Enhancing Precision of Drilling Parameters in Aluminium For Minimizing Power Consumption

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***Abstract**: Drilling is one of the basic machining process of making holes in a work piece with metal cutting tools and it is essentially for manufacturing industry like aerospace industry, automobile industry, medical industries and semiconductors. It is greatly affected by the cutting parameters like depth of cut, spindle speed, feed rate, cutting edge angle, cutting environment and so on. Present work basically involved experimental investigation of thrust force and power consumption by the change in the feed and spindle speed of multi point drilling tool for a drilling operation in the oblique cutting to be carried out with the set of machineries. Thrust force measured using lathe tool Dynamometer.*

Keywords: Drilling , Dynamometer, Thrust Force, Power Consumption, Taguchi, ANOVA

INTRODUCTION

Drilling is a most common used industrial machining process of creating and originating a hole in mechanical components and work piece. The tool used, called a drill bit and the machine tool used is called a drill machine. Drilling involves a rotary end-cutting tool having one or more cutting edges called lips, and having one or more helical or straight flutes for the passage of chips and passing the cutting fluid to the machining zone. The drilling operations performed on a drilling machine, which rotates and feed the drill to the work piece and creates the hole. Drilling usually performed with a rotating cylindrical tool that has two cutting edges on its working end (called a twist drill). Rotating drill fed into the stationary work piece to form a hole whose diameter is determined by the drill diameter.

Cutting speed is the speed difference between the cutting tool and the surface of the workpiece it is operating on. It is expressed in units of distance along the workpiece surface per unit of time. The speed of the work piece surface relative to the edge of the drilling tool during a cut, measured in meter per minute. Cutting speed of a material is the ideal number of Feet-per-Minute that the tool-bit should pass over the work-piece. This "Ideal" cutting speed assumes sharp tools and flood coolant. Adjustments need to be made for less than ideal cutting conditions. Different materials (High-Carbon/Low-Carbon Steels, The rotational speed of the spindle and the work piece in revolutions per minute. Feed refers to how fast a lathe-tool should move through the material being cut. This is calculated using the feed per Revolution for the particular material. The feed is measured in millimetre per revolution. The present work involves the experimental investigation of thrust force on aluminium casting work piece caused by changing the spindle speed and feed of the drill bit for a drilling operation on the lathe machine.

EXPERIMENTAL METHODOLOGY

This study consists of experimental work the drilling of aluminium casting specimen on Lathe machine. A drill bit dynamometer has been installed on Lathe machine for measuring thrust force, cutting force and feed force on workpiece while drilling is performed on the lathe machine. Taguchi method is used for the design of experimental approach for performing optimization process. Various input parameter have been taken under experimental investigation and then model has been prepared for doing experimentation. The result obtained has been analyzed using the model produced by using MINITAB-17 software. The model produced shows that which parameter is more effective in producing more thrust force and feed force. HSS material drill bit is used for the drilling.

Table 1 Materials Properties

S. NO.	Object	Material	Density	Elasticity
1.	Work piece	Aluminium	2.70 g/cm3	70 Gpa
2.	Drilling Tool	High speed steel	7.9 g/cm3	207 GPa

Experimental Setup

Experimental set up having drill bit of high speed steel was mounted on 3-jaw chuck of lathe machine and work-piece was mounted on work-piece holder which was fixed in lathe tool holder and this tool holder fixed at tool post of lathe machine. As shown in the line diagram. Work-piece is fixed at tool post and tool post of lathe machine can move left and right. So work-piece was moving towards the drill bit. Drill bit is fixed at chuck of the lathe machine. Spindle speed of drill bit and feed on work-piece was managed by lever mounted on head stock of lathe machine. Two wattmeter was connected with 3-phase motor of lathe machine which have given power consumption during drilling.

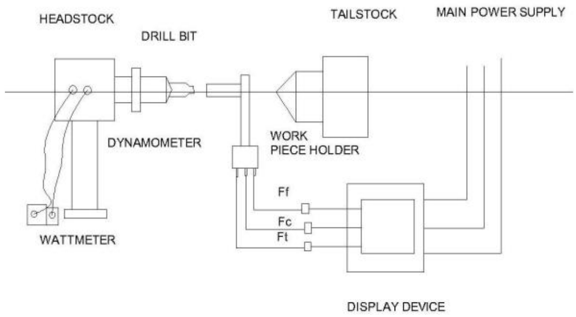

Figure 1. Line Diagram of Experimental Setup

Dynamometers are devices used to measure cutting forces in machining operation. The cutting force cannot be detected or quantified directly but their effect can be sensed using Transducer. For example, a force which can neither be seen nor be gripped but can be detected and also quantified respectively. Lathe Tool Dynamometer designed to measure vertical & horizontal/(radial force in case of three component) forces on tool during cutting process. The unit consists of a mechanical sensing unit or tool holder and digital force indicator. With this dynamometer, students can study the change in these forces due to change in speed and feed.

Figure 2 Display Device of Dynamometer

Conducting the experiment each independent variable have certain fixed levels as shown in Table 1 and it have 16 results in total of (4×4) 16 runs (i.e. full factorial design) to be conducted to test all the possible combinations of parameter levels.

MiniTab17 software has been used for processed all the possible run for full factorial design as specified in Table 2 which results in total of 16 runs. Full design approach has included each and every combination of possible experimental run.

Table 2. Experimental Levels of Drilling Parameter

Drilling parameter	No. of Levels	Values for each level			
		Level 1	Level 2	Level 3	Level 4
Spindle speed (rpm)	4	150	250	420	710
Feed (mm/rev)	4	0.05	0.07	0.10	0.13

RESULT AND DISCUSSION

To determine the effect of each parameter on the output variable, the signal-to-noise (S/N) ratio was calculated for each experiment by using Taguchi method in Minitab 17 statistical software and result of total 16 (4x4) runs were given in Table 3. Mean value of experimental data was also calculated for accurate value of power consumption during the drilling operation on lathe machine. After collection of experimental data, to show the effect of each input parameter namely feed (F) and spindle speed (SS) on power consumption (Pc), various plots are generated on the basis of collected data.

Table 3. Power Consumption for Independent Parameters (Constant feed)

Independent Parameters		Dependent Parameters		
Feed (mm/rev)	Spindle Speed (rpm)	Power Consumption (Kw)	S/N Ratio	Mean
0.05	150	2.08	-6.36127	2.08
	250	1.92	-5.66602	1.92
	420	1.83	-5.24902	1.83
	710	1.75	-4.86076	1.75
0.07	150	2.26	-7.08217	2.26
	250	2.12	-6.52672	2.12
	420	1.98	-5.93330	1.98
	710	1.86	-5.39026	1.86
0.10	150	2.54	-8.09667	2.54
	250	2.32	-7.30976	2.32
	420	2.23	-6.96610	2.23
	710	2.18	-6.76913	2.18
0.13	150	2.74	-8.75501	2.74
	250	2.45	-7.78332	2.45
	420	2.37	-7.49497	2.37
	710	2.28	-7.15870	2.28

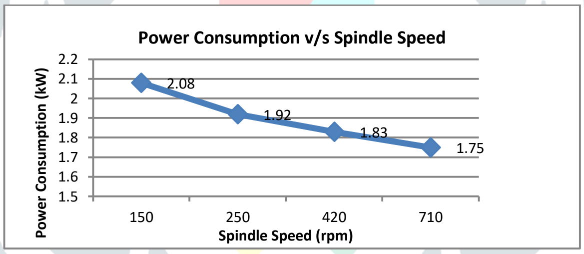

Figure 3 Power Consumption v/s Spindle Speed at Feed (0.05 mm/rev)

Figure 3 shows that at 0.05 mm/rev feed for 150, 250, 420 and 710 rpm spindle speed, percentage reduction in power consumption were 7.69%, 12.01% and 15.86% respectively with increasing spindle speed from 150 to 710 rpm.

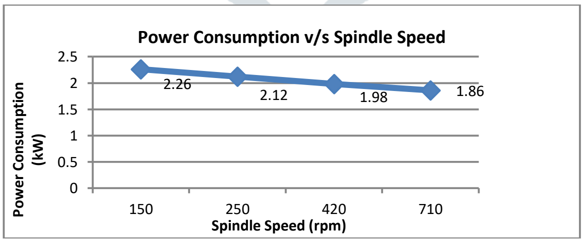

Figure 4power Consumption v/s Spindle Speed at Feed (0.07 mm/rev)

Figure 4 shows that at 0.07 mm/rev feed for 150, 250, 420 and 710 rpm spindle speed, percentage reduction in power consumption were 6.19%, 12.38% and 17.69% respectively with increasing spindle speed from 150 to 710 rpm.

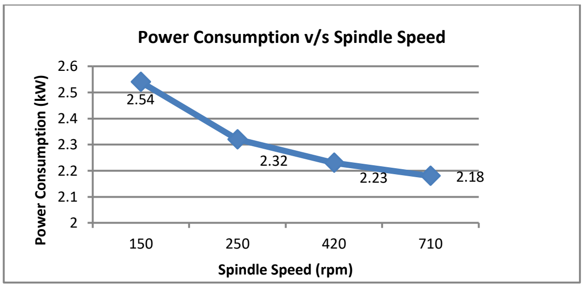

Figure 5 Power Consumption v/s Spindle Speed at Feed (0.10 mm/rev)

Figure 5 shows that at 0.10 mm/rev feed for 150, 250, 420 and 710 rpm spindle speed, percentage reduction in power consumption were 8.66%, 12.20% and 14.17% respectively with increasing spindle speed from 150 to 710 rpm.

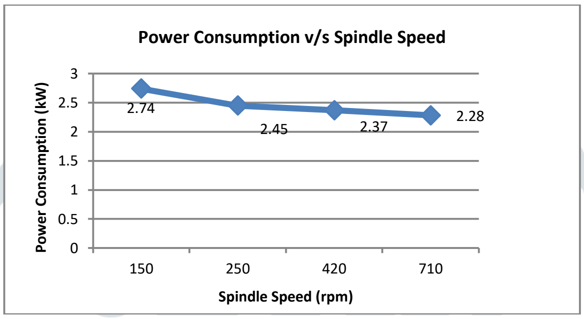

Figure 6 Power Consumption v/s Spindle Speed at Feed (0.13 mm/rev)

Figure 6 shows that at 0.13 mm/rev feed for 150, 250, 420 and 710 rpm spindle speed, percentage reduction in power consumption were 10.58%, 13.50% and 16.78% respectively with increasing spindle speed from 150 to 710 rpm.

CONCLUSIONS

From graphical and statistical analysis based on the combination of different input parameters under controlled condition it was found that if implemented in industries will decrease the production cost due to less power consumption.

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