EFFECTS OF VARYING JOB PARAMETERS ON RELEASE TIME USING LATHE MACHINE

T. I. OGEDENGBE, Department of Mechanical Engineering, The Federal University of Technology Akure, Nigeria, tioged@yahoo.com

B. KAREEM, Department of Mechanical Engineering, The Federal University of Technology Akure, Nigeria, karbil2002@yahoo.com

O. O. OJO, Department of Mechanical Engineering, The Federal University of Technology Akure, Nigeria, ojoolatunjioladimeji@yahoo.com

Abstract: This paper amply studied the effects of varying job parameters on release time of jobs produced on lathe machine and further showed the significance of careful selection of optimum complexity for lathe produced jobs. Job parameters are the salient factors apart from mechanical inputs or machine parameters on which release time of jobs is subject to. These parameters include complexity of job, material, and length of job and depth of cut employed in metal cutting. Directly measured release times were obtained at ranges of machine parameters of spindle speed from 300-550 rev/min and feed rate from 0.068-0.117 mm/rev on the lathe machine and the job parameters were conversely documented. The assessment of job parameters on the release time of jobs produced on lathe machine was carefully investigated using exponential, linear, logarithmic, polynomial, and power regression analyses. The R-square value on charts was employed as the decision criterion for checking the correlation between release time and each of the job parameters. A change in any of the job parameters bring about a proportional effect on release time. The polynomial model gives the optimum correlation for each of the job parameters.

Key-Words: *job parameters, release time, complexity, machine parameters, lathe machine, R-square value, correlation*

1. Introduction

This research work is a sequel to the investigation of factors that affect release time of jobs on lathe. In the preceding publication, the investigation of cutting fluid on release time of jobs produced on lathe machine was experimentally studied and it was acknowledged that cutting fluid has no significant effect on release time of jobs produced on lathe. Cutting fluids' application brings about improvement of machined surface quality and increases tool service life but not necessary the improvement of release time of jobs produced on lathe machine [8]. Though, cutting fluid is a vital job parameter and cooling agent [13] that decreases cutting zone temperatures, while extending tool life by reducing external friction between cutting tool and work piece, as well as the inbuilt internal friction accrued; as a result, in this research it is not considered in evaluating the effects of varying job parameters on release time of jobs based on the previous experimental corroboration. The others identified job parameters associated with metal shearing or cutting operations on lathe machine were explored.

Basically, job parameters are the fundamental attributes associated with a typical job and they include the nature of material, length of cut, complexity of the job, and depth of cut employed in producing a job. These parameters have their individual effect as well as combined effects on the release time of jobs produced on lathe machine. Though, there are other parameters known as machine parameters or key mechanical inputs which consist of spindle speed or cutting speed and feed rate that contribute to the overall machining

Received: 19, Sep., 2012, Accepted: 30, January. 2013
Available online: 4, February. 2013

time on lathe machine. In literature, estimation of release time was majorly based on these machine parameters while very little and nominal consideration was placed on job parameters. Machining time is expressed in terms of work piece diameter, length of the machined surface, cutting speed and feed rate [7]. The machine parameters are selected on the lathe head and they actually produce the relative motions required for metal shearing on lathe machine whereas job parameters have influences on the release time of jobs as well. Release time is termed to be equivalent to machining time which is the total time expended on the metal cutting/shearing operation or production of jobs. It could be referred to as machining time. Machining time refers to the time elapsed in a single cut during the turning of a work piece [1]. Jobs often have variable execution times and arbitrary release times [6] and this difference in release time is majorly as a result of variation in job parameters when the cutting process is performed with constant machine parameters for a job. Therefore, the effect of job parameters on release time of jobs is necessitated to explore the benefits of varying job parameters on the production time of jobs.

Optimization machining parameters are important in manufacturing world considering economic reason. In today's manufacturing world, the primary objective in machining operations is to produce high-quality products with low cost. In order to minimize the machining cost for machining economics problem, the optimization of cutting parameters is one of the most important issues since these parameters strongly affect the cost, productivity and quality. The optimization problem of machining parameters in multi-pass turnings becomes very complicated when plenty of practical constraints have to be considered [9]. Among these pertinent parameters are job parameters. These parameters also affect production or machining time. As a result, this research examines the relevant and significant job related parameters on lathe machine.

Lathe machine is an indispensable machine tool utilized in all metal workshops in Nigeria and lathes are generally considered to be the oldest machine tools still used in industry. About one-third of the machine tools operating in engineering plants are lathe machines. Lathes are employed for turning external cylindrical, tapered, and contour surfaces; boring cylindrical and tapered holes, machining face surfaces, cutting external and internal threads, knurling, centering, drilling, counter-boring, countersinking, spot facing and reaming of holes, cutting off, and other operations. Lathes are used in both job and mass production [3]. The lathe is a machine tool used principally for shaping articles of metal or other materials by causing the work piece to be held and rotated by the lathe while a tool bit is advanced into the work causing the cutting action [2]. The typical lathe provides a variety of rotating speeds and a means to manually and automatically move the cutting tool into the work piece. However, the effect of job parameters on the release time of jobs produced on lathe is highly pertinent for job planning, evaluation of productivity or manufacturing capacity of jobs on lathe.

Every engine lathe provides a means for traversing the cutting tool along the axis of revolution of the work piece and at right angles to it. Beyond this similarity, the lathe may embody other characteristics common to several classifications according to fields of application that ranges from manual to full automatic machining. Metal cutting lathes may differ in size and construction. Among these are the general-purpose machines that include universal engine lathes, plain turning lathes, facing lathes, and vertical turning and boring mills [3]. Production time estimation of jobs in lathe workshops is highly necessary for time management and planning of metal cutting activities. However, the nature of jobs will affect the machining time or completion time or release time of those jobs. This needs to be capture in the computation or estimation of release time and it has been considered to be among the job parameters on which release time estimation is based.

The machining system includes a number of subsystems such as the machine tool, the control system, the coolant supply system, the loading–unloading system, etc. The main objective of the machining system is to provide optimum conditions for the performance of the cutting system because the quality of the machine part and the efficiency of machining are determined by the performance of the cutting edge of the cutting tool(s) and the machine parameters. Therefore, the system interactions between the subsystems of the machining system and the cutting system should be established, optimized and maintained to achieve optimum performance of the cutting system [11].

Increasing the productivity and the quality of the machined parts are the main challenges of metal-based industry; there has been increased interest in monitoring all aspects of the machining process [5]. The aspect of production parameters including cutting or machine parameters and job parameters are not left out of this. Optimal selection of cutting parameters or job parameters has effect on machining time of jobs produced on lathe. The three important cutting parameters cutting speed (m/sec), feed rate (mm/rev) and depth of cut (dmm) need to be optimized to achieve lowest surface roughness (μm) in a turning operation [4][10][11]. The conventional parameters include material machinability; cutting tool material; cutting speed or spindle speed; depth of cut; feed rate; tool geometry; coolant; machine/ spindle power; and rigidity of machine [12]. However, these parameters have been investigated in publications but those of job parameters are yet to be examined; when parameters such as material of job and complexity of jobs are taken into consideration.

2. Method

An investigatory method of approach was employed in examining the effects of job parameters on release time of jobs. The methods employed in the research planning and analysis are four and they consist of classification of parameters, strategizing or planning for the experiment, jobs production for data acquisition and modeling to test for correlations.

2.1 Classification of Parameters

This involves analytical study of some typical jobs with the relevant time dependent factors/parameters on a lathe machine. The study gives the essential parameters required for time estimation and they are basically the spindle speed, the feed rate and the job strictures. These parameters were classified into two and they are machine parameters and job parameters. The speed and the feed are the machine parameters while the job strictures are referred to as job parameters. Though, machine parameters give the requisite motion required for metal cutting but job parameters are the other salient factors that greatly influence the release time of jobs produced on lathe. The effect of job parameters on release time was the focus of the research as a result; other parameters were not analyzed for the investigation of release time of jobs. The parameters allied to jobs production on lathe machine are itemized in table 1. The length of cut is the job's dimensional distance from end to end. Job complexity is the number of operation/processes or turnings required to produce a job. Material of job is the work piece or the engineering material from which the job is to be produced. Depth of cut is the distance thrust in by the cutting tool into the work piece during the production of a job. However, tool geometry and coolant were not treated in the assessment of the effects of job parameters on release time. Since, it has been established that cutting fluid has no significant effect on release time of jobs.

Table 1: Classification of Metal Cutting Parameters on Lathe

S/N	Machine Parameters	Job Parameters
1	Feed	Length of cut
2	Spindle Speed	Job Complexity
3	Machine/Spindle Power	Material of job
4	Rigidity of Machine	Depth of cut
		Cutting Tool Material
		Tool Geometry
		Coolant

2.2 Strategizing or Planning for the Experiment

The research planning entails considerations for material/work piece, coolant, cutting tool, the level of job complexity to be examined, and the total number of jobs necessary for the experiment. Stop watch was designed for release time measurement and a snap back technique was adopted in order to determine the exact time engaged in a particular cutting process.

A single work piece material was designed for the entire experiment in order to avoid mixed contribution of work piece material or composition on the release time of jobs. Material hardness was believed to have influences on machining time. Also, a single cutting tool was also designed for the experiment in order to avoid assorted contribution of tools on the release time of jobs produced on the lathe. In addition, a particular coolant was designed for the research experiment based on availability and cost.

One single lathe machine was designed for the experiment. This is necessary to avoid mixed efficiency of lathe machines on release times desired to be measured. Automatic engagement of the cutting tool on the lathe machine was designed and utilized for the entire experiments on lathe so as to have constant rate of tool movement on the lathe.

The classified machine parameters are essential for the research; the reason is that relative motions are provided by some of these parameters. Ranges of these parameters were designed for the experiment so as to accommodate large and small depth of cut on the metal work piece without enormous wear on the cutting tool. The spindle speeds of range 300-550 rev/min and feed rates of range 0.068-0.117 mm/rev were designed for the research to serve this purpose.

The number of operation or processes performed on a job is referred to as complexity of jobs. The complexity of jobs designed for the experiment was varied oddly in order to bring about different and more level of complexity into production operations on the lathe. Complexity of job was designed to be varied between 3 and 19; thus producing nine jobs.

2.3 Jobs Production for Data Acquisition or Design of the Experiment

Simple and multi-operational jobs were machined with various degrees of complexity for the assessment of varying job parameters on release times. Table 2 shows nine jobs designed for the research experiment as well as the level of complexity of jobs. Each job is produced nine times. Three spindle speeds of 300, 400 and 550 rev/min as well as three feed rates of 0.068, 0.094 and 0.117 mm/rev were employed in the metal cutting processes. Each of these machine parameters was designed to be employed in the production of jobs. It was assumed that the selected machine parameters on lathe were actually the cutting parameters utilized for cutting and a typical student lathe machine was employed throughout the entire production in order to avoid mixed contributions of different lathe machine's efficiency on release times. All the job parameters are designed to be recorded and release time to be measured for each jobs produced. A single material was utilized for the entire jobs and the level of complexity, length of cut and the depth of cuts are shown in table 2.

Table 2: Jobs Produced with Level of Complexity

S/N	Jobs Produced	Complexity	Length of Cut (mm)	Average depth of Cut (mm)
1	Stud	3	210.00	1.33
2	Plain Locator	5	190.00	1.62
3	Tensile Test Specimen	7	213.00	0.93
4	Bolt	9	288.75	0.67
5	Pulley	11	230.00	2.20
6	Screw Locator with Handle	13	592.00	1.04
7	Sleeve	15	531.20	1.80
8	Pin Punch	17	491.00	0.82
9	Chuck Key	19	1249.00	0.55

2.4 Modeling to Test for Correlations

Linear, exponential, logarithmic, polynomial, and power models were designed and adopted to test for correlations between each of the job parameters and release time. This is necessary to investigate the effect of job parameters on release times and Excel Trend or Regression analytical tool was designed for this analysis. All the orders of the logarithmic modeling technique were investigated to cover all the possibilities and true values involved in its approach of data analysis. R-square value on chart was employed as a criterion for deciding the optimum model or correlation between the job parameters and release time.

The linear, exponential, logarithmic, polynomial and power correlations take the general form of equations 1-5 for the assessment of job parameters on release times.

$$R_{Tw} = Aj + Bj + Cj + \cdots + nj \quad (1)$$

$$R_{Tw} = Ae^{aj} + Be^{bj} + \cdots + ne^{\sigma j} \quad (2)$$

$$R_{Tw} = A\log aj + B\log bj + \cdots + n\log \sigma j \quad (3)$$

$$R_{Tw} = Aj^{n} + Bj^{n-1} + \cdots + nj^{0} \quad (4)$$

$$R_{Tw} = AJ^{n-a} + \cdots \quad (5)$$

R_{Tw} is release time of a job, j is any of the job parameters, n is the constant for the last term, σ is a constant, while A, B, and C are numerical constants respectively.

3. Result

Stop watch was employed for direct measurement of release time of jobs produced on lathe machine while recording of job parameters was noted on the record sheets. Table 4 shows that the average spindle speed and feed rate are 416.67 rev/min and 0.093 mm/rev respectively when the average of the ranges are estimated. Each job was produced nine times and the averages of the job parameters were taken. As shown in Table 4, the average release times, length of cut, average depth of cut and job complexity obtained from the research experiments are the job parameters. Each of the job parameters were correlated with release times using linear, exponential, logarithmic, power and polynomial models.

Table 5 shows that job complexity, depth of cut, and length of cut have proportional effects on the release time of jobs produced on lathe machine. Since, R-square values that fall between 0.7 and 1.0 give excellent correlation.

Table 4: Overall Table for Average Release Time and other Average Parameters

Jobs Produced on the Lathe	Job Complexity	Average Depth of Cut (mm)	Average Spindle Speed (rev/min)	Average Feed Rate (mm/rev)	Average Length of Cut (mm)	Average Release Time (min)
Stud	3	1.33	416.67	0.093	210.00	6.30
Plain Locator	5	1.62	416.67	0.093	190.00	4.64
Tensile Test specimen	7	0.93	416.67	0.093	213.00	6.54
Bolt	9	0.67	416.67	0.093	288.75	9.19
Pulley	11	2.20	416.67	0.093	230.00	7.01
Screw Locator with handle	13	1.04	416.67	0.093	592.00	16.88
Sleeve	15	1.80	416.67	0.093	531.20	15.88
Pin Punch	17	0.82	416.67	0.093	491.00	15.50
Chuck Key	19	0.55	416.67	0.093	1249.0	36.53

This means that as job complexity of a job is increased, the release time of the job also increases; and this is applicable to the length of cut of jobs as well. Linear, exponential, logarithmic, power and polynomial correlations give outstanding correlations between release time of job and length of cut; as the R-square values range between 0.883 and 0.999. This further signifies that length of cut is a unique job parameter that has the greatest effect on release time. Operator or machinist should avoid excessive travels of tool during production of jobs so as to save some production time as well as material. Nevertheless, the correlation of depth of cut and release time gives a weak relationship for linear, exponential, logarithmic, and power regression. The R-square values range between 0.230 and 0.240. In contrast, its polynomial correlation shows some level of dependence on release time as its R-square values range between 0.410 and 0.888. This means that its correlation with release time may be influence by other factors such as tip of cutting tool and nature of material.

Table 5: R-Square Values of Release Time with Job Parameters

S/n	Type of Model	Order	The value of R^2 (Length of Cut)	The value of R^2 (Depth of Cut)	The value of R^2 (Complexity)
1	Linear		0.996	0.240	0.682
2	Exponential		0.883	0.230	0.824
3	Logarithmic		0.929	0.335	0.510
4	Power		0.985	0.303	0.677
5	Polynomial	2	0.996	0.410	0.834
		3	**0.999**	0.579	0.866
		4	0.999	0.594	0.919
		5	0.999	0.883	0.951
		6	0.999	**0.888**	**0.979**

Also, the R-square values of release time and complexity of job range between 0.510 and 0.979. This demonstrates that it has a fairly to excellent relationship with release time. Its influence on release time is subject to machinists' decision; right judgment or planning is paramount to have the least release time. Figures 1-3 show the optimum polynomial relationship of release time and length of cut, complexity of job and depth of cut respectively. d_c, R_{Tw}, n_p, and l_c are depth of cut, release time of job with the application of coolant, complexity of job and length of cut respectively.

Equations 6-8 shows the optimum regression equations for predicting release time of jobs when the length, complexity and depth of cut of the jobs are known. The equations show that a change in any of the job parameters brings about variation in the release time of jobs.

$$R_{Tw} = 6 \times 10^{-8} l_c^{\,3} + 0.090 l_c - 8.454 \qquad (6)$$

$$R_{Tw} = -0.018 n_p^{\,5} + 0.463 n_p^{\,4} - 5.732 n_p^{\,3} + 37.35 n_p^{\,2} - 120 n_p + 151.7 \qquad (7)$$

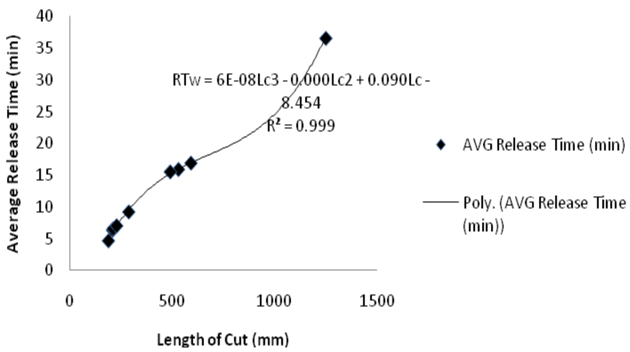

Figure 1: Optimum Polynomial Relationship between Release Time and Length of Cut

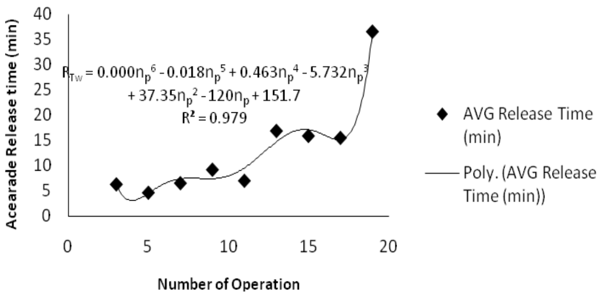

Figure 2: Optimum Polynomial Relationship between Release Time and Complexity of Jobs

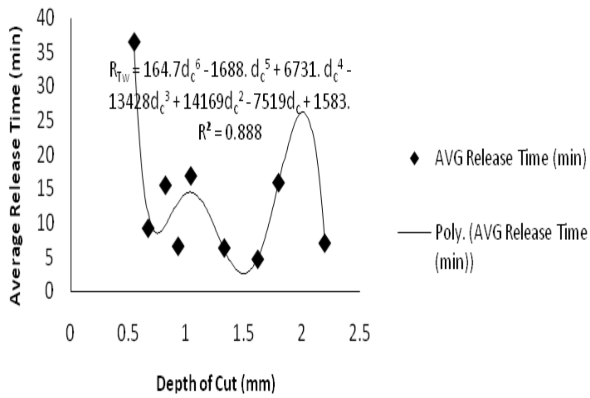

Figure 3: Optimum Polynomial Relationship between Release Time and Depth of Cut

$$R_{Tw} = 164.7 d_c^{\,6} - 1688 d_c^{\,5} + 6731 d_c^{\,4} - 13428 d_c^{\,3} + 14169 d_c^{\,2} - 7519 d_c + 1583 \qquad (8)$$

The selection of optimum complexity for a job is vital to attain the most favorable release time during metal cutting/shearing. As the complexity of a job is increased; the release time of the job also increases. Therefore, if the complexity or number of operations involved in the production of a job could be reduced or lower; then a reduced release time is attainable for better production efficiency and reduced charge cost.

With the assessment of job parameters on release time, the optimum R-square value of length of cut is 0.996, depth of cut is 0.888, and complexity of job is 0.979. These results show that there is a high correlation between release time and job parameters. As a result, the least release time is attainable when these parameters are carefully selected. However, production of jobs needs well-organized planning, the length of jobs is usually definite or left unaltered while depth of cut and complexity of job can be optimized to save some useful time. Depth of cut affects cutting tool, surface finish of work piece as well as release time, it requires appropriate selection to manage release time. Conversely, the complexity of jobs is the most flexible job parameter. The least number of processes is advised for metal shearing if some production time is to be saved.

4. Conclusion

Job complexity, depth of cut, and length of cut have comparative effects on the release time of jobs produced on lathe machine when linear, exponential, polynomial, logarithmic, and power regression analysis were utilized to examine correlation. Polynomial regression gives the optimum relationship between each of the job parameters and release time. Polynomial 3^{rd} order yielded the optimum correlation between release time and length of cut. Polynomial expressions for estimating release time at known values of either length of cut, depth of cut or complexity of job were formulated. Careful selection of optimum job complexity is therefore highly essential in order to have a reduced release time during machining of jobs on lathe machine.

References:

[1] Ahmad, N., Tanaka, T. and Saito, Y., Cutting parameters optimization and constraints investigation for turning process by GA with self-organizing adaptive penalty strategy, JSME International Journal - Series C, Vol. 49, No. 2, 2006 pp.293–300

[2] Edward M. Trent and Paul K. Wright, Metal Cutting Fourth Edition, Butterworth–Heinemann, 225 Wildwood Avenue, Woburn, MA, United States of America, 2000

[3] Helmi A. Youssef and Hassan El-Hofy, Machining Technology Machine Tools and Operations, CRC Press, Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300 Boca Raton, 2008, Pp. 59

[4] H.Ganesan, G.Mohankumar, K.Ganesan, K.Ramesh Kumar, Optimization of Machining Parameters in Turning Process Using Genetic Algorithm and Particle Swarm Optimization with Experimental Verification, International Journal of Engineering Science and Technology, Vol. 3, No. 2 2011, pp. 1091-1102

[5] Jitendra Verma, Pankaj Agrawal, Lokesh Bajpai, Turning Parameter Optimization for Surface Roughness of ASTM A242 Type-1 Alloys Steel by Taguchi Method, International Journal of Advances in Engineering & Technology, Vol. 3, No.1, 2012, pp. 255-261

[6] Jun Sun and Jane W.S. Liu, Bounding Completion Times of Jobs with Arbitrary Release Times and Variable Execution Times. Appeared in the Proceedings of 17th IEEE Real-Time Systems Symposium, Dec. 1996, Washington, DC

[7] Omar Bataineh and Doraid Dalalah, Strategy for optimizing cutting parameters in the dry turning of 6061-T6 aluminum alloy based on design of experiments and the generalized pattern search algorithm, International Journal of Machining and Machinability of Materials, Vol. 7, No. 1/2, 2010

[8] O. O. Ojo, T. I. Ogedengbe, B. Kareem, Effect of Cutting Conditions on Release Time of Jobs Using Lathe Machine, International Journal of Engineering Innovation and Management Vol. 2, No.3 2012, pp. 59-66

[9] Shutong XIE, Yinbiao GUO, Intelligent Selection of Machining Parameters in Multi-pass Turnings Using a GA-based Approach, Journal of Computational Information Systems, Vol. 7, No. 5, 2011, pp. 1714-1721

[10] Suleiman Abdulkareem, Usman Jibrin Rumah and Apasi Adaokoma, Optimizing Machining Parameters during Turning Process, International Journal of Integrated Engineering, Vol. 3, No. 1 2011, pp. 23-27

[11] V. Suresh Babu1, S. Sriram Kumar, R. V. Murali3 and M. Madhava Rao, Investigation and validation of optimal cutting parameters for least surface roughness in EN24 with response surface method, International Journal of Engineering, Science and Technology, Vol. 3, No. 6, 2011, pp. 146-160

[12] Viktor P. Astakhov, Tribology of Metal Cutting, International Journal of Machining and Machinability of Materials, Vol. 2, No. 3, 2007, pp. 309-315

[13] Y.S. Liao, H.M. Lin, Mechanism of minimum quantity lubrication in high-speed milling of hardened steel, International Journal of Machine Tools & Manufacture 47, 2007. Pp. 1660–1666