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Research Paper

A FINITE ELEMENT ANALYSIS OF ORTHOGONAL MACHINING USING DIFFERENT TOOL MATERIAL AND EDGE GEOMETRIES

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This work influences the process parameters and the motivated that machining process is widely used in the industries and the experimental procedure with the hit and trial methods are still the need of the optimization. The main of the study is to conduct two dimensional finite element models for the orthogonal cutting operation with different commercial codes. Finally observation of the different result will be done. The variable are divided into the two different categories, first the variable related to the work piece and second one is the process parameters related with the cutting tools. And the variable related to the finite element method. Cutting condition are changed alternately changing in the rake angle, also there is change in the velocity, variable are optimize for the different rake angle having change in the velocity for r the different cutting tool material, the study is conducted for the different cutting tool, comparatively study is done for the three different cutting tool material, finally three different model equation are prepared for the three cutting tool material for the optimization of stresses and the total deformation.

Keywords: FEM, Explicit dynamics, Cutting tool material, Numerical simulation

INTRODUCTION

Since after the industrial revolution, modern economics with the force has driven manufacturing technology, with the help of metal cutting process many machinery and the structure which permitted human comfort in every aspect of the life. In today's global era manufacturing become more sophisticated, many of the manufacturing process are design on the basis of the experience and on the institution. Manufacturing process are basically divided into two distinct classes, first is the deformation process which produce the required shape, having necessary mechanical properties, and second on is the plastic deformation process in this process the material is moved and finally its volume is conserved. In the machining process, by the removal of the material of the selected area required shape are produced. Many of the machining process are driven by straining a

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particular region of the work piece , by the relative motion of the work piece and the tool. In most of the machining process mechanical energy is used as input, some of the machining process is employ by the electrical, chemical and the thermal energy.

LITERATURE REVIEW

Many production technique are used in industry for converting the blocks of metal into desired shape and size with surface quality and dimension accuracy, Machining is one of them. In machining shaping operation formation of metal chip occurs. History of metal cutting studies is old as approx 100 years past. In early, metal cutting process started with Cocquilhat to remove a given volume of material in drilling. Firstly, how to chips are formed was introduced by Tresca (1873). Simplest and most widely used model for metal cutting was developed by Emest and Merchant in 1941. Later, Lee and Shaffer in 1951 and kobayashi and Thomsen in 1962 also be proceeds the study of Emest and Merchant. The first parallel-sided shear zone model of chip formation for predictive machining theory was introduced by Oxley and welsh in 1963. Books written by Amerago (1969), Boothroyed (1981), Shaw (1984) and Trent (2000) are most widely used. Text-books written by Kalpakjian *et al.* (2006) and DeGarmo *et al.* (1997) are for most general introductory knowledge for processes.

METHODOLOGY AND RESULTS

Design of experiment is technique developed to understand the behavior of the mechanical system. Data are collecting from the sets of the variable, and it can qualitatively explain the undergoing phenomenon. Hence it is well known that aim of any research is design the experiment with minimum number of the experiment and with this experiment collects maximum information as much as possible. Every experiment focuses on the major number of the factor which can directly affect the results of the experiment. And such types of factor can be detected by quantities which have major effect on the experiments outcomes. One of the most important concepts for identified such factor is to look after the experiment performed later or by theories. Example if one can know about the process undergoing is affected by the pressure maintain during the experiment, hence by knowing one can identified the minimum and the maximum value of the pressure presented in the experiment, so one can run an experiment by considering that values. In the Design of experiment can be design by the sets of factors and their levels, the value of factor and the level is decided by the operators. So many times with particular factor and the levels same experiment were repeated, these types of repeated experiment were known as replicate experiments.

Anova Analysis

Anova analysis is the method in stats use to differentiate between two or more mean, as the name from the definition is different it name should be Analysis of means rather than analysis of the variance, but the analyze variance inference the mean. There are different methods are used of Analysis the means but why anova analysis is best because of only one reason there are more and more complex types of problem were solved or analysis by the anova analysis. Second thing is the Anova analysis the most commonly used method for comparing the mean. And with the help of anova analysis it is very easy to understand the research.

Table 1: Design of Experiments and Value of Stress and Total Deformation

S. No.	Rake Angle	Cutting Speed m/s	Cutting Tool Material	Stress (Mpa)	Total Deformation
1	2.5	5000	T2	85699	74.605
2	2.5	7500	T2	42568	29188
3	2.5	10000	T2	29188	203.43
4	2.5	7500	M2	81951	0.541
5	2.5	5000	M2	13054	85.055
6	2.5	10000	M2	14180	370.91
7	2.5	10000	T%	2842.2	0.669
8	2.5	7500	T%	1646.2	198.71
9	2.5	5000	T%	1401.2	72.711
10	5	5000	M2	91387	31.298
11	5	7500	M2	44261	133.29
12	5	10000	M2	15615	31.298
13	5	7500	T%	2194.8	119.14
14	5	5000	T%	2156.9	280.48
15	5	10000	T%	1549.5	0.902
16	5	10000	T2	45377	0.799
17	5	7500	T2	59402	0.781
18	5	5000	T2	10409	37.32
19	7.5	5000	T%	1622	49.646
20	7.5	7500	T%	1843.1	223.18
21	7.5	10000	T%	1630.5	1.138
22	7.5	7500	T2	66747	1.015
23	7.5	5000	T2	12990	31.516
24	7.5	10000	T2	56526	1.059
25	7.5	10000	M2	86512	1.063
26	7.5	7500	M2	44297	161.22
27	7.5	5000	M2	11672	24.603

Table 2: Anova Analysis for Stress

Source	DF	Adj SS	Adj MS	F Value	P-Value
Model	11	14816404487	1346945862	1.92	0.12
Linear	4	11249309765	2812327441	4.01	0.021
Rake angle	1	7106450	7106450	0.01	0.921
Cutting speed	1	29463303	29463303	0.04	0.84
Cutting tool material	2	11212740012	560637006	7.99	0.004
Square	2	788439527	394219763	0.56	0.582
Rake angle*rake angle	1	2519770	2519770	0	0.953
Cutting speed*cutting speed	1	785919757	785919757	1.12	0.307
2-Way Interaction	5	2778655196	555731039	0.79	0.572
Rake angle*cutting speed	1	2474759326	2474759326	3.53	0.08
Rake angle*cutting tool material	2	252619369	126309685	0.18	0.837
Cutting speed *cutting tool material	2	51276500	25638250	0.04	0.964
Error	15	10528718692	701914579		
Total	**26**	**25345123179**			

Table 3: Anova Analysis for Total Deformation

Source	DF	Adj SS	Adj MS	F- Value	P-Value
Model	11	123900	11263.7	1.17	0.378
Linear	4	37760	9440	0.98	0.445
Rake angle	1	28001	28001	2.92	0.108
Cutting speed	1	321	320.6	0.03	0.857
Cutting tool material	2	9439	4719.3	0.49	0.621
Square	2	14454	7226.9	0.75	0.488
Rake angle*rake angle	1	3396	3395.6	0.35	0.561
Cutting speed*cutting speed	1	11058	11058.2	1.15	0.3
2-Way Interaction	5	71686	14337.3	1.5	0.249
Rake angle *cutting speed	1	16513	16512	1.72	0.209
Rake angle *cutting tool material	2	16705	8352.4	0.87	0.439
Cutting speed *cutting tool material	2	38469	19234.4	2.01	0.169
Error	15	143805	9587		
Total	**26**	**267706**			

Model Equation for Stress of Different Material

Stress (T2): 34451 - 19683 rake angle + 17.4 cutting speed + 104 rake angle*rake angle - 0.00183 cutting speed*cutting speed + 2.30 rake angle*cutting speed

Stress (M2): 26524 - 16050 rake angle + 16.0 cutting speed + 104 rake angle*rake angle - 0.00183 cutting speed*cutting speed + 2.30 rake angle*cutting speed

Stress (T%): - 5330 - 18323 rake angle + 16.0 cutting speed + 104 rake angle*rake angle - 0.00183 cutting speed*cutting speed + 2.30 rake angle*cutting speed

Model Equation for Total Deformation of Different Material

Total Deformation (T2): 324 - 23.0 rake angle + 0.1368 cutting speed + 3.81 rake angle*rake angle - 0.000007 cutting speed*cutting speed - 0.00594 rake angle*cutting speed

Total Deformation (M2): - 449 - 11.5 rake angle + 0.1502 cutting speed + 3.81 rake angle*rake angle - 0.000007 cutting speed*cutting speed- 0.00594 rake angle*cutting speed

Total Deformation (T%): - 196 + 6.6 rake angle + 0.1060 cutting speed + 3.81 rake angle*rake angle - 0.000007 cutting speed*cutting speed - 0.00594 rake angle*cutting speed

CONCLUSION

In this research finite element simulation and the optimization of the cutting process parameter had done using different cutting tool material. All 27 experiment design and analyzes into the response surface method and all this experiment were project into the simulation environment using ansys 14.5, a the process parameter rake angle, cutting speed and the cutting tool material are taken into the consideration as a input parameters. Following are the conclusion made from this research are given below

- In the first case the or anova analysis performed for the stresses, the value for the linear model is 0.021, which less 0.05 or minimum as compared to both other models, so that linear model in the stresses play major roles.
- In the linear model for the stresses, the P value of the cutting tool material is 0.04, which is less than 0.05 or into the confidence interval, it means the cutting tool material in the linear model is the parameter by virtue of which the stresses are getting effected or by changing the value of the cutting tool material the stresses will get deflected or the quality of the product can be changed by changing the value of cutting tool material in the linear model.
- In the two way interaction model rake angle*cutting tool material is parameter having the P value 0.080 which nearly to the 0.05, it means in the two way interaction model this is only parameter, by changing the value of which, stresses were get deflected. Or quality of the product in two way interaction can be change by changing the value of rake angle*cutting tool material.
- The value for the R-sq is 58.46 which show that there is strong relationship between the input and the output variables.
- Finally three different model equation were made for the three different cutting tool material for the stresses, now for further research, researcher only have to use this equation or industry operator can use this equation for calculating the value of stress.

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