EFFECT OF CUTTING CONDITIONS ON RELEASE TIME OF JOBS USING LATHE MACHINE

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Abstract: Non-coolant and cutting fluid applications are the principal cutting conditions examined with respect to release time of jobs produced on lathe machine. Dry cutting condition generates heat in industrial manufacturing whereas the heat generated during machining is apparently reduced by lubrication or cooling. Thus, coolant reduces external friction and, to a lesser extent, lowers internal friction; the effect of reduction in heat on release time of jobs is yet to be practically proven or known. This paper experimentally studied the effects of cutting conditions on the release time of jobs produced on lathe machine. Feed rate of 0.068, 0.094, and 0.117mm/rev while spindle speed of 300, 400 and 550 rev/min were employed in the practical assessment of cutting conditions on release time of nine different jobs on lathe machine. The results of dry and wet conditions were compared graphically and were statistically analyzed by paired t-test. It was acknowledged that cutting fluid or cutting condition has no significant effect on the release time of jobs produced on lathe.

Key-Words: *release time, lathe machine, cutting conditions*

1. Introduction

The assessment of cutting conditions (dry and wet cutting conditions) on release time needs considerable evaluation in order to know the productive time that could be saved for further machining or production purpose. Cutting fluids applied in the machining process act as cooling and lubricating agents [15]. By utilizing a high-pressure fluid jet, it is possible to significantly decrease cutting zone temperatures, while extending tool life; in certain instances by less than 200%, operating with lower cutting forces because of the improved frictional conditions between tool/chip interface, with an attendant reduction in machining-induced vibration levels [2]. All of these advantages will improve the machined surface texture and offer better and more consistent dimensional accuracy, by a reduction in component process variability [4].

Today's cutting fluids are special blends of chemical additives, lubricants and water formulated to meet the performance demands of the metalworking industry [10]. Cutting fluid can be expensive and represents a biological and environmental hazard that requires proper recycling and disposal, thus adding to the cost of the machining operation. For these reasons dry cutting or dry machining has become an increasingly important approach; in dry machining, no coolant or lubricant is used [5]. Though, the extent of stresses and pressure on cutting tools is greatly determined by the cutting condition employed in cutting [8]. However, detection of cutting tool condition is essential for faultless machining in flexible manufacturing systems (FMS) [13]. Industries are looking for ways to reduce the amount of lubricants in metal removing operations due to the ecological, economical and most importantly occupational pressure [9].

Coolant has a direct influence on the manufacturing

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economics [7]. The capability of cooling is characterized by tool life and tool wear [3]. Surprisingly, it was found that metal working fluids represent a significant part of the manufacturing costs. Just two decades ago, metal working fluids accounted for less than 3% of the cost of most machining processes [14]. Times have changed and today metal working fluids account for up to 15% of a shop production cost [4], while some European automotive companies reported 16.9% [4]. Therefore, the selection of cutting conditions is absolutely necessary in a machining process [6]. This is essential to either save the life of the tool, or to save some cost of production.

For a machining process such as turning, the cutting conditions play an important role in the efficient use of a machine tool [12]. Since the cost of turning on lathe machines is sensitive to the cutting conditions. Also, since cutting conditions have an influence on reducing the production cost and deciding the quality of a final product the determination of optimal cutting parameters such as cutting speed, feed rate, depth of cut and tool geometry is one of vital modules in process planning of metal parts [1].

Most reported studies tried to improve the performance through searching for the optimal cutting conditions (such as cutting speed and depth of cut), which satisfy some measure(s) of performance given a set of practical constraints [11]; without considering the assessment of cutting conditions on production time. This research work measures the practical and realistic assessment of cutting conditions (dry and wet conditions) on release time. Release time of jobs is essential in production to assess productivity rate and measure the cost associated with production.

2. Method

A practical method of approach was employed in investigating the effects of cutting conditions on release time of jobs produced on lathe machine. The methods could be summarized under these categories:

i. Experiment planning
ii. Production of the same jobs by dry cutting and wet cutting methods with the same cutting parameters (measurement of release times from the two methods)
iii. Analysis of the release time graphically and using Paired T-test

2.1 Experiment Planning

The cutting conditions on which investigation is based are dry and wet machining states; therefore, all the pertinent factors such as cutting tool, work piece, cutting fluid, and lathe machine required for the research are considered in the experiment planning. Coolant or cutting fluid selection, the category of jobs to be produced and the number of jobs required for the investigation of cutting conditions on release time were carefully planned. The cutting fluid selection was based on cooling effect and availability. Water soluble fluid was planned for the experiment. Nine different jobs were selected to be machined under the available cutting conditions and they include: studs; plain locators; tensile test specimens; bolts; pulleys; screw locator with handles; sleeves; pin punches; and chuck keys. Each of these jobs was produced nine times under the conditions of dry and wet cuttings with the same cutting or machine parameters that are spindle speed and feed rate. Low parameter range was adopted for this research in order to accommodate variation in depth of cut during dry cutting condition. Three of each parameter was selected. Feed rate of 0.068, 0.094 and 0.117mm/rev; and spindle speed of 300, 400 and 550 rev/min were the actual parameters planned for the research since they were among the low range parameters on the lathe machine selected for the research.

2.2 Production of Jobs

The production of nine different jobs was performed under the conditions of dry and wet machining with constant feed rate and spindle speed. However, stop watch was employed to take the time reading at each production. Automatic gear lever on the lathe machine was employed during production in order to generate uniform and constant tool travel.

2.3 Analysis of Data

The results obtained during the practical experimentation on lathe machine were taken for analysis. The release times produced during the conditions of dry cutting as well as that of dry cutting were analyzed. Tables 1-9 show the results obtained during dry and wet machining conditions for studs, plain locators, tensile test specimens, bolts, pulleys, screw locator with handles, sleeves, pin punches and chuck keys.

Table 1: Production of Studs

Jobs	Average Depth of Cut (mm)	Spindle Speed (rev/min)	Feed Rate (mm/rev)	Length of Cut (mm)	Release Time without coolant application(min)	Release Time with coolant application(min)
1	1.33	550	0.068	210	5.46	5.67
2	1.33	400	0.068	210	7.97	7.96
3	1.33	300	0.068	210	10.54	10.26
4	1.33	550	0.094	210	4.19	4.13
5	1.33	400	0.094	210	5.87	5.87
6	1.33	300	0.094	210	7.61	7.66
7	1.33	550	0.117	210	3.48	4.64
8	1.33	400	0.117	210	4.66	4.51
9	1.33	300	0.117	210	5.79	5.99

Table 2: Production of Plain Locators

Jobs	Average Depth of Cut (mm)	Spindle Speed (rev/min)	Feed Rate (mm/rev)	Length of Cut (mm)	Release Time without coolant application(min)	Release Time with coolant application(min)
1	1.62	400	0.068	190	5.80	5.83
2	1.62	400	0.094	190	4.34	4.32
3	1.62	400	0.117	190	3.57	3.61
4	1.62	550	0.068	190	4.21	4.22
5	1.62	550	0.094	190	3.24	3.18
6	1.62	550	0.117	190	2.66	2.64
7	1.62	300	0.068	190	7.54	7.54
8	1.62	300	0.094	190	5.68	5.70
9	1.62	300	0.117	190	4.73	4.76

Table 3: Production of Tensile Test Specimens

Jobs	Average Depth of Cut (mm)	Spindle Speed (rev/min)	Feed Rate (mm/rev)	Length of Cut (mm)	Release Time without coolant application(min)	Release Time with coolant application(min)
1	0.93	400	0.068	213	8.41	8.14
2	0.93	400	0.094	213	5.90	5.92
3	0.93	400	0.117	213	5.04	5.12
4	0.93	550	0.068	213	5.94	5.97
5	0.93	550	0.094	213	4.53	4.32
6	0.93	550	0.117	213	3.58	3.64
7	0.93	300	0.068	213	11.12	11.19
8	0.93	300	0.094	213	7.88	8.03
9	0.93	300	0.117	213	6.42	6.50

Table 4: Production of Bolts

Jobs	Average Depth of Cut (mm)	Spindle Speed (rev/min)	Feed Rate (mm/rev)	Length of Cut (mm)	Release Time without coolant application(min)	Release Time with coolant application(min)
1	0.67	400	0.068	288.75	11.85	11.89
2	0.67	400	0.094	288.75	8.49	8.57
3	0.67	400	0.117	288.75	7.09	7.04
4	0.67	550	0.068	288.75	8.34	8.35
5	0.67	550	0.094	288.75	6.21	6.26
6	0.67	550	0.117	288.75	5.07	5.02
7	0.67	300	0.068	288.75	15.13	15.13
8	0.67	300	0.094	288.75	11.06	11.12
9	0.67	300	0.117	288.75	9.21	9.32

Table 5: Production of Pulleys

Jobs	Average Depth of Cut (mm)	Spindle Speed (rev/min)	Feed Rate (mm/rev)	Length of Cut (mm)	Release Time without coolant application(min)	Release Time with coolant application(min)
1	4.93	300	0.068	230	11.94	10.86
2	4.93	300	0.094	230	8.65	8.65
3	4.93	300	0.117	230	7.30	7.69
4	4.93	400	0.068	230	7.82	8.28
5	4.93	400	0.094	230	6.50	6.46
6	4.93	400	0.117	230	5.48	5.36
7	4.93	550	0.068	230	6.67	6.92
8	4.93	550	0.094	230	4.88	4.94
9	4.93	550	0.117	230	3.84	3.91

Table 6: Production of Screw Locator with handles

Jobs	Average Depth of Cut (mm)	Spindle Speed (rev/min)	Feed Rate (mm/rev)	Length of Cut (mm)	Release Time without coolant application(min)	Release Time with coolant application(min)
1	1.04	300	0.068	592	27.85	27.88
2	1.04	300	0.094	592	20.80	20.81
3	1.04	300	0.117	592	16.43	17.29
4	1.04	400	0.068	592	20.90	20.88
5	1.04	400	0.094	592	15.38	15.26
6	1.04	400	0.117	592	12.37	12.43
7	1.04	550	0.068	592	16.72	17.12
8	1.04	550	0.094	592	11.27	11.21
9	1.04	550	0.117	592	9.02	9.02

Table 7: Production of Sleeves

Jobs	Average Depth of Cut (mm)	Spindle Speed (rev/min)	Feed Rate (mm/rev)	Length of Cut (mm)	Release Time without coolant application(min)	Release Time with coolant application(min)
1	3.80	300	0.068	531.2	27.80	27.62
2	3.80	300	0.094	531.2	19.80	19.76
3	3.80	300	0.117	531.2	15.46	16.30
4	3.80	400	0.068	531.2	19.76	19.80
5	3.80	400	0.094	531.2	14.40	14.52
6	3.80	400	0.117	531.2	11.67	10.66
7	3.80	550	0.068	531.2	14.36	15.51
8	3.80	550	0.094	531.2	11.72	10.90
9	3.80	550	0.117	531.2	8.85	8.89

Table 8: Production of Pin Punches

Jobs	Average Depth of Cut (mm)	Spindle Speed (rev/min)	Feed Rate (mm/rev)	Length of Cut (mm)	Release Time without coolant application(min)	Release Time with coolant application(min)
1	0.82	400	0.068	491	18.7	19.85
2	0.82	400	0.094	491	13.51	13.73
3	0.82	400	0.117	491	11.33	11.56
4	0.82	550	0.068	491	13.62	13.79
5	0.82	550	0.094	491	10.44	10.52
6	0.82	550	0.117	491	8.55	8.43
7	0.82	300	0.068	491	26.93	29.93
8	0.82	300	0.094	491	19.72	19.36
9	0.82	300	0.117	491	15.27	15.33

Table 9: Production of Chuck Keys

Jobs	Average Depth of Cut (mm)	Spindle Speed (rev/min)	Feed Rate (mm/rev)	Length of Cut (mm)	Release Time without coolant application(min)	Release Time with coolant application(min)
1	0.55	300	0.068	1249	61.79	61.82
2	0.55	300	0.094	1249	42.20	44.95
3	0.55	300	0.117	1249	36.22	36.10
4	0.55	400	0.068	1249	46.70	46.54
5	0.55	400	0.094	1249	33.92	33.84
6	0.55	400	0.117	1249	27.38	27.36
7	0.55	550	0.068	1249	33.88	33.86
8	0.55	550	0.094	1249	24.46	24.46
9	0.55	550	0.117	1249	19.94	19.88

3. Result

The effect of cutting fluid or cutting conditions on the release time of jobs was investigated using the release times of dry and wet cutting processes of different jobs produced on lathe machine. The data obtained from the experimentation were analyzed. Table 11 shows the different and average release times obtained during wet and dry metal shearing operations on lathe. Figure 1 also depicts the effect of coolant application on release time and it apparently signifies that there is no difference between the two sets of release time. The figure shows direct comparison of release time of jobs under the application of coolant as well as when no cutting fluid is applied. However, statistical analysis of this result was required to further corroborate the result.

However, the differences between the release times of the jobs produced by wet and dry machining processes look to be insignificant as shown in table 11 and figure 1; but further investigation was required to validate this upshot. Paired t-test was used to validate or confirm for significant difference between the two release times.

Table 11: Average Release Time of Wet and Dry Machined Jobs under the Application of the same Cutting Parameters

S/N	Jobs Produced	Average Release Time with Coolant Application (min)	Average Release Time without Coolant Application (min)
1	Stud	6.30	6.17
2	Plain Locator	4.64	4.64
3	Tensile Test Specimen	6.54	6.54
4	Bolt	9.19	9.16
5	Pulley	7.01	7.01
6	Screw Locator with Handle	16.88	16.75
7	Sleeve	15.88	15.98
8	Pin Punch	15.50	15.34
9	Chuck Key	36.53	36.28

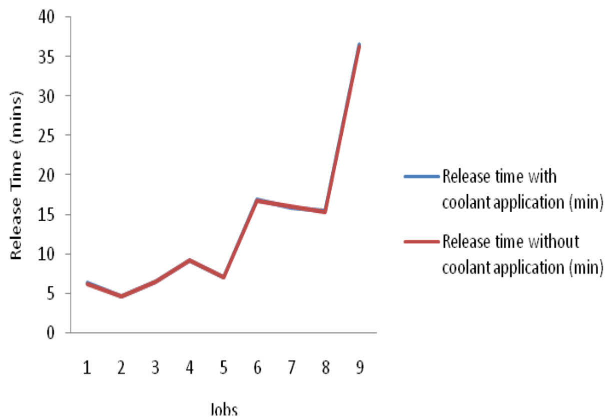

Figure 1: Effect of Coolant Application on Release time of Jobs

Table 12: Paired Samples Statistics of Release Times

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	R_{To}	13.0967	9	9.86907	3.28969
	R_{Tw}	13.1633	9	9.93684	3.31228

R_{To} is release time of job produced under the application of no coolant and R_{Tw} is release time of job produced under the application of coolant. From the paired samples statistics of release times (table 12), the standard deviations of the two set of release times are extremely close with 9.86907 and 9.93684 respectively. Also, the standard error means of the release times are very close with 3.28969 and 3.31228 respectively. These show that there is infinitesimal difference in the release times of jobs produced from both methods. This insignificant difference could be as a result of human error in taking release times from the stop watch used in obtaining readings. A further investigation was required to reinforce the deduction obtained from paired samples statistics of both release times.

Also, paired samples correlations (table 13) of both release times of jobs were examined to determine the effect of coolant on release time of jobs produced on lathe machine. The correlation value of both release time of jobs produced on lathe was 1.00 and the significant difference in release time of jobs was 0.000. The significant difference in release time is 0.0 because the machine parameters and job parameters employed in cutting are the same. Also, the power transmitted to the spindle is the same at each cutting despite the application of coolant to the cutting process. This confirms that there is no difference in the release time of jobs produced on lathe machine.

The last test was paired samples test of the two set of release times. However, in the table of paired samples test (table 14), the paired differences in mean, standard deviation and standard error mean were below unity. Also, 2-tailed

Table 13: Paired Samples Correlations of Release Times

		N	Correlation	Sig.
Pair 1	R_{To} & R_{Tw}	9	1.000	0.000

Table 14: Paired Samples Test of Release Times

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% conf. Inter. of the diff.				
					Lower	Upper			
Pair 1	R_{To} & R_{Tw}	-0.667	0.108	0.036	-0.1495	0.161	-1.86	8	0.1

significant difference of the release times was 0.1. This further validates that there is no significant difference in release times of jobs produced by both wet and dry lathe production methods.

4. Conclusion

Finally, it was generally established by machining experimentation that the release time of jobs has nothing to do with the application of lubricant, coolant or cutting fluids during the metal shearing or cutting operations on lathe machine. The investigation of cutting fluid on the release time of jobs on lathe machine was carried out using mild steel work pieces and HSS cutting tool with the application of water soluble cutting fluid. The results of dry metal cutting data were compared with that of wet metal cutting records when the same cutting parameters were selected for production. This provided the most excellent assessment of cutting fluid on the release time of jobs. The data obtained from machining were statistically analyzed by paired t-test and it was affirmed that cutting fluid has no significant effect on the release time of machined jobs on lathe. The primary function of a cutting fluid was to cool and lubricate both the work piece and cutting tool's edge. In addition, one could add the improvement of machined surface quality and an increase in tool life but not necessary the improvement of release time of jobs produced on lathe machine.

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