Research on the influence of a new tap drill geometry on C45, 42CrMo4 and X5CrNi8 steel processing

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Abstract. The shearing of the chips in a blind hole thread presents a particular problem in machining industry. The tap geometry plays an important role in the tool's durability, influencing the forces during the tapping process and also the way in which the chips are evacuated. This paper analyzes the influence of the tap geometry on the cutting of materials such as C45, 42CrMo4 and X5CrNi8. An adequate geometry will extend the tap durability by controlling the chip when the tap reverses while still engaged in the tapping process. It relates to the improvement of a spiral tap drill, which discharges chips towards the shank via a helical flute. The article contains details about the tap geometries and the results obtained in this research. Based on the results obtained in this research, the purpose of this paper was achieved. The tap durability was improved, the chip deposition on the rake surface was reduced and the torsion torque has a smaller value compared to the standard tap geometry.

1 Introduction

Internal thread tapping is one of the most demanding machining operations. One of the major problems in the process is tap breakage, resulting from excessive torque. Since tapping is often among the final operations performed on a workpiece, tap breakage is extremely costly. Tap breakage may either ruin the almost finished workpiece, or create a large down time to remove the broken tap from the workpiece. Other problems associated with the tapping process include thread dimensional accuracy, thread form error, and surface roughness of thread forms. [1] Apart of surface coating at inner threading operations and standard applications, these technologies are final and no other post-treatment or fabrication of the threads follows. [2] The interest in this process is growing, due to it s importance for the manufacturing industry, particularly in the automotive sector. Thus, new and advanced research on this process is significant. [3] This article aims to research the cutting tool geometry. The tap geometry is very important for the tool's life, influencing the forces that act upon the tap during cutting as well as the way the chips are removed. Chip removal is an important factor in the process of threading blind holes. The

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research aims at determining the optimal geometry of the tap, which is apropriate for cutting C45, 42CrMo4 and X5CrNi8 material.

2 Geometric variants

For this scientific paper three changes were realised to the geometry of the standard M8x1,25; DIN 371/376 tap with a tolerance class of 6HX from the cutting tool company Gühring. The changes that were done are the following: outside diameter reduced, two guide lands and increased core diameter.

2.1 The tap with the reduced outside diameter

By reducing the tap diameter, the arm strength shrinks but, more importantly, it decreases the amount of removed material (pre-drilling being carried out by the same drills), thus resulting in lower torque moments. The standard tap superposed with the tap with the reduced diameter is presented in Figure 1. This superposition was performed using the „Alicona Infnite Focus" measuring device. „Alicona Infnite Focus" is a highly accurate, extremely fast and highly flexible optical 3D measurement system. Users benefit from a 3D micro coordinate measurement machine and surface roughness measurement device in only one system. [4] For this research "Alicona Infinite Focus" was used to scan and create the 3D model of every tap and machined thread after a certain number of threads. After the geometric scan of different types of taps, the special software of the machine was used to superpose two machining tools with different geometries.

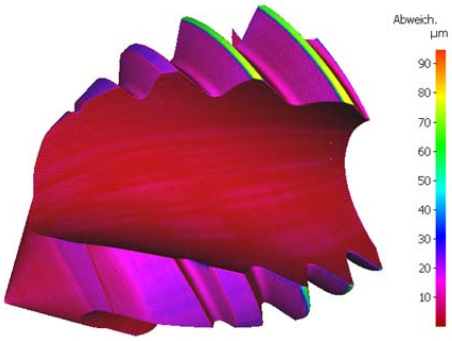

Fig. 1. Standard overlapped with the outside reduced tap diameter.

2.2 The tap with two guide lands

The guided land is carried out on the contact surface of the tap, as presented in Figure 2, this being intended to reduce friction with the workpiece. Compared to the standard tap, this geometric variant has a reduced outside diameter, it has no external relief but it doubled relief on teeth flanks. The constructive version aimed at reducing as much as possible the forces generated during processing due to friction with both the basic material and those that generate the torque moment. The two guide land tap do not allow the driving and ″galling″ of the chip between the front teeth and the processed material while withdrawing the tap.

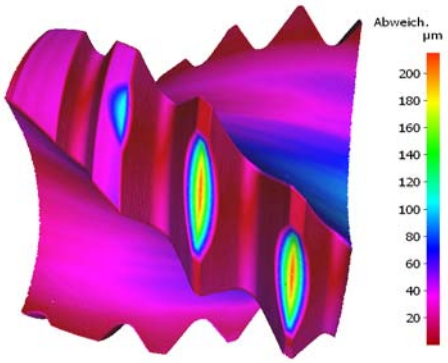

Fig. 2. Standard overlapped with the guide lands tap.

2.3 The tap with increased core diameter

The geometrical version with increased core diameter also has the exterior diameter reduced compared to the standard tap. The ascending core serves to deflect the chips without them being stuck on the guiding surface. The standard tap superposed with the tap with increased core diameter is presented in Figure 3. From this figure, the partial growth of the core as well as the reduced exterior diameter can be seen. Standard tap, chips obtained after processing stainless steel, tend to adhere to the surface of the guide land. The increased core determines directing of chips outwards, so after the withdrawal of the tap, the centrifugal force determines the chips to detach off the tap.

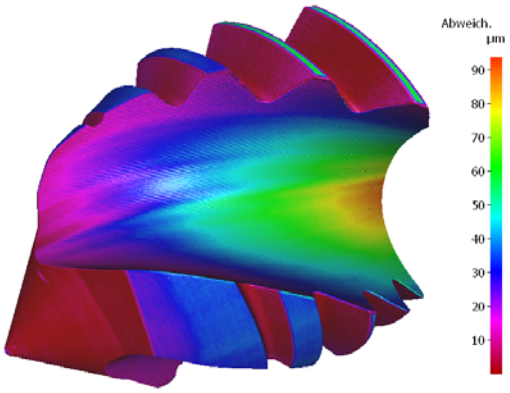

Fig. 3. Standard overlapped with the tap with increased core diameter.

3 Experimental methods and results

The workpiece material was Medium-Carbon-Steel C45 (1.0503), 42CrMo4 (1.7225) and X5CrNi8 (1.4301) in the form of a rectangular block of 30x200x500 mm. The test was conducted with the machining center „DMU 65 Monoblock" equipped with a „Spike tool" holder that allows us to measure the torsion moment and a Synchro chuck with compensation. The Synchro chuck allows compensation of axial forces resulting in a higher tool life and protects the spindle, because the direction of rotation of the chuck can be reversed. The threading was performed with external cooling. Coolant is used in machining operations to reduce tool wear, to dissipate heat from the workpiece and machine, and to aid chip breaking as well as chip removal. [5] The taps have standard coating (Hardlube)

and the same cutting parameter (1,25 pitch; 3xD depth, coolant 12%) only the cutting speed for processing each material differs (vc=12 m/min for C45, vc=15 m/min for 42CrMo4 and vc=8 m/min for X5CrNi8). All the taps have been measured before testing in order to check the geometry. In order to obtain reliable results, two taps were tested for each geometry, with a third one being tested where large differences were observed. During testing, at a certain interval of threads 3D scans on „Alicona Infinite Focus", force measuring with „Spike tool", pictures of tap, chips and threads were conducted.

3.1 Results in C45

By reducing the outside diameter of the tool, a major increase for the tool's life (approximately 20%) can be observed. By adding an increased core diameter for the tap with reduced diameter, the tool life is increased by approximately 30%. By adding two guide lands, the relief on flanks is doubled and there is no outside relief for reduced exterior diameter, which leads to a substantial increase of the tool life (approximately 40%) compared to the standard tap. The tap with a double flute and reduced outside diameter has no major influence on the tool's life. The durability of taps with different geometries, the reason for stopping the testing and the difference of durability for the same geometry are presented in Figure 4.

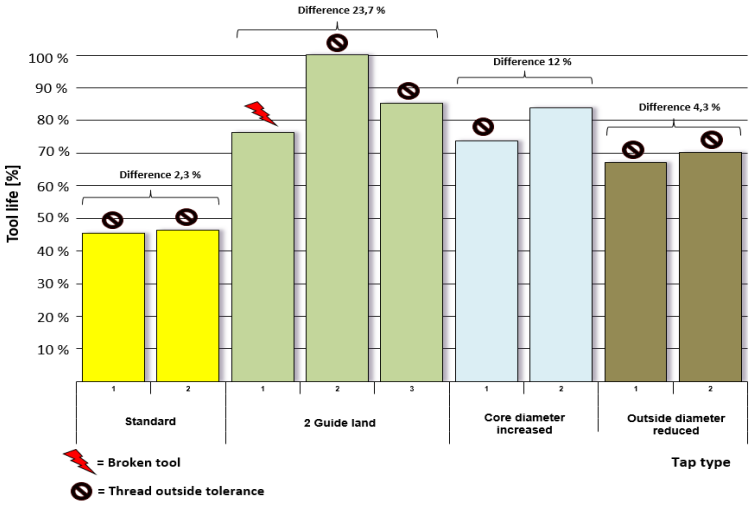

Fig. 4. Tool life in processing C45.

Fig. 5. The surface of the threads after processing 1000 threads.

In Figure 5 the quality of the obtained taps using different geometries can be seen, after machining 1000 threads. Compared to the other threads, the one made using the standard

tap is in the worst condition, having a high shape deviation. The highest quality taps obtained after machining are the ones made using the taps with two guide lands.

3.2 Results in 42CrMo4

After the experiments, a major inconsistence of the standard taps was observed when machining 42CrMo4 steel, compared to the tap with a reduced outside diameter and no exterior relief. This prooves the importance of the absence of the outside land relief during the threading process of this material. In Figure 6 the durability of the taps can be observed when processing 42CrMo4 steel, where the higher average durability of the taps that have two guide lands compared to the the other cutting tools.

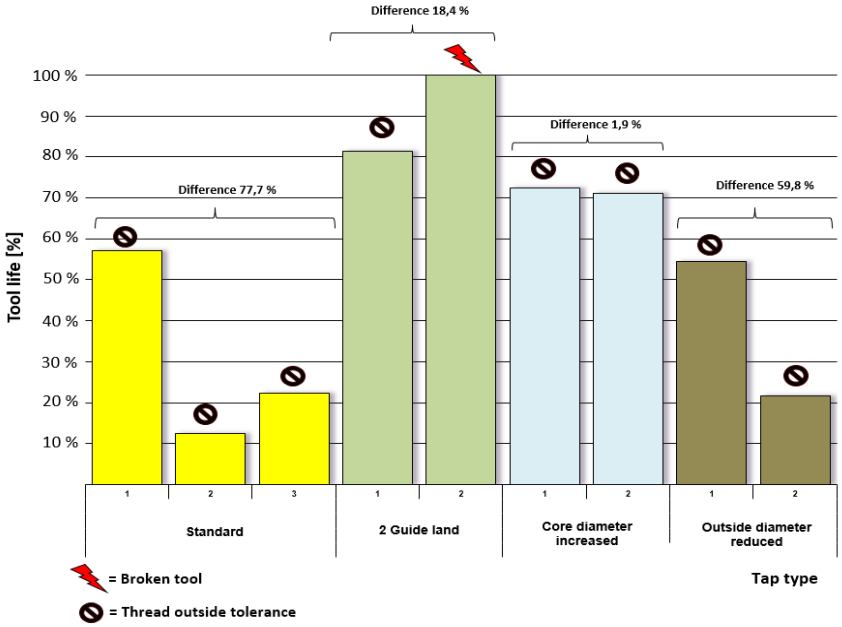

Fig. 6. Tool life in processing 42CrMo4.

3.3 Results in X5CrNi8

Because of the features of this material, cutting parameters are different from the ones used in the other materials. The recommended cutting speed used in this material is 8 m/min.

Unlike when machining the other materials, when machining stainless steel the majority of the taps are interrupted because they break and not because of the thread tolerance. After the tests, the tap with two guide lands has almost a double durability compared to the standard tap.

This can be observed in Figure 7.

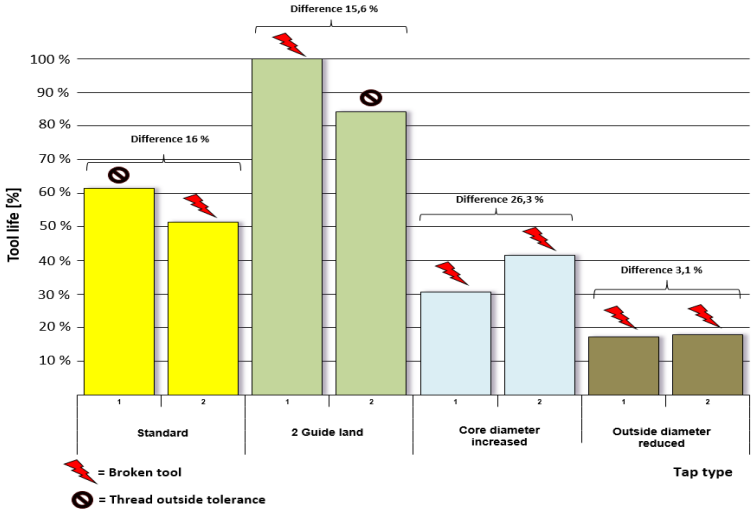

Fig. 7. Tool life in processing X5CrNi8.

4 Conclusions

Even though there is a large difference (23.7 %) between the three taps of the two guide lands taps, this is the best geometry for tapping C45 steel, having the smallest torsion moment during processing and the highest durability compared with the other types of taps. The increased core diameter being the best compared to the geometries that made the subject of this study. By reducing the exterior diameter related to the standard tap the tool's life increases with 20%, the tap's tooth having a higher resistance to failure. Like in C45 steel machining, when processing these two materials with different features, taps with two guide lands have a higher durability compared to other types of taps. Chip deposition during the tapping process of stainless steel X5CrNi8 is a major problem. Because of chip welding, on the clearance surface of the tap with an increased core diameter, it did not have a high durability, getting only to 30% of the durability of the tap with two guide lands.

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