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APROACHES UPON THE INFLUENCE OF A NEW TAP DRILL GEOMETRY ON C45 STEEL PROCESSING

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Abstract: *The article presents an analysis of the current state of research on the influence of a tap drill geometry on C45 steel processing, that extends the tap drill's life by controlling the chip when the tap drill reverses. It relates to the improvement of a spiral tap drill, which discharges chips toward a shank via a helical flute. The article contains general details about C45 steel and its applications, the importance of high speed steel and tap drills geometry, factors that influence the geometry and threading problems. The research will be divided into 4 stages, which will be achieved with the support of Gühring Company and Technical University of Cluj-Napoca.*

Key words: *C45 steel; high speed steels; tap drill geometry; threading problems*

1. INTRODUCTION

Although, several new and so-called “unconventional” methods have been discovered lately, for processing finished industrial pieces, splintering is still holding an important place among the procedures used in this field, with a percentage of 70% [1]. Tap drilling is a processing method used to manufacture inner threads. These threads can be obtained both by means of deformation and by use of the splintering process. This process can only be performed on already existing holes that have, on their outside surface, a helical channel, identical to the thread that has to be manufactured while longitudinally, they bear engraved channels, meant for chip evacuation, bearing the properties of the desired thread [2].

Making inner threads is one of the most difficult processing operations within the production process. Besides, in many cases, threads are made only at the end of the technological procedure, which raises high standards related to the process’ safety. However, in large series productions, threads have to be manufactured quicker and cheaper all the time, which requires ongoing improvement of the drilling and threading tools and procedures. There are mainly three processing methods available for manufacturing inner threads: tap threading (tap drilling), which is the recognized method; plastic deformation threading, or the splinter-free method and the milling threading, which is a highly reliable method. In order to choose the right execution procedure, it is essential to know the advantages and draw backs of each method, as well as their use limits [3].

Tapping involves relative axial and rotational motions between the tap and the workpiece. In most cases, the tap is rotated and fed into the workpiece, but sometimes the workpiece is rotated and either the workpiece or tap is fed. The feed per revolution must be the same as the pitch of the required thread. Unfortunately the tapping process is entirely hidden when it is performed. As a result, it is harder to determine what the underlying problems are and why. While chip formation and removal patterns provide key indicators of action, they are often not enough. The geometric complexity of the tap makes it difficult to fully characterize or measure. Tap design and conformance to design are two of the critical factors of successful tapping. Part design can play a significant role also if inadequate consideration has been given to the amount of full thread depth required, and remaining wall thickness. Insufficient lubrication, collet slipping, machine feed variations and tap retraction are all areas of additional potential problems. [15]

2. C45 STEEL STRUCTURE

C45 steel is an easy to find material, that can be used for multiple applications due to its properties and to the fact that its limits are easy to determine. It is a non-alloy steel, containing carbon as an additive, in a fairly high percentage, 0,45%. This determines the material's main characteristics. Its mechanical properties depend, naturally, on the way the steel is treated mechanically. Thus, its traction strength is 700-850 N / mm when covered and 620 N / mm when it is in a normal re-melting state. [4]

This type of steel is normally used in the car industry, especially for car parts, and it is preferred for parts submitted to lower stress levels. It is also used in all constructions fields because it is a versatile steel, even though, there usually are other, more appropriate types of steel for each application area.

The material is not recommended for welding processes because it can cause cracks induced by tension. Such tension is difficult to avoid, but it can be avoided by gradually cooling the steel. However, it is recommended that you avoid this material in welding operations. [4]

It is used to manufacture knives and gears, because it is easy to heat and modify, but its maximum resistance is 58 HRC.

Thus, it is used for standard knives, that tend to break easily since they have a low flexibility level. The ferritic-pearlitic grain structure of a normalized C45 steel is shown in Fig. 1.

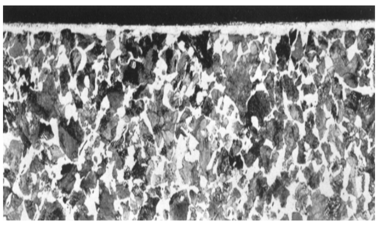

Fig. 1. C45 structure [5]

This steel is widely used in the car production industry and in manufacturing high resistance car parts, such as tools, spindles, pistons, forged parts, bolts, nuts, pipes, etc. [4]

3. THE IMPORTANCE OF HIGH SPEED STEELS

When choosing the type steel to manufacture a certain tool, the main criteria taken into account for classifying and characterising the various steels available and for determining the processing conditions needed to insure the appropriate structure, must be related to the processing type and conditions. By this criteria, steels can be classified as follows:

- Steels used for cutting tools, including high speed steels (for splintering steels running at high cutting speeds).
- Steels used for metal deformation and cold cutting tools.
- Steels used for measuring and checking tools.
- Steels used for tools designed to process non-metallic materials.[6]

I am presenting in this paper, 5 types of materials appropriate for manufacturing tap drill, that I shall use in my research:

- HSS-E Emo5Co5 (1.3243).
- HSS-E Emo5V3 (1.3344) .
- BlueTapCo.
- HSS-E PM30 (1.3294).
- HSS-E PM52 (1.3253).

3.1. HSS-E Emo5Co5 (1.3243)

HSS-E Emo5Co5 is alloyed with tungsten, molybdenum and 5 % cobalt, excellent cutting and edge holding properties, high red hardness and resistance to tempering with high wear resistance and toughness, excellent compression strength, fine grain size and carbide particle size being suitable for thermal stresses and continuous cutting. [7]

Table 1

Chemical composition of HSS-E Emo5Co5 [8]

C	Cr	Mo	V	W	Co
0,92	4,10	5,00	1,90	6,40	4,80

HSS-E is used for highest stressed twist drills, taps and cutters, heavy duty milling, drilling, turning and planning tools of all types, cold work tools, sectioning tools of all kinds, woodworking tools, hobs, reamers, saws, knives, broaches, profile cutting blades, machining of high strength materials, trimming dies, punches, tools for high cutting speeds, highly stressed dies and tools for in cold shearing and extrusion processes, cold forming tools. [7]

Physical properties:

At 20 °C, the density is 8,1 kg/dm^3 he thermal expansion is between 10-6 $m/(mK)$ and the thermal conductivity is 19,0 $W/(mK)$.

3.2. HSS-E Emo5V3 (1.3344):

HSS-E Emo5V3 has the same basic composition as HSS-E Emo5Co5, but with substantially higher V and C content. This steel grade thus combines maximum wear resistance, maximum cutting-edge endurance and good toughness. [5]

Table 2

Chemical composition of HSS-E Emo5V3 [5]

C	Cr	Mo	V	W
1,28	4,20	5,00	3,10	6,40

HSS-E Emo5V3 is used for screw taps, reamers, heavy-duty milling cutters, screw dies, shaper cutters and rotary shaving cutters for machining hard materials, socket-head and round-hole punching dies for manufacturing nuts. [5]

Physical properties:

At 20 °C, the density is 8,07 kg/dm^3 and the thermal conductivity is 20 $W/(mK)$. [9]

3.3. BlueTapCo:

BlueTapCo addresses specifically the needs of tap manufacturers by improving the grind ability of taps. Its superior characteristics will make BlueTapCo the material of choice for ease of manufacturers, leading to improved usage value. [10]

Table 3

Chemical composition of BlueTapCo [10]

C	Cr	Mo	V	W	Co
0,93	4,20	5,00	1,8	6,40	4,8

Grinding is the most costly operation in tap manufacture. Compared to Emo5Co5, BlueTapCo reduces manufacturing costs through increased productivity and savings in consumables (energy and grinding wheels). BlueTapCo grinding times are up to 40% lower when compared to Emo5Co5. Owing to greater micro structural consistency, manufacturing is more stable and process parameters can be finely tuned to minimize downtime between manufacturing batches. There is no need to modify your heat treatment procedures from those applying to Emo5Co5: they are also applicable to BlueTapCo and will release the same hardness levels. [10]

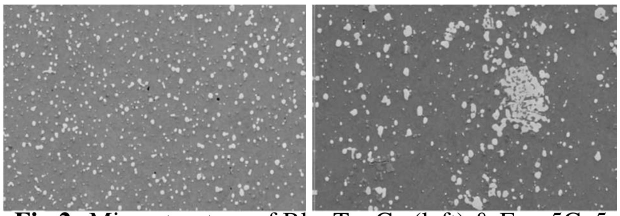

Fig.2. Microstructure of BlueTapCo (left) & Emo5Co5 (right), at the same magnification [10]

3.4. HSS-E PM30 (1.3294):

Powder metallurgical high speed steels are primarily developed for the use in cutting tool applications as tap drills, drills, milling cutters, broaches, hobs etc. The advantage is the freedom of segregation resulted in considerably higher cutting edge stability. This provides the user of PM-tools with the possibility of long tool life and/or the use of higher speeds and feeds. Positive loaded concepts as lean production, cost cutting, increased productivity are thus synonymous with the use of PM high speed steels. The cobalt addition of about 8.5% has a positive influence on the hot strength/hardness, temper resistance and modulus of elasticity. [11]

Table 4

Chemical composition of HSS-E PM30 [11]

C	Cr	Mo	V	W	Co
1,28	4,20	5,00	3,10	6,4	8,50

3.5. HSS-E PM52 (1.3253):

HSS-E PM52 is W alloyed grades for high performance tools used for tap drills; cutters. The applications for this material are:

mechanical precision machining, fine grinding, eroding and welding. [10]

Table 5

Chemical composition of HSS-E PM52 [10]

C	Cr	Mo	V	W	Co
1,60	4,80	2,00	5,00	10,5	8,00

4. HELICAL TAP DRILLS

A tap drill designed for blind holes can be used for long splinter materials and it has a higher traction strength.

Fig.3. Helical tap drill [12]

4.1. FACTORS INFLUENCING THE GEOMETRY

4.1.1. A NARROW DISCHARGE ANGLE

The narrow discharge angle has the following features:

- It increases the cutting edges' stability (with large discharge angles, ruptures can occur in the cone area).
- It usually produces splinters that are easier to contain.
- It generated parts with lower surface qualities.
- It increases the splintering forces, e.g. the cutting momentum. [13]
- It is necessary for processing tougher materials.
- It increases the compression tendency borne by the processed material, in other words, the tap drill splinters less with its main blade thus, creating smaller threads. [13]

4.1.2. A LARGE HELIX ANGLE

A large helix angle has the following features:

- It facilitates chip evacuation.
- It reduces the tool's stability, thus limiting the maximum cutting momentum.
- It reduces teeth stability.
- It reduces durability. [13]

4.1.3. THE FLANK POSITIONING ANGLE

The flank positioning angle must be adapted to the processed material. Materials bearing a higher traction strength and those prone to blocking need larger flank angles. As the flank angle increases, the tool's steerage properties drop. That's why, debits can occur in soft materials, when compensation mandrels are used. [13]

4.1.4. THE HELICAL CONE ANGLE

The helical cone angle is limited by the cone's length and the number of channels because, a larger cone angle means a smaller tooth width in the first cone prism. This decreases the cutting edge's stability (a higher risk of breaking in the cone area). However, a larger cone angle facilitates chip evacuation forward. If the cone angle is too narrow, chip evacuation may become a problem. The solution may be represented by tools bearing their helix towards the left side. Tap drilling remains the most frequently used method of manufacturing inner threads. When developing the right tools for this activity, one must focus primarily on determining the process, the quality and the production costs per thread. [13]

4.2. THREADING PROBLEMS

Threading control is a main issue when it comes to tap drilling blind holes, especially in the case of deep blind holes, made in tough materials, that produce long chips. Chip control issues are mostly raised by chip bundles, accidental couple tips, tooth breakings in the guidance area and/or full breakings.

The higher the material resistance and the lower its breaking elongation, the better you can control the chip. Chip control is the most difficult in cases of soft construction steels, of low alloy steels and stainless steels with low traction strengths. The more influences affect the formation of chips, through the above mentioned methods, the lower the quality of the thread surface. That's why, the measures taken must be correlated with the client's requirements.

The splinter rebutment phenomenon is most often encountered in tap drills used for making angle blind holes in large helixes. The forward axial force, resulted due to the helix's angle, may pull the tap drill into the hole, faster than the actual rhythm allows it. That's the corkscrew effect and the so called axial rebutment.

Due to their geometry, tap drills used for through holes, are subject to axial forces acting backwards, compared to their moving way, which may also lead to axial rebutment. This axial rebutment may be facilitated by using tap drills with large flank angles in soft materials or by employing the splintering edges inappropriately.

Fig.4. Inner threading with helical tap drill [13]

Fig.5. Blind hole thread, axially discarded [13]

Tap drills that fail frequently during the cutting process, due to the above mentioned reasons, systematically produce threads that are too large. Sporadic incidents of splintering rebutment can also occur when a tool is subject to radial unilateral forces, due to a splinter blockage or a material loading by welding. That's the radial rebutment. [13]

For steels under 1000 N/mm2 or, generally, for stainless steels and for other strong materials, the chips cannot be usually broken. In such cases, chips must be evacuated through helical tools.

If there is an inner cooling system, the cooling agent contributes only to the evacuation of chips. In certain cases, one can use tap drills with smaller helixes, thus increasing durability.

5. CONCLUSION

To get meaningful results, the research starts with testing tap drills from different high speed steel, with different coating and in the end we will make changes in the micro geometry. Taking into account the requirements defining the issues related to tap drill geometry, the following aims have been proposed:

- Determining the optimal material (for manufacturing a tap drill) to process C45 steel.
- Determining the appropriate geometry, bearing the best influence on the tool's life.
- Determining the appropriate coating for this tap drill.
- Determining the optimal micro geometry.

In order to achieve our desired purpose, we shall follow several steps:

- Stage 1: Determining the right material for manufacturing tap drills. For this stage, we have chosen 5 types of HSS. All tap drills shall bear standard geometries and coating. Only the type of steel used to manufacture them shall vary. At the end of this stage we shall know what type of high speed steel is appropriate for processing C45 steel.
- Stage 2: In the second stage, we shall prepare a series of tap drills, bearing different geometries. They shall be made of the optimal type of steel determined during stage 1 and they shall have standard coating and the same cutting parameter. At the end of this stage, we shall know the influence geometry has on C45 steel processing.
- Stage 3: After determining the appropriate material and geometry, we shall determine

how a tap drill's coating influences the processing operations.

- Stage 4: During the last stage, we shall test the cutting tools prepared, with their cutting edges rounded to various degrees, in order to determine the appropriate rounding. At the end of this stage we shall know which procedure used to prepare the cutting edge, has the best influence on the tool's life.

Future research opportunities:

- Determining the optimal geometry and micro-geometry for other types of tap drills.
- Determining the optimal micro-geometry for all types of materials used in manufacturing tap drills.
- Testing other threading technologies, that can be more economic, more productive and more precise.

6. ACKNOWLEDGMENT

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Stadiul actual al cercetărilor privind influența unei noi geometrii a tarodului la prelucrarea oțelului C45

Rezumat: *Articolul prezintă stadiul actual al cercetărilor privind influența unei noi geometrii a tarodului la prelucrarea oțelului C45, cu scopul de a crește durabilitatea sculelor așchietoare prin controlul așchiilor. Acesta se poate realiza prin îmbunătățirea geometriei tarodului elicoidal. Articolul conține informații generale despre oțelul C45 și aplicabilitatea lui, importanța oțelului rapid si geometria tarodului, factorii care influențează geometria tarodului si problemele care apar în timpul procesului de filetar. Cercetarea va fi impărțită în 4 etape și va fi realizată prin colaborarea Universității Tehnice din Cluj-Napoca și firma de scule așchietoare Gühring KG.*

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