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A Review on Burr Formation during Drilling Operation of Aluminium Alloy

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ABSTRACT

Making of holes on the parts during drilling process for precision assembling of parts facing problems with burr formation. Drilling operation is one of the finishing operations in the production cycle, removal of burrs during drilling process is a time consuming and non-value added process to the manufacturing sector. In the present work, minimization of burr size and hole quality is considered during drilling of aluminium alloy series of 6061.

Keywords: Drilling, Burr, Aluminium alloy, Hole, Quality, Precision

I. INTRODUCTION

Precision manufacturing has gained much prominence in manufacturing industries in the recent past. The best product dimensions and minimization of time and cost of production has become a measure of concern. Most of the manufacturing processes such as milling, drilling and boring etc. for product design are to achieve the qualitative products. Drilling process takes care about 35% of all machining processes [1-4] and influences the acceptability of the products as the drilling process is at the most final processing stage in the production line. The burr, which is a plastically deformed material, engendered during drilling is a preventable output and often lowers the surface quality, diminishes the product life and acceptability of the product. Total elimination of burrs during drilling process is a trivial task, however, with proper selection of process parameters, it can be curtailed. Selection of process parameters according to workpiece material and hole quality requirements, is critical for the minimization or prevention of burr formation. However, analytical models developed so far for the interaction between process conditions; material properties and burr formation are limited. Therefore, the burr, an unintended outcome of machining processes, has been a widely recognized problem in the industry. Burrs ruins the integrity of design of the part. All these side effects causes unnecessary cost to the industry in various forms such as additional machining, compensation, service, redesign and collateral damage on the company reputation. Therefore, in most cases, it is a must either to remove or to secure the burr in order to prevent from being detached as of the part. Traditionally, burr problems had been considered unavoidable so that most efforts made on removal of the burr as a post process. Nowadays, a trend of manufacturing is an integration of the whole production flow from design to end product. Manufacturing problem issues are handled in various stages, even from design stage. The methods of describing the burr are gaining much attention in recent years for the systematic approach to resolve the burr problem at various manufacturing stages. The present work aims at developing a mathematical model for thrust force and burr formation in drilling operation. Thereby validating these models, experiments are conducted by varying different process parameters. The proposed work is to minimize the burr formation and to evaluate the influence of process parameters in drilling are prescribed to achieve good quality to the product and minimize the deburring cost.

Burr Formation: While 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 Fig.1.

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.

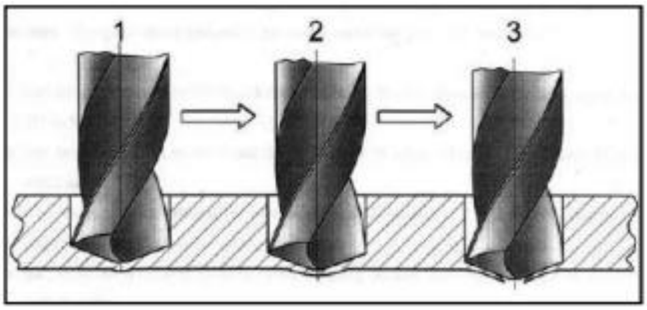

Fig.1: Burr formations in three different stages [2]

Surface Roughness: The reliability of the process in achieving the required surface finish is important as otherwise it adds to the cost of manufacture through part rejection and rework. One of the principal design considerations for extremely stressed components will be the surface condition produced during manufacturing. With regard to the quality characteristics of drilled parts, some of the problems encountered include hole surface roughness. Many factors effect hole diameter and surface quality, which can be divided into controllable and non-controllable parameters for better hole diameter accuracy and surface roughness.

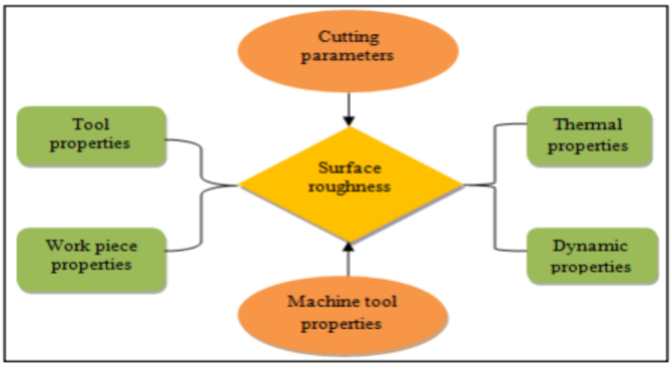

Fig.2: Six major categories that effect on surface roughness

There are three essential parameters in surface roughness, arithmetical mean deviation of the profile (R_a), maximum height of the profile (R_{max}) and height of the profile irregularities in ten points (R_z). In drilling, surface roughness mainly dependent on the feed rate, also influenced by the point angle of the drill and wear status of the outer corner of the two cutting edges. It has been found that drill material has the most important influence on surface finish of the work material.

Scope and Objectives of work: Al 6061 alloy is highly versatile and can be used for almost any structural component. Commercial and personal use vehicles utilize Al 6061 for truck frames and running boards, infrastructural uses include mass transit and subway platforms, steps, flooring, walkways and cover plates, and consumer products such as bicycle frames, components and tanks all benefit from the increased weldable nature and its ability to undergo hot forging. Other applications include military vehicles, bridges, weapons manufacture and structural applications. Various applications of aluminium alloy are as shown in Fig.3

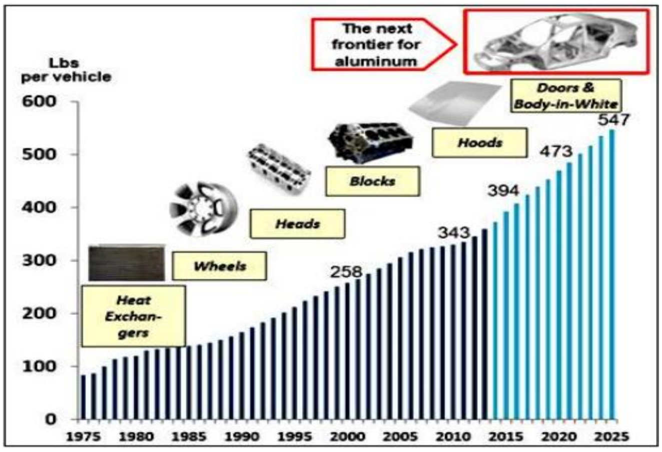

Fig. 3: Trend of aluminum components in cars in the last 50 years [9]

The most influence of a number of process parameters (both input and output) on the performance measures of drilling process. Grey relational analysis can be chosen based on the multi performance characteristics of the drilling and the optimal combination of parameters optimizes the burr size (height and thickness), thrust force and hole quality (surface roughness and roundness error). Most of the works on optimization of drilling parameters for Aluminum alloys and more over no study in drilling process using Grey Relational Analysis. When a new tool is available, the problem to find better and more economical. In recent years, grey relational analysis has been gaining more importance and attaining promising in industrial applications which improving the performance of drilling process for enhancing quality and economy. In this study, the main objective of the present work are to investigate the performance characteristics in drilling and the new technologies to overcome the minimize burr size by minimization of drill thrust and torque during drilling of aluminium alloys based on Grey based Taguchi approach by selecting the appropriate drill geometry and drilling conditions.

Literature Review: Literature review on drilling has been carried out in the direction of optimization of process parameters in drilling for minimizing damage of parts due to vibrations, burr formation on edges, out of roundness and cylindricity. As manufacturing processes became advanced, precision components require more attention to both the generation of surfaces and dimensions with tight tolerances. High quality products should be precisely manufactured according to the design specifications with minimal costs. Drilling is one of the most common and complex operations among many kinds of machining processes, used in a variety of manufacturing industries including aerospace and automotive sectors. An unwanted projection of material formed during the drilling process, termed as burr as a part size errors.

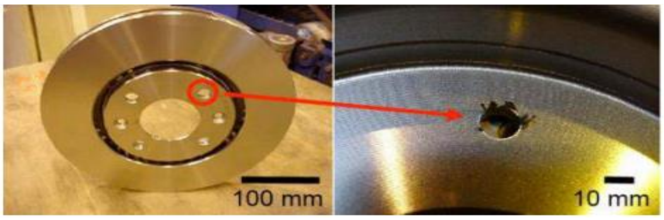

Fig.3: Micro image of burr formation on Flange

Burr formation in drilling is influenced by many factors, among those workpiece material like shear strength and hardness on the size of exit burrs while drilling of steels, drill geometry and process conditions are known to be more influential by Sofronas et al. [1,2] have focused on their effects on burr formation. Stein and dornfeld et al. [3] determined the sensitivity of feed, speed, drill wear and exit surface geometry in drilling of 0.91 mm diameter through holes in stainless steel material (304L). A quantitative burr formation model proposed by Ko and dornfeld et al. [4] for ductile materials during orthogonal cutting, reveals that the influence of machining parameters on burr size was evaluated with machining tests performed in a scanning electron microscope (SEM). Sugawara and Inagaki et al. [5, 6] investigated to know the effects of drill edge shapes and working conditions on burr formation, conducted a model experiment by selecting ten drill bits of each different diameter. Takazawa et al. [7] has explored several techniques that can be used for observing the effect of part material on burr formation in drilling. It was claimed that the drilling burrs produced by a drill with a nick on the cutting lips were smaller than the burrs produced by conventional drills. Kim et al. [8] carried out preliminary experiment to investigate the burr formation on drilling of Ti-6A1-4V titanium alloy, which is most widely used in aircraft industry because of its high specific strength. Shefelbine and Dornfeld et al. [9] investigated the effect of dry machining on burr size and reported that dry machining without coolant could be advantageous because of decreased costs associated with the use of coolant and a decrease in possible negative effects on worker health and the environment. Pande and Relekar et al. [10] observed that the burr formation tendency especially with reference to burr height and thickness at entry and exit of the holes during drilling by changing the drill diameter, feed rate, length of hole to diameter ratio (L/D ratio) and BHN of the work piece material. Lin and Shyu et al. [11] adapted variable feed machining process for improving cutting tool life and exit burr height for hard and difficult to machine materials. Wada and Yoshida et al. [12] emphasized on burr less drilling of various metals. The roundness of the drill's corner reduced the burr to a very small size. Takeyama et al. [13, 14] also reported that the burr around the hole exit can be minimized by applying ultrasonic vibration in the direction of drill feed. Simon et al. [15] highlighted the use of ultrasonic assistance, where the high frequency and low-amplitude ultrasonic vibrations are added in the feed direction for the reduction of burr size in drilling of aluminium work pieces. Nripen Mondal et al. [16] reported on minimization of burr height under different machining conditions for a low alloy steel specimens. Sanjib Kundua et al. [17] and Das, R, Barik, T et al. [18] also provided back up support on aluminium alloy to minimize burr height using orthogonal array design of Taguchi is applied to minimize burr height of aluminium alloy flats by optimizing three drilling process parameters viz. cutting velocity, feed and machining environment. A. Saravanakumar et al. [19] analyzed the burr height at exit of the holes during drilling of hybrid aluminium matrix composite using TiN coated solid carbide twist drills. Rajiv Chaudhary et al. [20], reviewed on experimental investigations in drilling using Taguchi techniques Ugur koklu et al. [21] investigated, the effect of mechanical properties of aluminum alloys, cutting speed, feed rate and drill diameter on burr height and surface roughness of drilling holes, using the Taguchi method. Shanti Parkash et al. [22] investigated experimentally by Taguchi method for minimizing the burr height in drilling of Al – Fly ash composite. Kilickap et al. [23] presented the use of Taguchi and RSM for minimizing the Burr height and surface roughness in drilling of Aluminium 7075 alloy under dry condition. Nouari et al. [24] experimentally tested the effect of the drilling parameters on the hole surface roughness and diameter deviations for different coated drills on aluminum alloys. Hari Singh et al. [25] conducted drilling experiments using L27 orthogonal array, to optimize the process parameters considering weighted output response characteristics using grey relational analysis. Tosun et al. [26] applied grey relational analysis to optimize the drilling process parameters for the surface roughness and burr height by considering various drilling parameters viz., feed rate, cutting speed, drill diameter and point angle. from the review of literature, it is observed that drilling of aluminium 6061 alloys are considered to minimize burr size by changing the feed rate, spindle speed and tool geometry under dry condition.

Conclusion: During the performed to burr size (height and thickness), roundness error, thrust force, torque and surface roughness. The feed rate, point angle and clearance angles are the most influencing parameters on burr height, thrust force, roundness error and surface roughness than the spindle speed and drill diameter for Al 6061 alloy. Therefore, the present work confirms that in drilling of Al 6061 alloy for all cutting conditions tested and the burr height, burr thickness, roundness error, thrust force, surface roughness and torque. On the basis of carry out further research on drilling of Aluminium alloys namely Al 6061 alloy with HSS twist drill bit, there is a lot of scope for future investigation.

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