Combined Drilling and Reaming Operation in Robot and CNC

Giridharan P1, Dr Stalin John2
1 Post-Graduate Student, Department of Mechanical Engineering, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, India.
2 Associate Professor, Department of Mechanical Engineering, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu, India.

E-mail: gp6237@srmist.edu.in

Abstract. The drilling and reaming operation are two separate machining processes. In our project drilling and reaming operation are combined by using combined drilling and reaming bit. The industrial robot with agile motion is possible to machine a component. The Industrial robots with high precision and six Degree of freedom are considered as better, for manufacturing processes. This work is to significantly compare the performance of robot drilling over CNC drilling. The manipulator used is ABB - IRB1410 with work volume of 2.6 meters, handling capacity of 5Kg and controlled by IRC5 Controller. Drilling machine utilized is specified with maximum speed of 2800 RPM and power of 600W. The speed of the drilling machine can be varied by using voltage regulator. Speed and feed are the two parameter that are varied and circularity, surface roughness are the parameter checked for. The drilling operation is also done in CNC machine. The parameters such as surface roughness, circularity are checked. Finally, comparisons between robot operation and CNC operation are performed, optimized values are found by using Taguchi method.

1. Introduction
In the detest years the drilling made physically with no robot. In computerization field the drilling the parts made obligatory to do fabricating parts and gathering. The drilling made on a few materials like wood, stone, steel, press, dividers, plastic, composite materials with separately. For modern plant in the event that we us a manual drilling it require investment to complete a few assignments with in a brief time frame. To defeat framework, require additional capability to do in brief time and well wrapping up. By using the robot, it can play out the task effectively. The mechanical technology had discovered the enthusiasm for people in general and few businesses of drilling. The historical backdrop of the robot application for drilling and conquers future pattern. The perplexing part which is impossible physically is performed by robot. The mechanical innovation trusts that it expels the physical and mental worry of work. The robot is educated by teach pendent. The robot has basic programming structure. The limited component examination gives boring activity exhibitions. The feed rate and speed ought to be known parameters in robot drilling. Once the drilling work is finished, further processes are carried on such as boring, reaming, counter sinking, boring etc. on other hand computerised drilling machine(CNC) is implemented in mass productions.  The factor affects the process is time involved is toll changes, so for speed, hole diameter variation is to be minimized. So CNC have equipped with multiple spindle in turrets with varying diameter, used to be mounted for drilling operation. For cost-effective, appropriate type of CNC need to be selected for a particular
geometry. For jobs with low volume production, manual or semi-automated drilling may suffice. The CNC programming should be studied for writing appropriate code for particular geometry. It requires a skilled programmer to do. But in robotic drilling, teach pedant ease the task. It is very easy to position the robot to particular point location in the job and perform the operation intended.

Kishore et al., [1] presented that cutting force and thrust force impact in drilling operations. The operations of drilling are performed in Aluminium 6061_T6 alloy with two-flute drill bit with different diameter and depth of cuts. They investigated the parameter which affects the process directly. The cutting force decreases as the drill bit advances through the material. The larger diameter bit generates larger thrust force and high feed rates. Chandrasekharan et al., [2] characterizes the cutting condition for the drilling by speaking to the parametric conditions. Utilizing an arrange machine estimating discover the focuses on cutting lips. They built up the calculations for parameters of robotic model for basic power. Focuses the self-assertive edge cutting is approve by scientific and unthinking power. This trusts the precise powers are at a few points. Weidong et al., [3] gives the mistakes in middle of the work piece in mechanical drilling and the bore pivot. They have been demonstrated by certain homogeneous grid of change. These estimations of blunders have estimated by 2D vision framework. In the estimation results they have utilized the device facilitate point camera frameworks for the disposal of specific blunders like abbe mistakes. These blunders checked by the wrong protest remove and the non-perpendicular has reasoned. By four laser uprooting detecting components likewise measure precision by protest separation and opposite controlling conditions. The reference proportion of opening is done through the arrangement of automated drilling. The vision framework has the 0.1mm exactness and precision of mistakes which meets automated boring norms. Yier et al. [4] approaches the structure of sequential robots by certain adjustment tests. This utilizes execution of industry measures by giving position precision and plan adjustment. Measures the weights followed by framework covariance. By comparing test represent the coefficient of weighting. The geometric parameter calculation depends on the estimation of halfway techniques. For a few end effectors focuses the main direct position. To maintain a strategic distance from the end effector segments introduction and for discovering parameter precision it permits client increment these parameters. Ueda et al [5] studied the drill with the reamer edge. Drill reamer has edges for drilling, semi-finishing, finishing purpose. The investigated their study on carbon steel. The cutting parameter by aid of values obtained from cutting torque, thrust force, surface roughness, wear of edge and finally cutting temperature edge. Edges of the reamer provide an improvement in cutting stability. For small depth of cut the edge temperature reached maximum around 420 degree Celsius and inner side surface roughness was performed very well to that conventional drill. Zhu et al [6] performed drilling operation in aircraft structure which requires higher dimensional accuracy. To achieve this 2D vision system was implemented. The determinations of TCP, measurement error are mathematically modelled and experimentally verified. Laser sensor are utilised to achieve perpendicularity of camera optical axis. Experiment was performed by the Robot which can achieve accuracy of approximately 0.1mm with this method. Badea et al [7] discussed the influence of parameter involved during cutting which affects the accuracy in drilling operations. The axial force and cutting torque are crucial factor in determining the accuracy it should have an optimum magnitude. They also found out the relationship between process parameter to have optimum values of torque and axial force. Meral et al [8] developed a new drill geometry in order to improve the performance such as surface roughness, tool wear, force, cutting torque, energy consumed etc. the fabricated drill undergoes an experiment where four different feed rate and speed are selected to evaluate its performance. Two optimization are done mono optimization aid by Taguchi S/N ratio and followed by GRA method for multi-objective optimization. They fabricated four different drill geometries and tested each of them, to find which one gives the better performance in drilling operation. Prakash et al [9] performed drilling operation in MDF (medium density fibreboard) which has been widely used in furniture, cardboard, plywood etc. which is a composite panel. They optimised drilling parameter using GRA method. Speed and feed are the two factors to be optimised. They found that feed rate had significant influence in surface roughness and delamination. Finally, ANOVA is used to find the interaction between
parameters. So the objective of this paper is to find values of speed and axial feed rate for which the inner surface roughness and circularity is minimum in both Robot and CNC drilling reaming operation by using combined Drill-Reamer bit.

2. Methodology

2.1. Process Overview

Design of experiment principle is adopted. The L9 orthogonal arrays are obtained by fixing two parameter values speed and feed. The speed (rpm) of the machine is set from 2300, 2400 and 2500. The axial feed rates (mm/sec) are set to 60, 120 and 180. Aluminium Al6061 alloy is used for machining operation. The operations are done by setting the corresponding values of speed and axial feed rate by voltage regulator and robot speed controller. For CNC machining operation, speed and feed are controlled by computer program. For setting up the location in work piece where to be drilled, Rapid programming language are used to write the program and how much depth is to be moved inside the work piece material. Setting up the work piece is time consuming process in Robotic operation.

![Design of experiment](image)

**Figure 1.** Process Flowchart.

2.2. Combined Drill-Reamer Tool

Drilling and reaming tool bit has been made up of carbide material. It has following dimensions parameter (Table 1).

| Parameter      | Length | Diameter |
|----------------|--------|----------|
| Drill          | 25mm   | 9.7mm    |
| Drill shank    | 10mm   | 9.7mm    |
| Reamer         | 40mm   | 10mm     |
| Reamer shank   | 10mm   | 10mm     |
| Main shank     | 50mm   | 10mm     |
| Point angle    | 118deg |          |
Figure 2. Drill-Reamer Combined Bit.

2.3. Material used

The material used drilling and reaming operation is aluminium AL-6061. Aluminium and brass have good machinability parameters. But brass is costly, so aluminium is selected. Aluminium is also light in weight because of lower density when compared with brass.

3. Experimental Values

The surface roughness and circularity values are obtained by measurement taken by Zeiss surface hardness machine and Zeiss circularity machine in previously drilled-reamed hole. Surface roughness (RA) and Circularity values are listed in table for both Robot and CNC. The tabulated values are shown below.

| Spindle speed(rpm) | Axial-feed rate(mm/sec) | Robot-surface roughness RA(μm) | Robot circularity(mm) | CNC-surface roughness RA(μm) | CNC circularity(mm) |
|-------------------|-------------------------|--------------------------------|------------------------|-----------------------------|---------------------|
| 2500              | 60                      | 11.2567                        | 0.113                  | 1.34                        | 0.117               |
| 2500              | 120                     | 3.2510                         | 0.118                  | 3.12                        | 0.091               |
| 2500              | 180                     | 9.7320                         | 0.121                  | 3.77                        | 0.122               |
| 2400              | 60                      | 2.1374                         | 0.103                  | 3.23                        | 0.046               |
| 2400              | 120                     | 1.5666                         | 0.106                  | 0.53                        | 0.024               |
| 2400              | 180                     | 5.9344                         | 0.137                  | 1.45                        | 0.169               |
| 2300              | 60                      | 3.3814                         | 0.159                  | 3.10                        | 0.203               |
| 2300              | 120                     | 4.0781                         | 0.221                  | 2.18                        | 0.194               |
| 2300              | 180                     | 6.4592                         | 0.137                  | 2.15                        | 0.081               |

4. Taguchi Analysis

Minitab software is used create Taguchi design. The values shown above are uploaded in that table in software. Surface roughness value should be minimum and Circularity values should be also be minimum. In that cases, since two objectives are same, smaller is better option is selected for surface roughness and circularity. Signal to noise ratio, rank are shown below. Response Table for Signal to Noise Ratios: Smaller is better
5. Result and Discussion

The optimised values are found by examining the SN ratio graph. From that graph, the experiment which had speed of 2400 (rpm) and axial feed rate of 120 (mm/sec) are the one which had the optimised robust values. However surface roughness obtained are minimum in case of CNC when compared to Robot. This is due to multiple drill bit used for drilling operation before the actual drill-reamer bit is introduced. This can be visualised in the scatter plot shown below. To overcome this factor, drill machine used should have more power thereby enough cutting force is generated and compact size as well weight to fit in to robot end effector.

**Table 3. Response Table**

| Level | SPINDLE SPEED (rpm) | AXIAL FEED RATE (mm/sec) |
|-------|---------------------|--------------------------|
| 1     | -8.388              | -9.346                   |
| 2     | -4.606              | -4.242                   |
| 3     | -12.160             | -11.566                  |
| Delta | 7.555               | 7.324                    |
| Rank  | 1                   | 2                        |

**Figure 3. Signal-to-Noise Ratio.**
Figure 4. Scatter plot.

6. References

[1] P. Kishore kumar, Dr.k.kishore and P.laxminarayan, March - 2013 “Prediction of thrust force and torque in drilling on aluminium 6061-T6 alloy”. International Journal of Engineering Research & Technology (IJERT) Vol. 2, ISSN: 2278-0181

[2] V. Chandrasekharan, S. G. Kapoor, and R. E. DeVor, 1998 “Mechanistic model to predict the cutting force system for arbitrary drill point geometry,” J. Manuf. Sci. Eng. Trans. ASME, 3, pp. 563–570

[3] C. C. A. Eguti and L. G. Trabasso, 2014 “Design of a robotic orbital driller for assembling aircraft structures,” Mechatronics, 24, pp. 533–545

[4] C. Dumas, S. Caro, M. Cherif, S. Garnier and B. Furet, 2012 “Joint stiffness identification of industrial serial robots,” Robotica, vol. 30, no. 4, pp. 649–659

[5] Masato okado, and naoki asakawa, may 2014 “Cutting characteristics of twist drill having cutting edges for drilling and reaming”

[6] Weidong zhu, Biao mei, Guorui yan and Yinglin ke (2014) “Measurement error analysis and accuracy enchance ment of 2D vision system for robotic drilling” Robotics and Computer-Integrated Manufacturing 30 160–171

[7] Badea lepadatescu “Study of axial force and torque drilling on ZTAL4Cul alloy” international journal of mechanical engineering

[8] Guven meral, Murat sankaya, Mazammed mia, Hakan dilipak, Ulvi seker and Munish k.gupta “Multi-objective optimization of surface roughness, thrust force, and torque produced by novel drill geometries using taguchi-based GRA” the international journal of advanced manufacturing technology

[9] Prakash S, Mercy JL, Salugu MK and Vineeth KS. 2015 Jan 1 Optimization of drilling characteristics using grey relational Analysis (GRA) in medium density fiber board (MDF). Materials Today: Proceedings.,2 1541-51