Study on Drilling Process Parameters - Review

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***Abstract*:- Drilling is a cutting process to make hole of circular cross section by using drill bit and it is one of the important machining processes having vast application. This paper illustrate a literature review on drilling process for various metals and its alloy about the chip thickness, cutting speed, feed rate of machining, temperature distribution during drilling, surface integrity after machining, surface roughness, burr formation by considering the various input process parameters. This Paper reviews the main difficulties during drilling of various parts. Due to its distinctive properties, titanium and its alloys are used in major aeronautic and automotive industries, also used in jet engine components, turbine blades for its fine corrosion resistance even at high temperature. Titanium also used for replacement of human body parts because of its high strength to weight ratio. At the same time it has superior quality such as hardness and tensile stress at high temperature but they are regarded as hard-to-machine material. So it is necessary to develop the cost effectiveness of drilling in titanium and its alloy. Based on review, it is essential to improve the quality of drilling process with minimum cost.**

Keywords: Drilling process, machinability, input process parameters, output responses.

I. INTRODUCTION

Titanium and its alloys are unique materials due to their distinct high strength-weight ratio which is maintained at elevated temperatures and its exceptional corrosion resistance. It possess good mechanical properties and having wide variety of application because of its low density, good erosion resistance and also its modulus of elasticity is low. Titanium alloys are very difficult to machine due to its mechanical and chemical properties, and also it has increase in demand for its application, which makes high machining cost per part. High material strength of titanium alloys leads to larger cutting forces and higher temperatures which make the material more difficult to drilling, also the other reasons such as low thermal conductivity and maximum heat generated is very important factor need to care during machining, because it more amount of heat can easily damage the tool rapidly. The tool-chip interface friction and tool-work piece interface friction are the main source to produce large amount of heat. Also inconsistent cutting pressure, vibration, lack of rigidity to hold tool are all makes tool damage. Drilling is a process of making a hole in solid material of circular cross section. Conventional drilling in titanium alloy is considered as more difficult when compared to milling and turning operation. This literature review inspected about many researchers reports on drilling process and the study of titanium alloy under various working condition.

Venkata Ramana (2017) demonstrated optimization and influence of process parameters on surface roughness in turning of Titanium alloy under different lubricant conditions. The cutting performance of Minimum Quantity Lubrication condition showed better results as compared to dry and flooded conditions in reduction of surface roughness. Effect of feed rate is more on the surface roughness. Akhil K.T et al. (2017) illustrated optimization of drilling characteristics using grey relational analysis (GRA) in glass fiber reinforced polymer (GFRP).The cutting speed is the most significant process parameter which influences the delamination factor and surface roughness. Cutting Speed has highest contribution on the multiple performance characteristic followed by feed rate as obtained from analysis. Aravind.S et al. (2017) inspected the optimization of micro-drilling parameters by taguchi grey relational analysis. The result shows the best values for the minimized delamination factor and the maximized material removal rate. Shunmugesh et al.

(2017) studied grey relational analysis based optimization of multiple responses in drilling of carbon fiber-epoxy composites. The present study investigate multiple performance characteristics of surface roughness, delamination factor and circularity in drilling of CFRP composite materials for various cutting speed and feed rate with HSS, TiAlN, TiN drill tool material. The most significant parameter which affects the response is feed rate.

Shunmugesh et al. (2017) examined optimization of drilling characteristics using grey-fuzzy logic in glass fiber reinforced polymer (GFRP). The drilling operation performed with the identified optimum values of the parameters within the ranges fixed in the study produced better surface roughness and delamination factor. Johan Merzouki et al. (2017) investigated the method of hole shrinkage radial forces measurement in Ti6Al4V drilling. The responses to be considered are internal residual stresses, thermal expansion and diverse thermo mechanical loads applied to the work piece and the tool. Giuseppe Bonaiti et al. (2017) demonstrated the micro-milling machinability of DED additive titanium Ti-6Al-4V. The increase in laser power produces lower porosity, thus improving the overall integrity of the material samples. Roughness increases with the increase in cutting parameters including depth of cut and feed rate. Hemant S et al. (2017) inspected the modeling of temperature distribution in drilling of titanium. The temperature distributions in the tool and the work piece are simultaneously predicted for variation in cutting speed and feed rate. In both the cases, increase in cutting speed and feed rate results in significant increase in temperature. Shuang Yi et al. (2017) studied the performance and mechanisms of graphene oxide suspended cutting fluid in the drilling of titanium alloy Ti-6Al-4V. Thermal conductivities of conventional coolant and the graphene oxide suspended fluid has measured and the effects of different cutting parameters such as cutting speed and feed rate were analysed. Thrust force, surface roughness, tool wear and the formation and morphology of chips were discussed. Thrust force increased when feed rate was increased. .Higher the spindle speed, the lower the thrust forces. Lower thrust force has been obtained in using graphene oxide suspended fluid than conventional coolant.

Shunmugesh et al. (2016) investigated the multi-response optimization in drilling of carbon fiber reinforced polymer using artificial neural network correlated to meta-heuristics algorithm. Artificial Neural Network approach has found to be effective in predicting the minimum value of thrust force, torque and surface roughness compared to the experimental values. Balaji et al. (2016) examined optimization of cutting parameters in drilling of AISI 304 stainless steel using taguchi and ANOVA. This work deals with the effect of cutting parameters namely cutting speed, feed rate and helix angle on the tool life and observed that Vibration of drill bit is found to be increased along with the progression of the tool wear and also the result showed that Helix angle is found to be significant on surface roughness followed by acceleration of drill vibration velocity. Shunmugesh et al. (2016) demonstrated the machinability of carbon fiber reinforced polymer in the longitudinal and transverse direction and optimization of process parameters using PSO–GSA and optimize the process parameters of cutting speed, feed rate and drill tool material. The result shows Axial thrust decreases with increasing cutting speed, increases with increasing feed rate and is minimum with hardest tool material employed. Feed rate is the most influential process parameter which affects the thrust force, torque and work vibration. Suman Chatterjee et al. (2016) investigated Simulation and optimization of machining parameters in drilling of titanium alloys. The response surface methodology is adopted to take experimental readings. Various drilling parameters such as spindle speed, feed rate and drill bit diameter on performance characteristics such as thrust force, torque and circularity at entry and exit of the holes in drilling of titanium alloy using coated drill bit were analyzed. Thus the Author concluded that the proposed simulation model can be used for machinability analysis of drilling of titanium alloys so as to save experimental time, cost and resources. Gurmeet Singh et al. (2016) studied the optimization of process parameters for drilled hole quality characteristics during cortical bone drilling. This paper discussed above the optimization of parameters like rotational speed, feed rate and type of tool with respect to the output response such as surface roughness and material removal rate. The results from the SEM and the magnified images had shown that the twist drill gives a fine and circular hole.

Maksym Ziberov et al. (2016) demonstrated the effect of cutting fluid on micro milling of Ti-6Al-4V titanium alloy. The main objective of this work is to study the performance of micro mill tools in terms of burrs, machined surface and tool wear in machining of Ti-6Al-4V titanium alloy and evaluate the effect of the application of cutting fluid. In dry machining, the tool edge radius and tool life increases. Tebbe Paulsen et al. (2016) studied the influence of different machining conditions on the subsurface properties of drilled TiAl6V4. The impacts of different drilling kinematics on the subsurface layers of boreholes in TiAl6V4 were examined for different cooling conditions and states of tool wear. It was found that an increased width of wear land has a great influence on the subsurface layers of the work piece regarding significantly increased process temperatures and plastic deformations. Nithin Tom Mathew et al. (2016) examined the drilling of titanium aluminide at different aspect ratio under dry and wet conditions. This paper demonstrated about the machinability in dry and wet conditions were assessed based on the thrust force, torque, burr formation, surface quality, and tool condition and chip morphology. The supply of cutting fluid eased chip evacuation and reduced thrust force and torque. The dry condition can

be employed only to low aspect ratio drilling. For better machinability, wet condition is recommended for drilling both low and high aspect ratio holes. Zdenka Rysava et al. (2016) examine micro-drilling and threading of the Ti6Al4V titanium alloy produced through additive manufacturing. Experiment is carried out at high-precision micro-milling machine under dry cutting conditions at varying cutting speed and feed rate. The result shows the lowest values of the cutting speed and feed rate seem to be the best trade-off for achieving the required hole quality. Nieslony et al. (2016) demonstrated the experimental of the cutting force and surface morphology of explosively clad Ti–steel plates. The study was conducted for two types of indexable insert drills with different tool coatings, it is found that the parameters of the surface morphology are dependent upon the type of drill and found that the parameters of the surface morphology are dependent upon the type of layers of the clad and the type of drill. Swapnil Pawar et al. (2016) examined the experimental analysis of axial and torsional vibrations assisted tapping of titanium alloy. The experiment is carried out in the presence of axial and, axial and torsional vibration assisted tapping (AVAT and ATVAT). To reduce tapping torque, axial force and temperature over that of the conventional tapping without compromising the thread quality, ATVAT gives best and improve performance and also reduction in chip thickness is observed in vibration-assisted tapping.

Takashi Matsumura et al. (2015) studied the cutting of titanium alloy drilling with energy analysis and FEM. The main objective of the paper is to presents a hybrid simulation of drilling to save the time for analysis. This study presented the hybrid simulation of the energy and the FE analyses to evaluate not only in the cutting process but also the surface quality. The effects on cutting parameters and tool geometry in residual strain were also evaluated by the hybrid simulation. It is concluded that the 2D FE analysis takes less time when compared to 3D FE analysis. Umesh Gowda et al. (2015) demonstrated on optimization of process parameters in drilling of epoxy Si3N4composite material using taguchi technique. The input process parameters considered during experiments are viz., %volume of Si3N4, Speed, Feed, diameter of drill bit and machining time. Author concluded that the optimized parameters have shown good results, so these parameters can be used to achieve good surface finish, circularity and cylindricity. Parida et al. (2015) studied the surface roughness model and parametric optimization in machining of GFRP composite using Taguchi and Response surface methodology approach. The main objective is to determine the optimum drilling conditions to minimize the surface roughness. From the study it is concluded that spindle speed is the most significant parameter on surface roughness followed by diameter of drill bit and the feed is found to be insignificant parameter. And also the result showed that the surface roughness increases as the spindle speed increases. Prakash et al. (2015) demonstrated the optimization of drilling characteristics using Grey Relational Analysis (GRA) in Medium Density Fiber Board (MDF). The main aim is to find the optimal solution of process parameters for drilling. The feed rate was identified to be the most influencing factor on surface roughness. From the experiment, the author concluded that the feed rate and drill diameter is most significant parameter affecting the multiple process response. Priyadarshini et al. (2015) demonstrated the multi characteristics optimization of laser drilling process parameter using grey fuzzy reasoning method. This paper presents grey relational optimization approach combined with fuzzy methodology for determining the optimum process parameters which minimizes heat affected zone and hole circularity and maximize material removal rate in a Pulsed Nd:YAG laser micro-drilling. The input process parameters considered are pulse width, number of pulses, assist gas flow rate and its supply pressure. The result showed that the desirability fuzzy algorithm with Grey relational methodology is suitable for optimizing the multi response characteristics in drilling of high carbon steel.

Tej Pratap et al. (2015) studied the modeling cutting force in micro-milling of Ti-6Al-4V titanium alloy. The main objective of the investigation is to simulate stress distribution, temperature distribution and cutting force generation considering the effects of tool edge radius, uncut chip thickness, cutting speed and feed rate using FEM model. This paper describe the cutting force modeling in micro-end milling of titanium alloy Ti-6Al-4V using ABAQUS/Explicit finite element method. The finite element simulation of specific cutting forces showed the size effects in micro-end milling process. The simulated cutting forces were successfully validated with experimental results. A. Díaz-Alvareza et al. (2015) inspected the estimation of thermal effects in dry drilling of Ti6Al4V. The main objective is to establishing a methodology to quantify the heat generated in the material, and the heat fluxes towards it during a machining process. The evolution of axial force and torque was measured using a dynamometer. Taking into account the thermal distributions obtained numerically, it has established a methodology to determine the heat that acts on the material due to the action of the edges of the tool. The Author concluded that the methodology has been described for dry drilling processes of the Ti6Al4V alloy, but is directly applicable to any drilling process. Nobre et al. (2015) evaluated the residual stresses induced by drilling of Ti-6Al-4V alloy by using an Experimental Numerical methodology. The main objective is to analyze the influence of ultra-high cutting speeds on the residual stress distribution. Induced stress drilling due to UHSD of Ti-6Al-4V alloy was determined. The author concluded that the result presents the good repeatability and, therefore the proposed methodology is an important tool for optimization of drilling operation parameters, regarding improving the induced residual stress.

Kaynaka et al. (2015) modelled and simulated the machining-induced surface integrity characteristics of NiTi alloy. This study shows the results of combined experimentation and simulation of cutting induced phase transformation in orthogonal machining of NiTi shape memory alloys. Two different cutting speeds were considered for simulation. The result showed that the increased cutting temperature leads to reduced martensitic volume fraction in machining of NiTi shape memory alloys. Abdelhafeeza et al. (2015) studied the burr formation and hole quality when drilling titanium and aluminium alloys. Chemical vapour deposited (CVD) diamond coated carbide drills were used for the aluminium work pieces while uncoated carbide tools were employed for the titanium material. An experimental design based on response surface methodology was implemented. The author concluded that cutting speed was found to be significant when drilling Ti-6Al-4V.

Ramesh et al. (2014) examined the Effect of the standard and special geometry design of a drill body on quality characteristics and multiple performance optimization in drilling of thick laminated composites. Here experiment is carried by fixing cutting speed and feed rate along with both standard and special geometry drill. Study concluded that standard geometry drill performs better than special geometry drill. And feed rate is most influencing factor for good quality drill. Gaurav Chaudhary et al. (2014) demonstrated the Optimization of drilling parameters of hybrid metal matrix composites using response surface methodology by using input response as speed, feed and point angle and the output response parameters considered are MRR, oversize and surface roughness. It is found that the feed rate is the most significant machining parameter used to predict the surface roughness. And also obtain the optimum condition for the output response. Deepan Bharathi Kannan et al. (2014) studied the application of artificial neural network modeling for machining parameters optimization in drilling operation. Genetic algorithm and particle swarm optimization are two optimization technique used in this paper. From that genetic algorithm gives good result for thrust force and surface roughness, particle swarm optimization give better result for ovality and machining time. Also found that spindle speed and feed value are significant factor for quality of drilling operation. Rupesh Kumar Pandey et al. (2014) demonstrated the optimization of bone drilling process with multiple performance characteristics using desirability analysis. In this study, the drilling parameters feed rate and spindle speed are optimized for minimum temperature and force. It concluded that minimum feed rate and spindle speed having minimized the temperature and thrust force during bone drilling. Chettan et al. (2014) demonstrated parametric optimization in drilling EN-8 tool steel and drill wear monitoring using machine vision applied with taguchi method. The optimization is developed for tool life and required surface roughness in machining parameters, having the input response as spindle speed, feed rate and drill diameter on flank wear. The flank wear area increased with the number of holes drilled is observed.

Oliver Pecat et al. (2014) examined the low damage drilling of CFRP/Titanium compound materials for fastening. In the experiment, low frequency assisted vibration drilling was applied. The result shows that the cutting temperatures can be reduced by more than 40 % when using low vibration assisted drilling compared to conventional drilling and it denotes that the cutting temperatures in titanium are mainly caused by insufficient extraction of metallic Ti-chips which are reaming at the newly generated bore surface. Prdeep Kumar Shetty et al. (2014) demonstrated the machinability study on dry drilling of titanium alloy Ti-6Al-4V using L9 orthogonal array. This paper shows selection of minimum cutting speed indicates minimum burr formation and higher cutting speed indicates minimum chip thickness and surface roughness. At high cutting speed, temperature increases due to small contact between the tool work piece interface, it decreases the coefficient of friction between the interface and it contribute improve surface roughness. Oliver Pecat et al. (2014) investigated tool wear analyses in low frequency vibration assisted drilling of CFRP/Ti6Al4V stack material. It was found that the tool wear as well as the cutting temperatures are significantly decreased by the application of LFVAD, whereas the mechanical load is raised compared to conventional drilling. This indicates that the thermal load has a major impact on the tool wear, most probably due to a facilitation of diffusion processes, which further degrades the mechanical properties. I. Balasundar et al. (2014) demonstrated hot working and geometric dynamic recrystallisation behavior of a near α-titanium alloy with acicular microstructure. As diffusion of β phase to separate the globularised particles is the rate controlling step, the fraction globularised increased with increasing temperature and decreasing strain rate. By increasing deformation temperature and decreasing strain rate, the globularisation curve shifts to lower strains which concurs well with the micro structural observations. Sanjib Kundu et al. (2014) examined the optimization of drilling parameters to minimize burr by providing back-up support on aluminium alloy. Height of burr observed with providing back-up support is quite less when compared to that without using a back-up support. Optimum testing conditions are adopted to reduce burr height by about 33%. The analysis of variance shows machining environment and cutting velocity have good influence on burr height for aluminium alloy.

Senthil Kumar et al. (2013) demonstrated on tool wear and chip formation during drilling carbon fiber reinforced polymer (CFRP)/ Titanium Alloy (Ti6Al4V) Stacks. Chip formation has a significant influence on the thrust force and tool performance. Tool fails when the

chip produced has a long ribbon shape. The overall performance of 130° point angle drill bit is better than 118° pint angle drill bit. Amran et al. (2013) demonstrated the effects of machine parameters on surface roughness using response surface method in drilling process. From the result, surface roughness decreases with increase in spindle speed, feed rate and drill diameter. Sanjay Mishra et al. (2013) examined modeling and optimization of laser beam percussion drilling of thin aluminum sheet. At a given thickness, the MRR increases with an increase of laser parameters, i.e., pulse width, pulse frequency, and peak power. The effects of pulse width and pulse frequency are more prominent than those of peak power in enhancing the MRR. As the thickness of work piece increases the MRR also increases. Nagesh et al. (2013) studied the parametric study of CO2 laser drilling of carbon nano powder/vinyl ester/glass nano composites using design of experiments and grey relational analysis. The input parameters are laser power, pulse frequency and scanning speed on the heat affected zone and taper angle. Heat affected zone and taper angle can be minimized by dispersing carbon black in vinyl ester/glass. Thiagarajan Rajmohan et al. (2013) investigated the application of the central composite design in optimization of machining parameters in drilling hybrid metal matrix composites. CCD can be employed to develop mathematical models for thrust force, surface roughness and burr height. It shows feed rate and surface roughness are the two dominant factors for improving surface roughness and reduces thrust force and burr height.

Balasundar et al. (2013) demonstrated the modeling the hot working behavior of near-α titanium alloy IMI83 using the experimental data generated by carrying out hot compression tests over arrange of temperatures (850–1060°C) and strain rates. It concluded that the continuous dynamic recrystallization or globularisation of α lamellae, dynamic recrystallization and growth of β grains through micro structural are observed. Antoine Poutord et al. (2013) examine the local approach of wear in drilling Ti6Al4V/CFRP for stack modeling. Here the impact of the local wear is assessed by investigating the variation of the cutting forces along the cutting edge. And conclude that the wear generated by Ti6Al4V is mostly confined to cutting edge chipping on the drill corner. The distribution of the forces along the cutting edge denotes the importance of the chisel geometry for the total cutting forces. Takashi Matsumura et al. (2013) examined the cutting force model in drilling of multi-layered materials. This paper presents an analytical model to predict the cutting forces in drilling of multi-layered materials and the cutting force is predicted in the determined the chip flow models. It shows the chip flow direction is determined to minimize the cutting energy consumed and the force model predicts the change in the cutting force in drilling well. Ramazan Cakıroglu et al. (2013) inspected optimization of cutting parameters on drill bit temperature in drilling by taguchi method. Here the factors consider as input are cutting speed, feed rate and cutting tool. The result found that the drill bit temperature increases with increase in cutting speed and temperature decreases with increases in feed rate. But the most significant factor in affecting the drill bit temperature was the feed rate. Anna Carla Araujo et al. (2013) demonstrated analytical and experimental investigations on thread milling forces in titanium alloy. This paper is mainly focused on cutting force and torque and the valves are analyzed and found optimum condition. The result shows Low feed per tooth values induce low uncut chip thickness which can lead to higher cutting pressure on cutting edge. And the average resultant forces are linked to cutting conditions and also to tool geometry used.

II. CONCLUSION

Due to the excellent properties of titanium and its alloy, it is preferred for many applications, and also drilling is essential for almost in any manufacturing process. From the literature review, it is found that conventional drilling in titanium alloy is depend on cutting speed, feed rate, chip thickness, temperature distribution and the following points are concluded.

- Quantity of lubrication denotes the surface roughness quality in titanium alloy. Minimum quantity gives better result than dry and flooded condition.
- Surface roughness increases gradually with increase in feed rate and also increase in depth of cut. It does not change significantly with increase in cutting speed.
- Feed rate is the most influential process parameter which affects the thrust force, torque and work vibration. Axial trust decreases with increase in cutting speed, increases with increase in feed rate and decreases with high hardest tool which employed.
- For achieving the better quality of drilled hole, lowest value of cutting speed and feed rate should be maintained.
- Tool wear rate increases with increase in depth of cut and feed rate during machining.
- Temperature of the material increase significantly with increase in cutting speed, minimum feed rate and increase in depth of cut.
- At high cutting speed, heat will increase at the small contact between tool and work piece interface, which decreases the coefficient of friction and it will increase the surface roughness.
- The value of torque and thrust force decrease with increase in cutting speed and increases gradually with increase in feed rate.

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