Machining Performance Using the Mitsubishi Micro MZS Drills With 2 Coolant Holes Through.

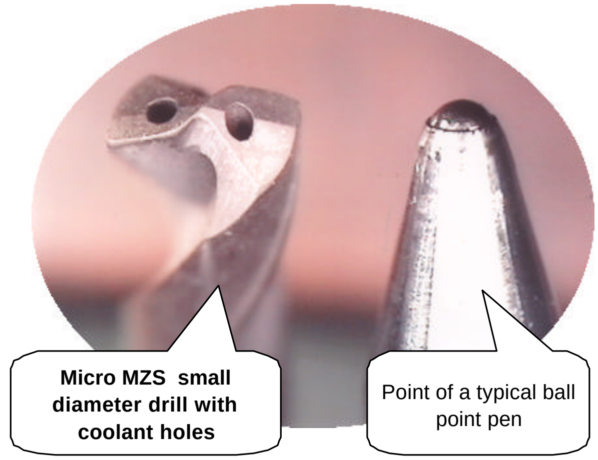


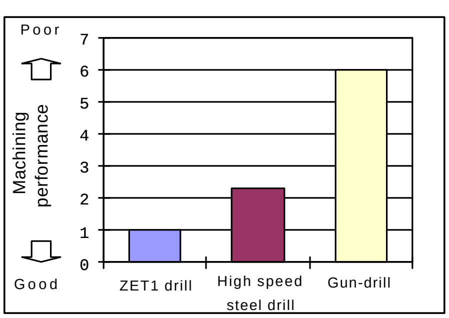
Photo.1: Close up of theMicro MZS drill

With the ever increasing demands and needs of the consumer, producers are fighting to reduce the lead-time in research and development of new and upcoming products. This can be especially seen within the IT industry where new and smaller products are being developed at an explosive rate. The products used within the IT industry are by far much smaller and lighter than products used within other industries.

As the required products become smaller so do the parts that are needed to produce them. With the parts becoming smaller, the holes that are needed to be machined also reduce in size. Therefore cycle-time and lead-times need to be reduced while maintaining the requirement for high performance machining.

However, drilling is often conducted using high-speed steel drills or gun-drills. These drills have characteristics that result in low performanc1 machining, therefore these types of drills do not provide the desired performance that is required today.

To resolve the machining problems related with the drilling of small diameter holes and to provide high machining performance, Mitsubishi Materials has developed a new series of small diameter carbide drills with through coolant capacity. Touted as the worlds smallest drill with coolant through, these drills are being offered in a size range from .039 to .125. The drill depth capability is L/D=10. Special lengths can be provided up to L/D= 20.

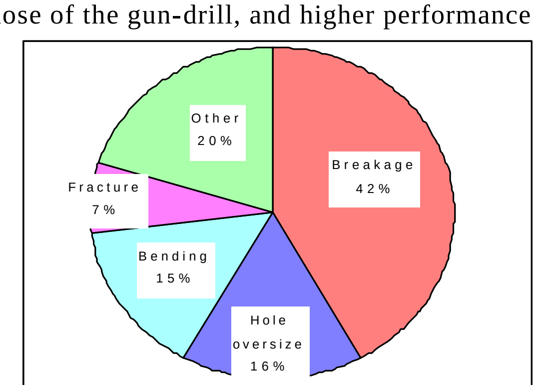


Dia. 1: Machining performance when drilling small diameter holes (workpiece: Stainless steel)

Small diameter hole drilling and Problems.

Diagram 1, shows the efficiency of the ZET1 drill in comparison with high-speed steel drills and gun-drills. The gun-drill that can machine without using step machining is often used at cutting conditions such as Vc=50~60m/min (160~195ft/min), and f=0.005mm/rev (.0002IPR). While the cutting speeds are high, the feed rate is extremely low. Therefore high performance machining can not be realized. Additionally, when employing a gun-drill for machining, the tool management can be very time consuming.

High speed steel drills use cutting conditions such as Vc=15m/min (50ft/min), and f=0.05mm/rev (.002IPR). These conditions are higher than those of the gun-drill, and higher performance



Dia.2: Problems related with small hole drilling

machining can be attained. However, high-speed steel drills use external cooling, and as such problems related with chip disposal arise. In order to counter this problem the drills often need to use peck drilling in order to evacuate the chips during machining. Thus in doing so more time is spent on machining and machining efficiency is reduced.

Diagram 2, shows the problems related with the drilling of small diameter holes. As it can be seen drill breakage represents the majority of the problems.

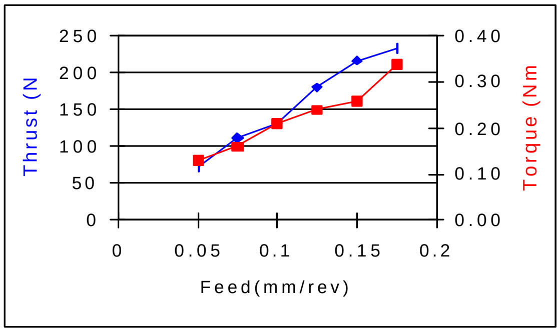
The reason for the drills breaking is due to poor chip disposal that results in chips becoming jammed while machining and then finally breaking the drill. This can be especially seen when drilling holes where the L/D is greater than 5.

Another major problem often faced with when machining small diameter holes is poor machining accuracy (oversize, bending etc.). These problems can easily been seen when machining with high-speed steel drills. The chisel edge of the high-speed steel drills has a large influence on the machining accuracy. It reduces the accuracy when entering the workpiece and also increases the thrust forces generated when machining. These problems combined with the poor rigidity of high-speed steel result in poor accuracy.

So from the above points, the 3 main areas that need to be focused on are:

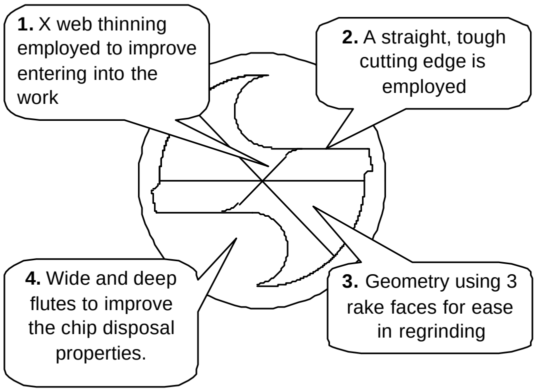
- Machining performance
- Chip disposal properties
- Drill geometry / rigidity.

To resolve the problems that occur with conventional drills and to provide reliable and high performance machining of small diameter holes, Mitsubishi Materials has developed a series of small solid carbide drills with through coolant capability. (Micro MZS style)



(a) Thrust & Torque

Dia.4: Cutting resistance of the ZET1 MZS drill



Dia.3: Characteristics of the ZET1

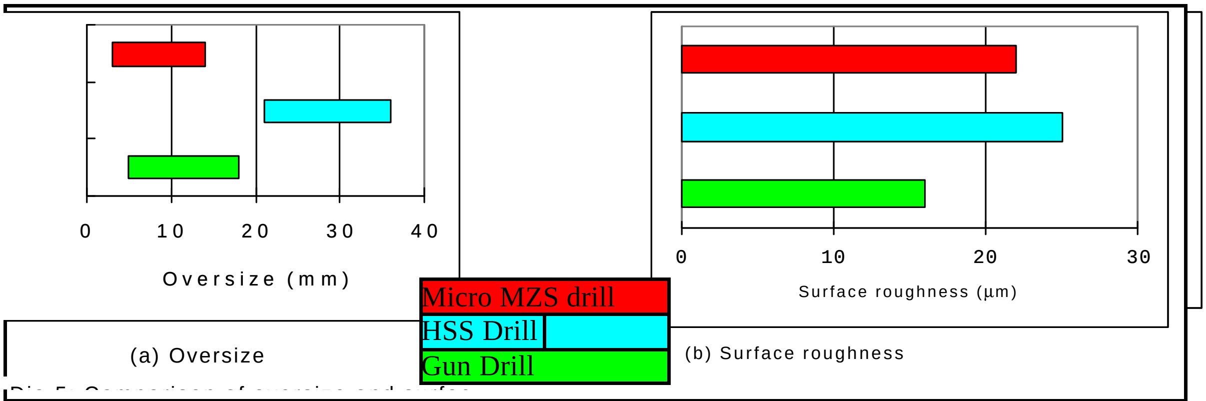
Characteristics of the Micro MZS drill.

Photo 1, shows a magnified photo of the MZS drill. Up until now, due to the lack of technology the smallest drill of this type that was possible to produce was limited to 3mm. However, new technology has made it possible to produce a drill with a diameter as small as 1mm (.039)

The Micro MZS drill, with large and wide flutes provides excellent chip disposal. The drill also uses X web thinning of the chisel edge, therefore improving the performance when entering the work piece. The characteristics of this drill are the same as the very popular existing larger size MZS drills. Additionally, the material used for the drill is a tough micro-grain cemented carbide. The drill has a thick web therefore problems with breakage have been greatly reduced.

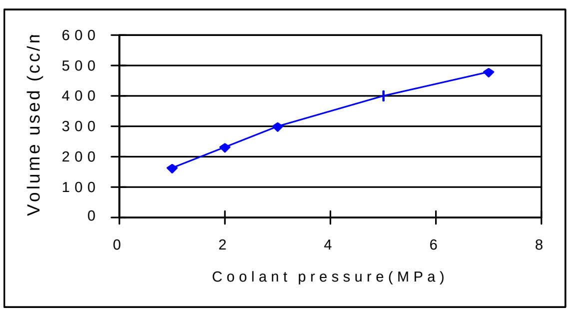
Diagram 4, shows the cutting resistance of the Micro MZS drill (2mm dia.) when machining 1050 material, depth of cut=10mm (.400), Vc=60m/min (195ft/min), emulsion cutting fluid 10%, and coolant pressure of 1000psi.

Even at high feed rates the cutting resistance is stable, therefore even with a ϕ2mm drill machining at a feed rate of 0.15mm/rev(.006") is possible. Also when machining the amount of power needed doesn't vary with the increase in the depth



of the hole. This proves that the chip disposal properties are very efficient. Additionally, by employing a wide flute geometry, the load generated when machining is reduced. The chips curl and with internal coolant being used, the chips are disposed of effectively resulting in stable and reliable machining.

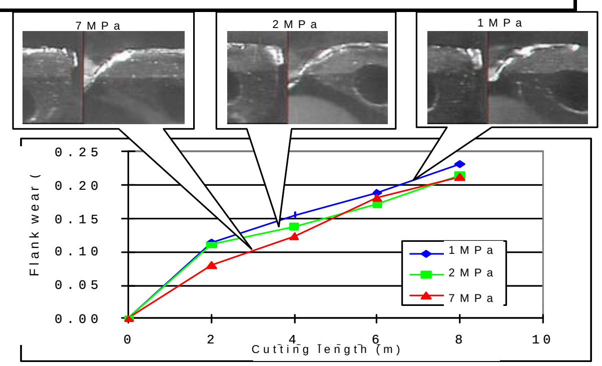
Diagram 5, shows the comparison of oversize and surface roughness when machining with a



Dia.6: Relationship between coolant pressure and the volume used.

ϕ2mm drill, depth of cut=10mm (.4in) with a high-speed steel drill and a gun drill. The cutting conditions used were Vc=30m/min (98ft/min), f=0.07mm/rev (.003IPR). The gun-drill was used with Vc=60m/min (196ft/min), f=0.005mm/rev (.0002IPR). Emulsion cutting fluid 10% with a coolant pressure of 7Mpa.

By looking at the results it can be seen that for low feed rates, when compared to the gun-drill (using a guide bush) the surface roughness achieved was similar. Additionally due to the use of X web thinning of the chisel edge the increase in the performance when entering the workpiece



Dia.7: Relationship between coolant pressure and flank wear

can also be seen.

Diagram 6, shows the relationship between the coolant pressure and the volume of coolant used. As the coolant pressure rises so too does the amount of coolant being used. An experiment was conducted to see if there was any relationship between coolant pressure and tool damage.

Diagram 7, shows the relationship between coolant pressure and flank wear. The material machined was JIS S50C, the depth of the hole 10mm (.4in), the tool used was MZS0200LA. The cutting conditions used were Vc=60m/min (196ft/min), f=0.02mm/rev (.0008IPR), coolant pressure set at 7MPa.

It was found that there was no real relationship between the amount of wear and the coolant pressure. However, when machining with a coolant pressure as low as 1Mpa, minute chipping of the cutting edge did occur leading to wear. Above 2MPa the wear patterns were normal. Thus there was no real difference between the use of high-pressure coolant in comparison to the 2MPa coolant. Mitsubishi Materials recommends that you should try to maintain when using the ZET1 drill the minimum required coolant pressure is 2MPa. However, when machining different workpiece materials, or when using varied conditions, there maybe a need to increase the coolant pressure depending on the chip disposal performance. Machining performance of the ZET1 drill.

So far the machining of carbon steel has been explained. The following are examples when machining different workpiece materials.

(1) Machining of stainless steel.

Chart 1, shows the comparison of machining time and surface roughness when machining precipitated hardenic stainless steel (JIS SUS630) with a variety of drills. The hole depth was 12mm (.47in), emulsion cutting fluid 10%.

The machining requires high hole accuracy, therefore all were carried out using the same drill diameter with a prepared hole. The drilling was conducted in 3 methods. Method A step machining (drill 1mm and return to a position near the hole entrance and resume machining). Method B, step machining (drill for 1mm then move back 0.5mm and then resume machining), and finally plain drilling without using step machining.

First, comparing the machining time. The MZS drill using method A performed the same as the high-speed steel drill. However, when comparing the machining of the MZS drill using method B it can be seen that the machining time was reduced by approximately 40%. Also by using MZS drill with plain drilling with a high cutting speed the machining time was reduced by over 50%.

In terms of surface roughness, step drilling and plain drilling the surface roughness attained using MZS drill was either better to or equal that the high-speed steel drills.

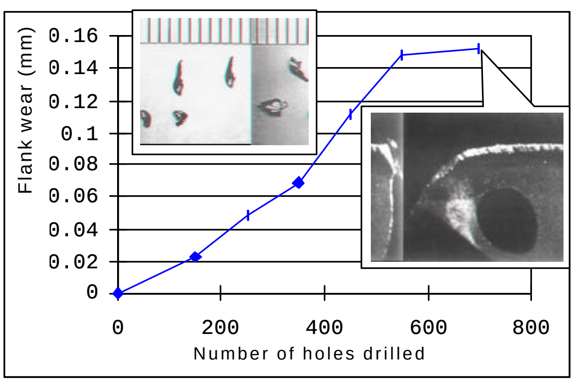
Diagram 8, shows the results of a tool life test of a MZS drill, when using plain drilling. The cutting conditions were, Vc=60m/min (196ft/min), f=0.02mm/rev (.0008IPR), emulsion cutting fluid 10%, coolant pressure 7MPa.

The cutting edges of the drill suffered from normal wear. The drill displayed stable machining of 700 holes. The chips that were generated during machining were of one curl, displaying the efficiency of the drill chip disposal properties. Additionally, the surface roughness that was achieved was with in a range of 4-8µm with only a slight amount of deviation.

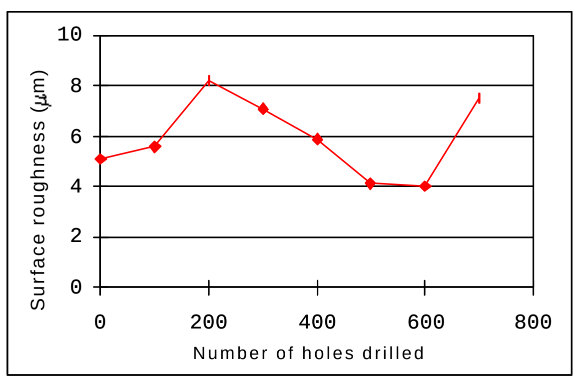
Thus it can been seen from the above results that for the machining stainless steels the MZS drills perform much better than that of high speed steel drills. Offering increased machining performance and tool reliability.

(2) Machining of Chromium steel

Diagram 9, shows the test results when drilling a blind hole, depth 20mm (.8in), for a diesel en-

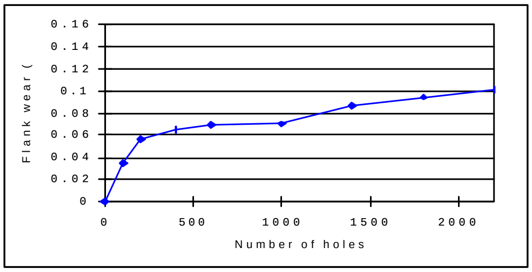


(a) Flank wear

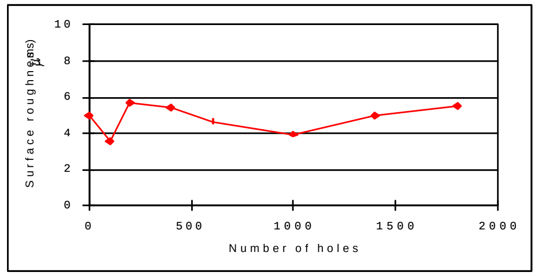


(b) Surface roughness

Dia.8: Flank wear and roughness when machining stainless steel.

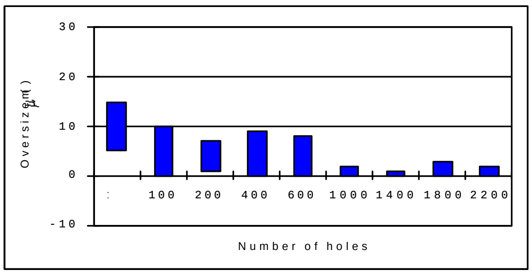


(a) Flank wear

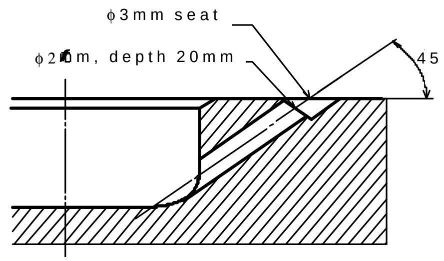


(b) Surface roughness

Dia.9: Flank wear, surface roughness & oversize when machining Chromium steel.



(c)Oversize



Dia.10: Machining of an aluminium block

gines injector pump. The workpiece was Chromium steel (JIS SCr420, 183~192HB). The cutting conditions were cutting speed=60m/min (7639mm-1), f=0.12mm/rev (.005IPR), coolant pressure was set at 7MPa. A total of 2200 holes were drilled, a total machining length of 44m (144ft). The amount of wear suffered by the drill after drilling the 2200 holes was normal and it was still possible to machine further. The results show that it could attain the required accuracy stated by the customer. Even when machining 2000 holes the range of surface roughness was within 4-6µm and hole oversize was within a range of 0-10µm.

Diagram 10, shows an example of plain drilling into an aluminium workpiece on a 45° slope with a seat (workpiece: A2219). Drilling into a surface of a workpiece on a slant can be very problematic. As the drill enters the workpiece it doesn’t enter correctly. Resulting in the drill bending, and poor hole accuracy. Additionally, under these conditions the drills are prone to suffering from breaking. This can be seen especially with cemented carbide drills. Therefore to make this kind of drilling possible, it is general practice to use an endmill or another tool to machine a seat into the workpiece prior to drilling. If possible it is also advantageous to machine a seat at the point that the drill comes out of the workpiece.

As it can be seen from diagram 10, it is impossible to machine a seat at the point where the drill exits the workpiece, and as such drilling was conducted without it. The cutting conditions were Vc=75m/min (246ft/min), f=0.1mm/rev (.004IPR), L/D=8 (20mm, .8in). To improve the chip disposal properties the cutting fluid pressure was set at 7Mpa. The results showed favorable results and that it was possible to carry out this type of machining. The surface roughness of the drilled hole was found to be less than 2µm.

Points to take into consideration when using the small diameter ZET1 drill.

The following points should be taken into consideration when using the small diameter MZS drill.

1. Cutting fluid and the filter: The diameter of the hole that supplies the coolant is approximately .2-.3mm (.008-.012”); therefore if minute pieces of dirt or chip fragments get into the hole, there is a possibility that the drill holes may get blocked. To prevent blockage of the drill holes and to assure a continuous supply of cutting fluid, a filter capable of filtration to 10 microns is recommended.

2. Machining Method: Plain drilling (non-step) examples mentioned in this article are possible. However, variations in workpieces, cutting conditions, drilling methods, and the hole accuracy may deviate from the stated articles. Consequently, it may be necessary to use step drilling, or the use of a prepared hole.

3. Drill Geometry: When machining small diameter holes, drill breakage may occur. To reduce this possibility, it is essential to maintain the rigidity of the drill. To do this, employ a drill that has the minimum flute length for the desired hole, and also try to maintain an L/D ratio, as small as possible.