

Burr Formation in Drilling of Aluminum Alloy

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Abstract— The exit burr formation in drilling of aluminum alloy 319 will be investigated. Particular attention will be focused on the relation between the exit burr type and size and the cutting parameters. A wide range of cutting conditions (feed rate and surface speed) will be tested in order to explore also the unusual and extreme cutting conditions. Data will be collected and analyzed for the establishment of the Drilling Burr Control Chart. Eventually the data obtained for aluminum will be compared to the data obtained for stainless steel, low carbon steel and titanium alloy.

Introduction and background

Aluminum and its alloys are considered easy-to-machine materials [11]. Many studies have been conducted on the machinability of aluminum alloy, but almost none of them focus on the problem of burr formation. Burrs are frequently considered as an unavoidable consequence of metal cutting and the deburring operation has always been treated like the usual operation after machining. Manuals or handbooks suggest the cutting conditions and the tool characteristics for many materials and for many metalworking operations, but they provide no information about the burr formation, because the burrs are always supposed to be removed later in the deburring operation. Moreover a standard classification of different kinds of burrs doesn't exist [9]. In precision machining operations the cost of the deburring can reach 30% of the total machining cost. The possibility of controlling the burr formation allows to optimize the deburring process, and, in some cases, to get rid of it.

The research that has been conducted up to now on the burr formation can be divided to analytical [1,2,3,4,5] and experimental [6,7,8]. The goal of analytical research is to model the process of burr formation and to establish a mathematical model capable of predicting the burr formation in a real machining operation. The complexity of the problem limits the capability of these models to predict the burr size and shape. Moreover, due to the complexity of the drilling operation, the modeling operation becomes consequently more difficult.

The goal of experimental investigations is to study the burr formation of different materials for different machining conditions. The aim of this research is to establish the link between the burr characteristics, the tool geometries and materials and the cutting parameters.

The burr formation process

When drilling, two burrs are formed: a small entrance burr and a much bigger exit burr. The process of drilling exit burr formation can be divided into three different stages as shown in Figure 1 [6,10].

1. When the drill approaches the exit side of the workpiece, the chisel edge of the drill produces the plastic deformation of the work beneath material.
2. Then a bulge develops on the bottom surface of the workpiece. The remaining material in front of the corners of the tool is still strong enough to withstand the thrust force of the drilling operation. Thus, no plastic deformation occurs in this region and the normal cutting process continues.
3. As the material beneath the chisel edge reaches its maximum elongation, it starts to tear and finally the drill breaks through and the remaining material is bent out and becomes the burr.

Planned Work

The experimental research in burr formation is still bound to the material of the workpiece. For stainless steel ANSI 304 and for low carbon steel AISI 4118 a Drilling Burr Control Chart (DBCC) has already been developed by Kim [6]. Further investigation is necessary for the titanium alloy Ti-6Al-4V. The objective of this study is to complete the first set of DBCC for different material classes, providing data on the burr formation in drilling the aluminum cast alloy Al 319. Two drill sizes will be used for developing the aluminum DBCC. In this chart the burr type is plotted as function of the cutting speed and the ratio between feed rate and drill diameter. This ratio is also equivalent to the ratio between the height and the width of the uncut chip. Similar values of this parameter mean that the local cutting conditions are similar, even if the dimension of the drill is changed. As a

consequence, the DBCC, which is plotted as function of the local cutting conditions, can be considered as independent from the drill diameter [6].

Expected results

The plastic characteristics of the workpiece material are fundamental parameters to understand the burr formation. The more brittle behavior of this aluminum alloy will probably produce quite different and smaller burrs than those shown in drilling the stainless steel. As a consequence of the higher temperature, a more ductile behavior (and consequently a different type of burr) is expected when drilling with high speed and low feed rate. It's expected that a transition burr type may also occur.

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Figure 1 (according to Gillespie [10])

