)	16 (0.63)
100mm	3 (0.12)	7 (0.28)	15 (0.59)	30 (1.18)	16 (0.63)
150mm	4 (0.15)	8 (0.31)	18 (0.71)	35 (1.38)	16 (0.63)

Tolerances for squares, straightness of contact surfaces in microns (and thou)					
Blade length	**DIN875/00**	**DIN875/0**	**DIN875/1**	**DIN875/2**	**BS939B**
75mm	2 (0.08)	3 (0.12)	5 (0.20)	11 (0.43)	8 (0.31)
100mm	2 (0.08)	3 (0.12)	6 (0.24)	12 (0.47)	8 (0.31)
150mm	3 (0.12)	4 (0.15)	7 (0.28)	14 (0.55)	8 (0.31)

Tolerances for steel straightedges in microns (and thou)				
Blade length	**DIN874/00**	**DIN874/0**	**DIN874/1**	**DIN874/2**
500mm	4 (0.15)	7 (0.28)	12 (0.47)	21 (0.83)
750mm	6 (0.24)	9 (0.35)	17 (0.67)	27 (1.06)
1000mm	8 (0.31)	12 (0.47)	21 (0.83)	33 (1.30)
	BS5204A	**BS5204B**		
12"	5 (0.20)	10 (0.39)		
24"		12 (0.47)		
36"	7 (0.28)	14 (0.55)		

In hand tool woodworking, we are normally preoccupied with eliminating bumps that can hold joints open. A slight concavity left by the cambered edge of a smoothing plane is much more forgiving and indeed often helpful in ensuring tight fitting faces. A quick way to check for bumps is to swing a straightedge across the surface with one end resting on the workpiece. Encountering a bump will cause the pivot point to change from the end to somewhere in the middle.

Light can be very useful when inspecting against reference surfaces like squares and straightedges; it can tell you whether there is a gap and it can tell you what shape the gap is, but it isn't a measurement. The only way to establish the size of a gap is by contact measurement using feeler gauges.

Continuously checking your work is a great habit to get into from the start. Always keeping a small accurate square to hand, and using it often, will improve your chances of catching mistakes as soon as they happen.

Industrial norms and standards come in various degrees of accuracy from 00 or AA inspection grade – highest accuracy – through to 0 or A, 1 or B, 2, 3 and so on. There are various other requirements, e.g. DIN875/00 squares can only be of the knife-edged variety, but the chart above shows the straightness and squareness tolerances for comparison.

The correct way to inspect a plane sole, using feeler gauges and a reliable straightedge

Conclusion

The aim of this article was to expose some commonly encountered myths and misunderstandings relating to flatness, and hopefully save the reader some time, frustration and sore fingers. I appreciate that some of the points raised may prompt further questions, so if you would like to discuss anything further, or request clarification on any of the points mentioned, I am happy to answer questions on the Woodworkers Institute forum – www.woodworkersinstitute.com. F&C