Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2017, 4(10):1-6**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Optimization of Cutting Parameters for Minimizing Power Consumption in Drilling of Aluminium Casting using Taguchi Methodology and ANOVA

Mukesh Kumar Lohar[1], S. Jindal[2], Chitranjan Agarwal[3], M.S. Khidiya[3]

[1]M.Tech Scholar, Department of ME, CTAE, Udaipur, Rajasthan, India
[2]Professor, Department of ME, CTAE, Udaipur, Rajasthan, India
[3]Assistant Professor, Department of ME, CTAE, Udaipur, Rajasthan, India

Abstract To ensure quality of machined products at minimum machining costs and maximum machining effectiveness, it is very important to select optimum parameters when metal cutting machine tools are employed. The design objective preceding most engineering design activities is simply to minimize the cost of production or to maximize the production efficiency. The machining parameters such as cutting speed, feed rate and depth of cut are optimized by multi-response considerations namely power consumption and tool life. Taguchi methodology, signal to noise (S/N) ratio and analysis of variance (ANOVA) were employed to analyze the effects and contributions of depth of cut, feed rate and cutting speed on the response variable. The results of this research work showed that feed rate is the most significant factor for minimizing energy consumption.

Keywords Cutting Parameters, 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 and sometimes lathe machine is used. 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. Geometrically, drilling is one of the most complex machining process due to the complex geometry of the drill bit. The difficulty of producing drills with consistent geometries has traditionally limited accuracy although recently drill consistency and repeatability has greatly increased with the advent of CNC drill grinders. The same complexity of the tool geometry has inhibited the introduction of new tool materials to have the productivity gains in drilling, which lagged from those made in turning and milling over the past 30 years [1].

Review of Literature

Gaitonde *et al*., (2006) worked on Taguchi methodology with a new concept of fitness function for each trial of orthogonal array to optimize multi-objective response during the drilling of AISI316L stainless steel. For the multi-objective optimization problem, the Taguchi design is a new concept of fitness function to minimize burr size. Various drilling parameters are the cutting speed, feed, point angle and lip clearance angle and burr height and burr thickness have been considered as response. For the drilling process this new approach can be efficiently employed for the multi optimization [2].

Langella *et al*., (2005) presented a mechanistic model for use in predicting thrust and torque during composite materials drilling. Authors have focused on the influence of feed rates on thrust and torque, with respect to cutting lips and the chisel edge. It was found that total force value generated by cutting lips and chisel edge during glass-reinforced composites drilling the risk of damaging the material increase in proportion to feed rate [3].

Strenkowski *et al*., (2004) used analytical finite element technique for predicting the thrust force and torque in drilling with twist drills. Good agreement between the predicted and measured forces and torques was found in orthogonal and oblique cutting and in drilling tests. The drilling tests were performed on AISI 1020 for several drill diameters, spindle speeds, and feed rates [4].

Experimental Works

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 [5].

According to present work, experiments were performed on conventional centre lathe machine. The machine tool selection is a main factor which affects the outcome of experimental work. The major technical specifications of the lathe machine used shown in Table 1.

Table 1: Technical Specifications of Conventional Lathe Machine

S. No.	Specifications	Range
1	Spindle speed	32-1200 rpm
2	Spindle motor power	3 kW
3	Made	HMT-LTM
4	Number of station of turret head	8
5	Weight	1550 kg

In this experiment workpiece of aluminium casting having dimension 100*20 mm (Length * Diameter) were used. Tool material as HSS drill bit is used. The effect of spindle speed and feed on the thrust force along with power consumption was experimentally investigated [6].

Figure 1: Experimental Setup on Lathe Machine

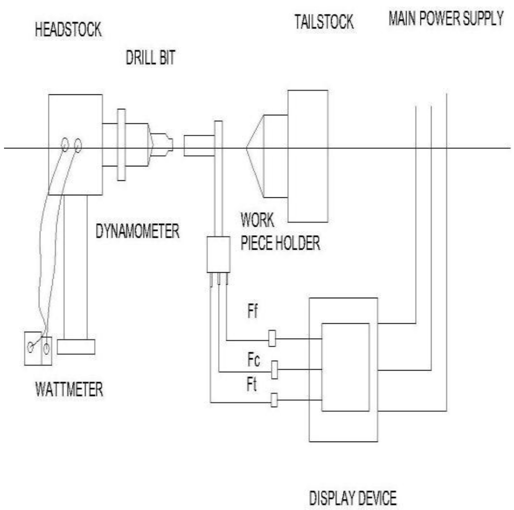

Figure 2: Line Diagram of Experimental Setup

A randomized schedule of runs have been created for all the possible sets of parameter levels being used in the experiment for a number of samples of work piece having same material. Spindle speed and feed were the independent parameters and thrust force and power consumption were dependent parameters [7].

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

For different feed rate and changing the spindle rate the relation with thrust force was found. Here in this analysis was done for fee rate from 0.05 mm/rev to 0.13 mm/rev. Likewise spindle was varied from 150 rpm to 710 rpm. The values of S/N ratio were generated from Minitab 17 software.

Results and Discussion

Table 3: Thrust Force for Different Independent Parameters (Constant Feed)

Independent Parameters		Dependent Parameters	
Feed (mm/rev)	Spindle Speed (rpm)	Thrust Force (kgf)	S/N Ratio
0.05	150	98	-39.8245
	250	78.48	-37.8952
	420	49.05	-33.8128
	710	29.43	-29.3758
0.07	150	117	-41.3637
	250	78.48	-37.8952
	420	58.86	-35.3964
	710	49.02	-33.8075
0.10	150	127.53	-42.1122
	250	117.7	-41.4155
	420	98	-39.8245
	710	88.29	-38.9182
0.13	150	206	-46.2773
	250	180.6	-45.1344
	420	166.7	-44.4387
	710	147.15	-43.3552

The final conclusion is clear from above Figure 3 that for every feed (mm/rev), increment in spindle speed (rpm) leads to reduction in thrust force. Maximum feed line is above from all lines it is mean maximum feed 0.13 mm/rev is having maximum thrust force of 206 Kgf but on increasing spindle speed there is reduction in thrust force (147.15 Kgf for same feed 0.13 mm/rev) [8].

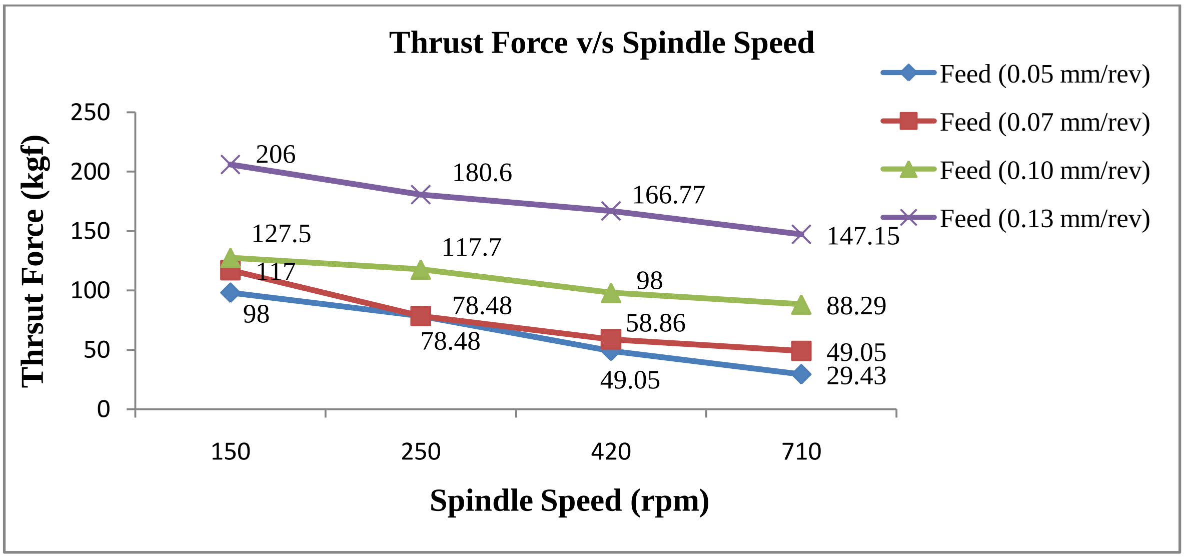

Figure 3: Variation of Thrust Force with Spindle Speed at Different Feeds

Mini Tab- 17 (Taguchi Method for Power Consumption)

In this method uses a special set of arrays called 'Orthogonal Arrays'. These standard arrays stipulate the way of conducting the number of experiments which could give the full information of all the factors that affect the performance parameter. This method involves a technique of reducing the variation in a process through robust design of experiments. In Taguchi method, there are three categories for analysis of S/N Ratio i.e. the smaller is better, the larger is better and the nominal is best. For this experimental analysis, the first category 'The smaller is better' was chosen to reach the optimization conditions for minimization of thrust force which is the desired condition for drilled machined parts [9].

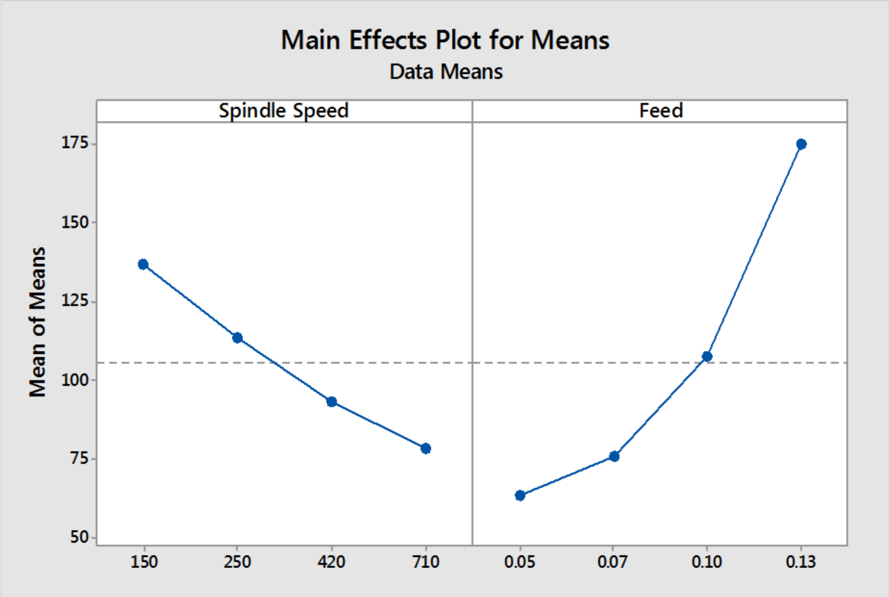

Figure 4: Main Effects Plot for Means for Thrust Force

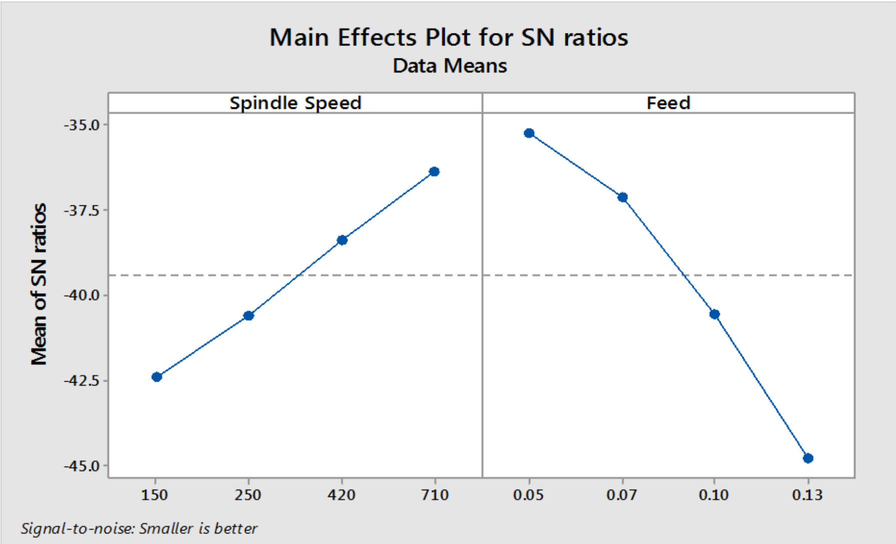

Figure 5: Main Effects Plot for SN ratio for Thrust Force

Figure 4 and Figure 5 plot for increasing feed with respect to S/N ratio and Mean is in decreasing and increasing way respectively while plot for increasing spindle speed with respect to S/N ratio and Mean is in increasing and decreasing manner respectively. The effect of feed was more than as comparison to spindle speed. So S/N ratio for thrust force has been found in negative manner. It can be analyzed from the main effect plots for S/N Ratio and main effect plot for mean that in order to obtain optimized value of thrust force, the feed should be set to its lowest value (0.05 mm/rev) while spindle speed to their largest values *i.e.* 710 rpm.

Table 4: Response Table for S/N Ratios for Thrust Force

Level	Spindle speed (rpm)	Feed (mm/rev)
1	-42.39	-35.23
2	-40.59	-37.12
3	-38.37	-40.57
4	-36.36	-44.80
Delta	6.03	9.57
Rank	2	1

Table 5: Response Table for Means for Thrust Force

Level	Spindle speed (rpm)	Feed (mm/rev)
1	137.13	63.74
2	113.82	75.84
3	93.15	107.88
4	78.47	175.11
Delta	58.66	111.37
Rank	2	1

Response tables also show rank value of first, second to feed and spindle speed respectively. Rank value of independent parameters indicates feed is more and spindle speed is less affecting parameter to thrust force.

Conclusion

- Experimental analysis depicts that the thrust force is directly prapotional to feed apart from the spindle speed is least affected at the time of drilling process on lathe machine. Reason is if feed increases force acting on lips of the drill bit increases rapidly and also on increasing feed material removal rate increases more as compare to increasing spindle speed.
- Analysis is based on graphical and statistical concludes that addition of input parameter under controlled condition discussed above is use then due to less thrust force, tool cutting edge takes more time to get blunt which reduce time and energy for regrinding of tool cutting edge.
- Graphically Taguchi method shows that for minimum thrust force, combination of 0.05 mm/rev feed and 710 rpm spindle speed is optimum.

References

[1]. Jaybal, S. and Nataranjan, U. 2010. Influence of cutting parameters on thrust force and torque in drilling of E-Glass/Polyester composites. *Indian Journal of Engineering & Material Sciences.* 17.12.2010. vol 17: 463-470.

[2]. Gaitonde, V. N., Karnik, S. R., Acyutha, B. T. and Siddeswarappa, B., 2006. Methodology of Taguchi optimization for multi-objective drilling problem to minimizeburr size. International J. Advance Manufacturing Technology. 34(1): 1-8.

[3]. Langella, A., Nele, L. and Maio, A., 2005. A torque and thrust prediction model for drilling of composite materials. Applied Science and Manufacturing. 36(1): 83-93.

[4]. Strenkowski, J. S., Hsieh, C.C. and Shish, A. J., 2004. An analytical finite element technique for predicting thrust force and torque in drilling. International Journal of Machine Tools & Manufacture. 44: 1413–1421.

[5]. Zitoune, R., Krishnaraj, V. and Collombet, F., 2010. Study of drilling of composite material and aluminium stack. Composite Structures. 92: 1246–1255.

[6]. Szwajka, K., 2011. Torque and thrust force in drilling. Annals of Warsaw University of Life Sciences. 76: 108-115.

[7]. Tamilselvan and Raguraj, 2014. Optimization of process parameters of drilling in Ti-Tib composites using Taguchi technique. International Journal on Mechanical Engineering and Robotics. 2(4): 1-5.

[8]. Vaishak, N., Ramakrishna, L., Devananda, J., Quadros, D., Shetty, R. and Balakrishna, S. S., 2014. Analysis of thrust force and torque in drilling granite particulate reinforced epoxy composites by using multi facet HSS twist drill. Proceedings of 8th International Conference on Engineering and Technology Research, Novotel World Trade Centre, Dubai, UAE. 49(8):1-9.

[9]. Vankanti, K. V. and Ganta, V., 2013. Optimization of process parameters in drillin GFRP composite using Taguchi method. Journal of Materials Research and Technology. 3(1): 35-41.