RCMOS – Multidisciplinary Scientific Journal of Knowledge.
ISSN: 2675-9128. São Paulo-SP.

**Year V, v.1, n.1, Jan/July 2025. | submission: 20/01/2025 | accepted: 22/01/2025 | published: 24/01/2025**

# GEOMETRY OF TWIST DRILLS AND THEIR APPLICATION IN INDUSTRY *THE GEOMETRY OF SCREW DRILLS AND THEIR APPLICATION IN INDUSTRY*

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## SUMMARY:

The drilling process is an extremely important event in the machining process of materials. For this operation to occur, the use of drills is essential. In the historical context, drills are characterized as one of the oldest machining tools developed by man, with the first records of similar tools dating back to ancient Egypt, where cylindrical metal structures with sharp tips were rotated with the aid of a rope and a bow to produce holes in wood or soft materials. Currently, drills are used in a variety of ways and their use in the industrial context is increasing. The geometry of this type of tool has undergone considerable evolution with technological development; however, drills still use the shearing mechanism, which in turn characterizes drilling as a conventional machining process. Regarding the machining of metallic materials, the models and types of drills can be diverse and their application will be related to the type of operation to be performed. For this reason, twist drills must present geometric characteristics and resistance inherent to the material from which they are manufactured. These characteristics must be such as to best optimize resistance to fatigue and buckling, durability, and suitability to cutting parameters, in order to promote efficient drilling free of dimensional and geometric deviations, ensuring the precision and tolerance required in the design. In this context, this work seeks to address the design and geometry of twist drills, promoting a discussion about their increasing use in the mechanical industry and their economic impacts.

**Keywords:**Twist drills, Drilling, Tool geometry, Metalworking.

## ABSTRACT:

The drilling process is an extremely important event in the machining processes of materials. For this operation to occur, the use of drills is essential. In the historical context, drills are characterized as one of the oldest machining tools developed by man, with the first records of similar tools dating back to ancient Egypt, where cylindrical metallic structures with sharp ends were rotated with the help of a rope and an arc for producing holes in wood or low hardness materials. Currently, the use of drills is diverse and their use in the industrial context is increasing. The geometry of this type of tool has considered considerable evolution with technological development, however, the drills still use the shearing mechanism, which in turn characterizes drilling as a conventional machining process. Regarding the machining of metallic materials, the models and types of drills can be diverse and their application will be related to the type of operation that will be performed. For this reason, twist drills must have geometric characteristics and resistance inherent to the material from which they are manufactured. These characteristics must be such that they best optimize resistance to fatigue and buckling, durability, and suitability for cutting parameters, with the aim of promoting efficient drilling and free from dimensional and geometric deviations, guaranteeing the precision and tolerance required in the project. In this context, the present work seeks to address the design and geometry of twist drills, promoting a discussion about their growing use in the mechanical industry and their economic impacts.

**Keywords:**Twist drills, Drilling, Tool geometry, Metal machining.

## 1. INTRODUCTION

The drilling process is one of the most commonly found processes in industry. Along with turning, it is one of the most important operations, involving approximately 33% of all metal machining operations. It is normally performed in the last stages of manufacturing a part, when a large amount of time and money has already been spent, and therefore must be very reliable (TONSHOFF and KÖNIG, 1994).

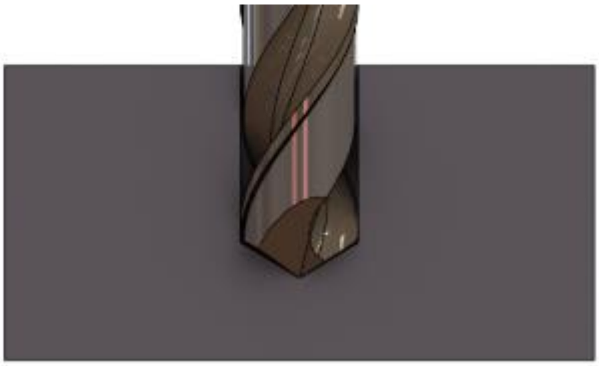
Thus, according to Groover (2007), the growing need for industry to promote efficiency in production processes to obtain better economic results stands out. Therefore, improving production methods is a matter of survival for companies that wish to achieve or maintain technological vanguard in their field, since the incessant search for innovation can be the key to success, or, on the contrary, determine the failure of the business. This tendency to innovate leads to the search for technologies that are linked to available scientific knowledge. However, it is noticeable that the excellence of research in this area does not always reach the industrial environment, since there are great challenges in determining the ideal values for machining conditions in a mass production environment. Thus, the industry generally limits itself to the use of suggested values that are rarely improved by carrying out prior machining tests or economic optimization criteria.

## 2 DEVELOPMENT

According to Ferraresi (1970), drilling can be defined as a mechanical machining process designed to obtain a generally cylindrical hole in a part, with the aid of a generally multi-cutting tool. To do so, the tool or part rotates and simultaneously the tool or part moves along a straight path, coinciding or parallel to the main axis of the machine. This machining process can be divided into other main operations such as:

a) **Drilling through:**This is the actual drilling process, as illustrated in Figure 1. It consists of opening a generally cylindrical hole in the workpiece in such a way that all the material contained in the volume of the final hole is removed in the form of chips. To perform drilling at great depths, the aid of a special tool is required to extend the length of the drill.

Figure 1 – Representation of full drilling, section view.



Source: Prepared by the author.

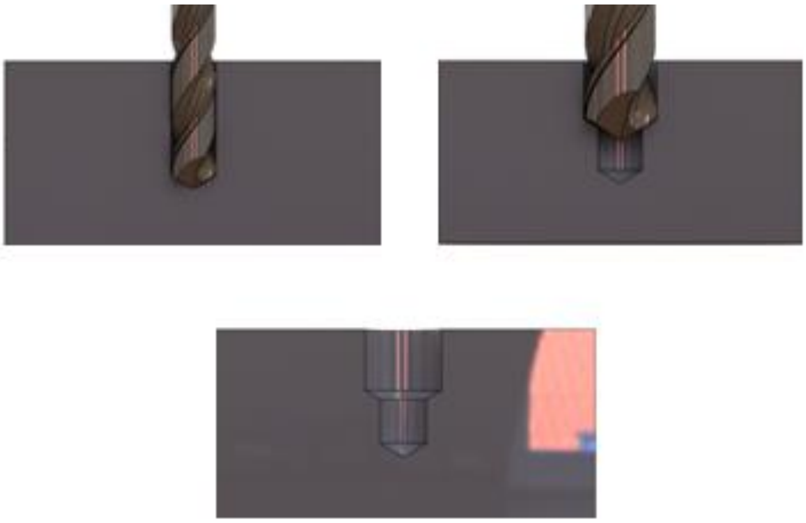
b) **Countersinking:**Operation intended to open a shallow cylindrical hole in an already drilled part. It can be performed with a drill with a larger diameter than the hole or with the aid of a countersink tool, as illustrated in figure 2.

Figure 2 – Representation of countersinking in a hole, section view.

Source: Prepared by the author.

**c) Step drilling:**This drilling process is designed to obtain holes with more than one different diameter, as shown in figure 3. Special stepped drills are generally used to open these holes, however, it is common in the industry to use conventional twist drills combined to reproduce the same effect.

Figure 3 – Representation of stepped drilling, section view.

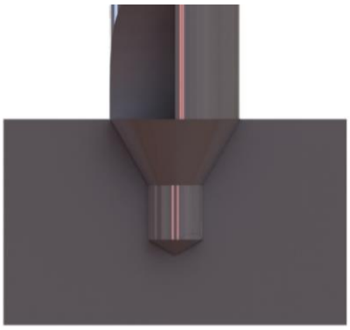


Source: Prepared by the author.

**d) Center drilling:**It is an initial machining process, that is, it is followed by other manufacturing processes. As shown in Figure 4, center drilling is generally performed in order to produce a small hole for fixing parts with counterpoints.

on lathes, or even for opening a guide hole to support a subsequent drill.

Figure 4 – Representation of center drilling, section view.



Source: Prepared by the author.

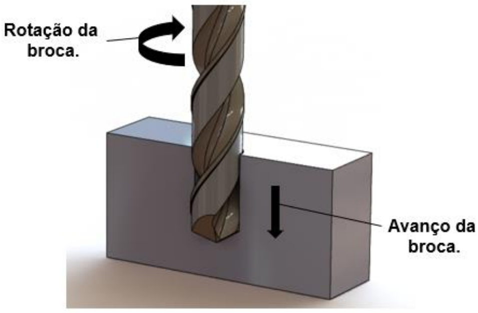
**e) Trepanation:**This is a drilling process that is rarely used. It consists of removing only part of the material contained in the final hole volume. The removed material is reduced to chips, leaving a solid core in the machined part as shown in Figure 5.

Figure 5 – Representation of drilling by trepanation.

Source: Sandvik Coromant (2024).

Regarding the movements in the drilling process, the rotation movement of the drill around its axis and the advancement movement of the drill in relation to the piece to be drilled stand out. The two movements combined are responsible for promoting the shearing of the material, generating the desired result in the machining process as shown in Figure 6.

Figure 6 – Representation of the main movements of the drill, section view.

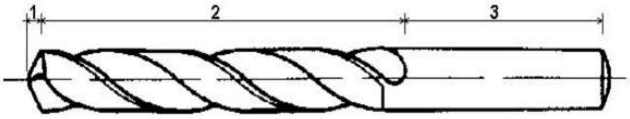


Source: Prepared by the author.

According to Chiaverini (1986), during the material cutting process, the tool's cutting edges tear off the material, and the resulting chip, as it is removed, curls into a cylindrical spiral, sliding through the tool's two helical channels. In this way, the entire geometry of the tool works to execute the drilling perfectly. The part of the drill responsible for shearing the material is its tip, where there may be two or more cutting edges.

Figure 7 shows the basic parts of twist drills, which according to Watson (1985) are composed of a tip (1), body (2) and shank (3). These parts are used, respectively, to cut the material, remove the sheared portion and fix it in the chuck of the machine tool.

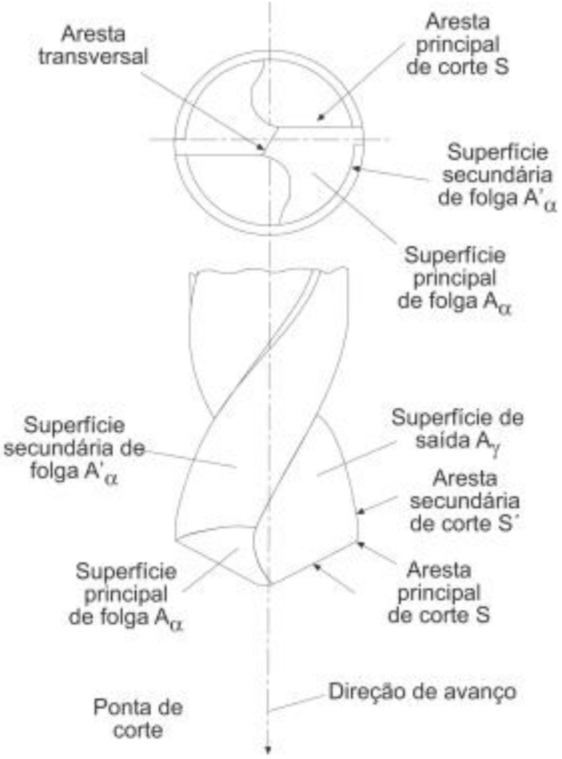
Figure 7 – Main parts of the twist drill.



Source: Watson (1985).

According to Diniz, Marcondes and Coppini (2014), drills can have the following parts, as exemplified in figure 8:

Figure 8 – Main parts of the twist drill.



Source: Diniz, Marcondes and Coppini (2014).

Secondary clearance surface (α) — is the surface of the tool cutting wedge that contains its secondary cutting edge and that faces the secondary machining surface.

Main cutting edge S — is the cutting edge of the wedge formed by the intersection of the rake and main clearance surfaces. It generates the main machining surface on the workpiece

Secondary cutting edge S' — is the cutting edge of the cutting wedge formed by the intersection of the rake and secondary clearance surfaces. It generates the secondary machining surface on the workpiece.

Cutting point — is the part of the cutting wedge where the main and secondary cutting edges meet. The cutting point can be the intersection of the edges, or the convergence of the two edges through a rounding, or their meeting through a chamfer.

## 3. FINAL CONSIDERATIONS

This paper discusses in detail the geometry of twist drills and their importance in the machining processes of metallic materials. Throughout the research, it became clear that the evolution of the geometry of twist drills is directly related to the growing demands of the industry for greater efficiency, precision and cost reduction. Drilling is one of the most recurrent operations in the industrial context, representing about one third of all machining operations, which makes the continuous development of these tools essential and indispensable.

When considering the complexity of drilling processes, we realize that technological advances in drill geometry play a crucial role in improving the quality and productivity of operations. The geometry of these tools directly influences their ability to perform efficient and precise cuts, preventing premature wear, increasing the life of the drills and reducing downtime due to tool replacement. This increase in efficiency is essential in mass production environments, where any dimensional deviation can compromise the final quality of the product.

Furthermore, a historical analysis of the development of drills has shown how the evolution of cutting technology has been accompanied by significant changes in the industry, from the simple rotary tools used in ancient Egypt to modern twist drills, optimized for different types of materials and applications. The introduction of new materials and treatments for drills, such as TiN (titanium nitride) and TiAlN (titanium aluminum nitride) coatings, has further expanded the range of applications and durability of these tools. The advent of high-speed machining (HSM) has also driven the demand for tools capable of withstanding greater mechanical and thermal stresses, which has led to the need for constant improvements in drill geometry.

Another fundamental aspect addressed throughout this study was the diversity of drilling operations and their respective criteria. Depending on the type of hole to be made, whether full, countersunk, stepped or by trepanning, the drills must be designed with specific characteristics to meet these requirements. Conventional tool selection can result in failures in the machining process, such as excessive wear, formation of inadequate pits, failures in material removal or dimensional deviations. Therefore, the correct choice of drill must take into account the operation to be performed and the material to be drilled.

In addition to the technical aspects related to drill geometry, this study also highlighted the economic impacts of using these tools in industry. The appropriate selection of drills with optimized geometries and resistant materials has the potential to significantly reduce production costs, increasing the efficiency of drilling processes. Reduction in machining cycle time, reduced need for tool replacement and reduced rework are just some of the benefits that can be reaped when the right drills are applied in drilling operations. These factors, in turn, have a direct impact on the profitability of companies, especially those operating with large production volumes.

On the other hand, it was also mentioned that, despite the advances, the industry still faces challenges in implementing new technologies related to drill geometry. Although there is a vast scientific knowledge available on the subject, the transfer of this knowledge to the industrial environment is not always quick. To face these challenges, closer integration between academic research and industry becomes essential. Conducting studies that evaluate the application of new drill geometries in different types of materials and operations is a strategy that can bring significant results for the continuous improvement of machining processes. Practical tests in industrial environments, in combination with computer simulations, can provide more accurate data for optimizing cutting configurations and for developing drills with improved geometry, focusing on reducing failures and increasing durability.

In summary, the present study highlighted that the geometry of twist drills plays an essential role in the efficiency and accuracy of drilling processes. Continuous innovations in the design of these tools, driven by advances in materials science and manufacturing technologies are essential to meet the growing demands of modern industry. As technology advances, new solutions are expected to emerge, further increasing the productivity, quality and competitiveness of companies that use drilling in their machining processes.

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## ACKNOWLEDGMENTS

I would like to thank God first and foremost for the gift of life and for the inspiration on the path of scientific knowledge. I would like to express my gratitude to Our Lady of Aparecida and the Catholic Church for their constant moral and spiritual support, which guided my search for truth and wisdom.

To my parents, Edson Rosa Moreira and Angela Maria Morais Moreira, and to my brother, Edson Júnio Morais Moreira, I am deeply grateful for their unconditional moral support and encouragement at every stage of this journey.

To Prof. Dr. Sandro Cardoso dos Santos, my sincere gratitude for the trust placed in me, for the knowledge shared and for the constant encouragement in the search for knowledge.

Finally, I would like to extend my thanks to the entire teaching team at CEFET-MG, whose unwavering dedication and commitment were fundamental to the development of this research and the advancement of science in Brazil.