

## A Review Paper on Friction Drilling Process on Various Materials

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**Abstract:** Drilling plays significant role in machining. More than 40% of material removal operations are related with this kind of action. Usually high temperature is generated during drilling operation. Therefore, the drilling tool becomes dull and leads to a limited service life. The chips cling to the exit of a penetrated opening decimation the surface quality and weakens drilling exactness. To eliminate this difficulty form drilling established. Form drilling, also known as “thermal drilling”, “flow drilling”, “friction drilling”, or “friction stir drilling”, is the best result to the above-mentioned difficulty. Form drilling is a non-traditional hole making operation. A rotating conical tool is implemented to penetrate a hole and create a bushing in one step without initiating chip. The form drilling process depend on the heat produced from the frictional force between the tool and workpiece to soften the work material, penetrate, and deform the work material into a bushing. The present review focus on an explanation of the influence of various drilling process parameters of form drill tool on different work material in form drilling process.

**Keywords:** Bushing, Form Drilling, Temperature

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### I. Introduction

In the automotive assembly plant, one of the main problems in manufacturing engineering is joining of sheet metal, tubing or thin walled profiles in a simple, effective way. Among many processes currently used are J nuts, Weld nuts and other threaded inserts. These processes have drawbacks like material wastage, addition of external elements, more cycle time and therefore more weight and costs with compromising quality. Friction drilling is the best solution to all these problems in simple, efficient and most economical way. Friction drilling, is also known as thermal drilling, flow drilling, form drilling, or friction stir drilling and it is a non-traditional hole making method. Form drilling is suitable to apply ductile materials only. The Form drill comes into contact with the material with relatively high axial force and rotational speed. The heat generated from friction between a rotating conical tool and the work-piece makes the material soft and malleable enough to form a plastic state near the heat generated zone, thus it causing the tool to pierce into work material and deform the work material into a bush shape, form drill.

#### 1.1 Technical Features

All work material in friction drilling is contributed to create the bushing, it eradicates chip generation. And thus, it is a clean and chip less hole making process in which the hole is made from the plastic deformation of the work material. This chip less machining process reduces the time required for drilling and tool wear is less, thus increase the service life of the drill tool. This process is a dry drilling process.

### II. Working Principle

The tip of the tool approaches and contacts the work-piece. The tool tip, indents into the work-piece and supports the drill in radial and axial directions. Friction on the contact surface, created from axial force and relative angular velocity between tool and workpiece produces heat and softens the work-piece material. The tool penetrates into the work-piece, it at first pushes the softened work-material sideward and upward. With the work material heated and softened the tool is able to penetrate the work-piece. Once the tool pierces the work-piece, the tool moves further forward to push away more workpiece material and form the bushing by the cylindrical part of the tool. The shoulder of the tool can come into contact with the work-piece to collar the back extruded burr. Finally, the tool withdraws from work-piece and leaves a hole with a bushing on the work-piece.

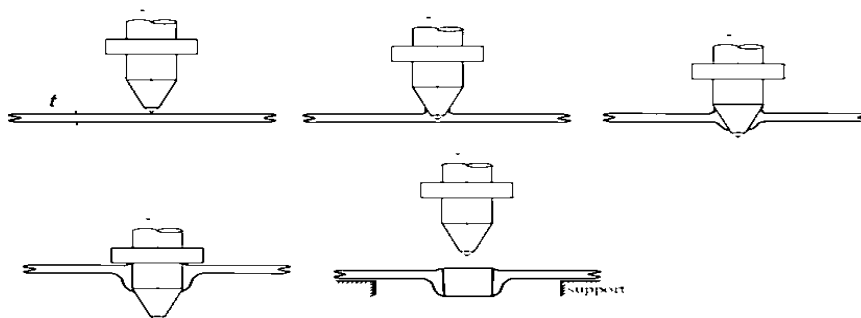


Fig 1 Illustration of stages of friction drilling process

### III. Literature Survey

Different methodologies have been adopted by investigators to understand the drilling process.

S. Rajendra Boopathy, G. Somasundaram and K. Palanikumar [2011] [1]: Utilized conical drill tool with  $d=5.3$  mm,  $\alpha=90^\circ$ ,  $\beta=36^\circ$ ,  $h_c=0.970$  mm,  $h_n=7$  mm,  $h_l=15$  mm, shoulder region length is 7mm, shank region length is 30mm of high speed steel (HSS) and conducted comprehensive analysis on friction drilling of Al/SiCp metal matrix composites and discussed the roundness errors on friction drilled holes. The result and discussion show effects of individual input parameters on roundness error in form drilling process. They prepared design of experiments by using response surface methodology. They analysed roundness errors of workpiece with experimental design matrix and gave experimental relation between the process parameters which are spindle speed and feed rate. The conclusion from result explained that this method is suitable to predict the main effects and interaction effects of machining parameters.

G.Somasundaram, S.Rajendra Boopathy [2010] [2]: Adopted a low volume low cost fabrication technique to fabricate the AlSiC MMC plates and manufactured conical drill tool with  $d=5.3$  mm,  $\alpha=90^\circ$ ,  $\beta=36^\circ$ ,  $h_c=0.970$  mm,  $h_n=7$  mm,  $h_l=15$  mm, shoulder region length 7mm, shank region length 30mm of high speed steel (HSS), which is an economical and efficient one. They proposed the efficiency and advantages of this technique on drilled holes and analysed the interaction effect of parameters by using design of experiments method called response surface methodology. They concluded that roundness error increase with increase in spindle speed, feed rate and thickness of plate. Also, it decreases with increase in weight percentage of SiC.

Dr. A. Gopichand, M.VeeraBrahmam, D. Bhanuprakash [2014] [3]: Used optimal drill tool geometry with  $d=7.3$  mm,  $\alpha=90^\circ$ ,  $\beta=36^\circ$ ,  $h_c=0.970$  mm,  $h_n=8.490$  mm,  $h_l=8.896$  mm of tungsten carbide (WC) conical tool and proposed to use FEM to analyse the stress, strain and deformation of the work material in friction drilling as modelling and simulation is essential tool to understand the material flow. They used the Ansys software to simulate the behaviour of friction drilling process which is difficult to measure experimentally. The modelling of the friction drilling tool HSS, WC and work material A7075-T6 was developed in PRO/E software. They conclude that the minimum equivalent von-mises stress is obtained at maximum speed and feed rate for HSS tool and proper burr formation occurred at 2000 rpm and 40 m/s feed rate for both HSS and tungsten tools.

Diwakar Reddy.V, Krishnaiah.G, Gopi Chand and Indumathi [2011] [4]: Analysed mechanical aspects of form drilling by using Aluminium (A1100) as work material and high-speed steel as conical drill tool. They designed Experiment layout by full factorial method and did analysis by analysis of variance ANOVA method. They applied Taguchi method to estimate the performance of high-speed steel form drill on AA1100 work piece of thickness 6mm. The experimental measurements revealed that for base tool requires less torque and thrust force compared to pointed tool, also from the contributed values it is concluded that the R2/R1 ratio is a critical parameter.

P. V. Gopal Krishna, K. Kishore and V. V. Satyanarayana [2010] [5]: Investigated mechanical aspects of friction drilling by taken Aluminium (AA6351) as work material. They designed proper experimental design and applied taguchi method to estimate the performance of HSS drill on AA6351 workpiece of 1mm thickness. They concluded that a highly burnished surface is obtained for AA6351 at low and medium speed, at high speed discolorations is observed.

Han-Ming Chow, Shin-Min Lee, Lieh-Dai Yang [2008] [6]: Performed experiment of form drilling to make holes on austenitic AISI304 stainless steel as a work piece material using tungsten carbide drills. From the experimental results it was observed that the surrounding area of drilled hole obtained fine grain size and compact structure with a higher micro hardness than that of the area away from the drilled area. They explore the optimal geometrical shape of drill and drilling optimal parameters were found to obtain a quality hole surface after exploring the surface roughness using Taguchi Method. They concluded that friction drill had a better performance and avoid serious tool wears, prolonging the tool life significantly, enhancing hole quality.

ShinMin Lee, HanMinChow, Fuang YuanHuang, BiingHwaYan [2009] [7]: Compared friction drilling on austenitic AISI 304 stainless steel by using uncoated and PVD AlCrN- and TiAlN- coated tungsten carbide drills. They concluded that coated tungsten carbide tool experiences less tool wear than uncoated drills at the same spindle speed and for the same number of drilled holes and also drill coating suffered greater tool wear and the difference in surface temperature between coated and uncoated tools moderated at higher spindle speeds.

Scott F. Miller and Albert J. Shih [2006] [8]: Study summarizes the research on friction drilling, a chip less hole making process by means of the rotating conical tool. Wide research in experiment, modelling, metallurgical analysis, tool wear of drilling tool and workpiece has been carried out to determine the feasibility of this technology for hole-making. The experimentally thrust force and torque were measured and analysed. Result were validated by comparing with analytical and finite element modelling results. The microstructures and indentation hardness on the cross-section of drilled holes were characterized for different work-materials. Common pattern curves of thrust force and torque were observed. Friction drilling is at a point where it can be used in industry.

Shi shaojun, zeng xianping and Sun Chengtong [2018] [9]: The high-speed steels have been widely used as the most basic material for cutting tools. At present, high speed steel cutting tools still occupy the foremost position of the tool market. Even though that of tipped carbide cutting tools and grinding of cemented carbide cutting tools development is very rapid, other varieties of the cutting tools still mainly use HSS material. The choice of the HSS cutting tool material and heat treatment process plays very important role to ensure the performance of HSS cutting tool.

Pantawane. P.D, Ahuja. B.B [2011] [10]: Investigated the effect of friction drilling input parameters on the responses. Friction drilling tools of standard geometry have been used to produce the holes in workpiece of AISI 1015. The Response Surface Method (RSM) has been used to develop an experimental model for the responses. To optimize the machining conditions an objective function called as 'Desirability Function' has been used. Mathematical models were developed to find the relationship among input variables and their interaction on the quality of the hole produced in friction drilling process.

Erol Kilickap, Mesut Huseyinoglu & Ahmet Yardimeden [2010] [11]: Developed mathematical prediction model. Surface roughness model was developed using response surface methodology (RSM). The effects of drilling parameters on the surface roughness were assessed. RSM and genetic algorithm were used for determining optimum machining conditions for minimizing the surface roughness. As a result, it was predicted that the developed model can be effectively used to predict the surface roughness. Machining time and product cost were saved by using this model. Main contribution of the study is to the minimize surface roughness. Integration of RSM and GA is used to find out optimum drilling conditions.

Chetan M Rathod, Dr. Mahesh Chudasama, Mr. Swaraj Darji [2015] [12]: Determined an experimental investigation of a full factorial design performed on thin CFRP laminated sheet using HSS drill with different point angle 90°,120°,150°and by varying different spindle speed (3500,4500,5500 rpm) and feed rate (200,500,900 mm/min). Hole diameter, circularity and delamination were analysed. Hole quality parameters and their contribution rates was determined with the help of analysis of variance. Full factorial DOE methodology was used in the multiple objective optimizations to find the optimum cutting conditions for defect free drilling.

Turgay Kivak, Kasım Habali, Ulvi Seker [2012] [13]: Investigated the effect of cutting parameters. Hole quality (circularity and hole diameter) and tool wear in the drilling of super alloy Inconel 718 with coated and uncoated carbide drills were investigated. CNC vertical machining centre were used to carry out drilling tests with uncoated TiN and TiAlN coated carbide drills of 5 mm diameter under dry cutting conditions by drilling blind holes of 8 mm depth and employing different cutting speeds and feed rates. Comparison has been made in terms of the quality of the hole between cutting tools regarding hole diameters and the circularity measurements. There was a decrease of tool performance and hole quality at high cutting speed and feed rate combinations. A serious increase in tool wear was observed with respect to increasing cutting speed.

Navasingh Rajesh Jesudoss Hynes, Ramar Kumar, Jebaraj Angela Jennifa Sujana [2017] [14]: Developed a predictive model using a feed-forward artificial neural network for the bushing length. As the bushing length is closely associated with the tapping process, the effects of the input process parameters play a vital role in fastening galvanized steel with threaded fasteners in engineering applications. Implemented a genetic algorithm under constraint limits to maximize the bushing length to solve optimization problem. Optimum value and its corresponding bushing length predicted by the genetic algorithm were compared by conducting a confirmation test.

T. Deepan Barathi Kannan, G. Rajesh Kannan, M. Umar and S. Ashok Kumar [2015] [15]: Developed an Artificial Neural Network (ANN) modelling technique and Genetic Algorithm (GA) optimization technique to reduce problems while drilling 6mm hole in brass plate. Selection of proper parameters plays a vital role in reducing the surface roughness and ovality errors. In manufacturing of couplings, brass plates are widely used. While manufacturing it, there is need to make holes of diameter 6mm. Thus, the results found in this work will be helpful to improve the quality of drilled holes for coupling manufacturing industries.

#### IV. Conclusion

Form drilling process for different tool regions is reviewed. The heating is mainly from friction, producing high temperature of 760°C, about half of the melting temperature for ferrous and nonferrous materials. The conical and cylindrical regions of the tool play an important role in formation of the bushing. Increasing both material thickness and hole diameter, the material volume, bushing height and bushing wall thickness increases and the bushing shape become cylindrical due to high t/d ratio. Roundness error increase with increase in spindle speed, feed rate and thickness of plate. R2/R1 ratio is a critical parameter and it influences both torque and thrust force. Optimal geometrical shape of drill and optimal parameters of drilling are necessary for better performance of drill and to avoid tool wear, enhancing hole quality, and prolonging the tool life significantly.

The general-purpose molybdenum steels (M1, M2, and M7 and tungsten steel T1) are more commonly used than other high-speed tool steels. Toughness and cutting ability are good of this steel. The selection of the HSS cutting tool material and heat treatment process are very important to ensure the performance of HSS cutting tool.

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