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# REVIEW OF TOOL WEAR ESTIMATION USING RESPONSE SURFACE METHODOLOGY

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Abstract- *Tool wear is the progressive loss of material from the surface of tool in the form of very small metallic particles. From decade tool wear rate mostly used as to predict the tool lift. However, tool wear weight assesses real damage to the tool and is also one of the criteria to predict tool life. This paper discusses the development of first & second order mathematical model to predict the tool wear rate and the validation of the result by experiment using Response surface methodology. There are many designs are available to optimize the response for example Taguchi design, Response surface design, Mixture design & factorial design. Each design method has different accuracy, complexity, no of run & operational machining cost. However, the response surface methodology (RSM) takes into account the simultaneous variation of the cutting variables and predicts the response very accurate as compare to other available method. This paper reviews the best design method by considering different factors.*

***Keywords***— surface roughness, tool wear, tool life, RSM, process parameter

## 1. INTRODUCTION

In manufacturing technology machining process are very common. This type of operation is used in every mechanical part because it is frequent used and more efficient than conventional process. In metal cutting operation tool wear is most important consideration which is affect surface quality, cost, productivity etc. Different method to find out tool wear rate, in this we were select response surface methodology .Response surface method was introduced by G.S.P Box and K.B Wilson in 1951. Then Box and Wilson suggested that to use first degree polynomial model for to approximate the response variable. After first ordered model for developing second ordered model scientist and engineers were study about central composite design and three level design is introduced by Box and Behnken in1960.In this method collection of mathematical and statistical method use for modeling optimization of different engineering problem.

### 1.1 Tool wear

Tool wear has a large influence on the economics of the machining operations. Prediction of tool wear is complex because of the complexity of machining system. Tool wear in cutting process is produced by the contact and relative sliding between the cutting tool and the work piece and between the cutting tool and the chip under the extreme conditions of Cutting area; temperature at the cutting edge can exceed 1000 °C. Thus, knowledge of tool wear mechanisms and capability of predicting tool life are important and necessary in metal cutting. Any element changing contact conditions in cutting

Area affects tool wear these elements come from the whole machining system comprising work piece, tool, interface and machine tool. .In metal cutting three basic causes have been suggested for tool wear as follows.

**Abrasion**: Tool material is removed away by the mechanical action of hard particles in the contact interface passing over the tool face. These hard particles may be hard constituents in the work material, fragments of the hard tool material removed in some way or highly strain-hardened fragments of an unstable built-up edge.

**Adhesive:** Adhesive wear is caused by the formation and fracture of welded asperity junctions between the cutting tool and the work piece.

**Diffusion:** Diffusion wear takes place when atoms move from the tool material to the work piece material because of the concentration difference. The rate of diffusion increases exponentially with the increase of temperature.

 

## 2. LITERATURE REVIEW

**1]. Lijo paul, et al [1]** The paper was research on new non-conventional method for meet the requirement of machining of conducting material in industry is electro discharge machining and electro chemical machining. (EDM and ECM). Response surface modeling were used for optimize the process parameter which is effect on ECDM. On experiment, the micromachining of borosilicate glass is done using ECDM to produce blind hole. Material removal rate is increases with concentration of electrolyte, voltage, and duty factor. With increase in voltage tool wear rate is increase and then heat is dissipated through tool material and then works piece or electrolyte.

2] **JBSeddon et al [2],** The paper was research on a first ordered and second ordered model for tool life of micro milling steel tool AISI d2 62 HRC. Central composite design is used for developing this model which is in term of cutting speed, feed, and depth of cut in response surface methodology. In tool life testing the combination of factorial design and response surface methodology are very useful. Cutting speed is main factor affecting on tool life followed feed rate and depth of cut which is significant in first ordered and second ordered model . With increase feed, speed, and depth of cut decrease the life of tool. More effective prediction of response was interaction with all factors by second ordered model. So this model is very useful for determine maximum possible tool life at specific material removal rate with help of contour of tool life were constructed in planes.

3**]. Cj Rao et al [3],** They was research on to determine best process parameters used to forecast cutting force, surface finish and tool life. Aluminium as work material and tungsten carbide as a tool material was used to perform the experiment. At different value of cutting speed, feed and depth of cut at particular condition tool life, cutting force, and surface finish were calculated. With increase in cutting speed, material removal rate and cutting force a tool life is decrease. MATLAB are used for calculate the different parameter like speed, feed, depth of cut etc. This obtained parameter will give good surface finish and better tool life.

4]. **K kant havel et al [4],** In casting process shrinkage defect are mostly produced. So remove this defect by considering different parameter in Taguchi method for doe. For analysis ANOVA are used in this paper. Second ordered mathematical model are generate by response surface methodology .on design of experiment the shrinkage defect is on actual production line of the ball valve's flange. The dimension of shrinkage cavity are affecting by thickness of chill. In formation of shrinkage cavity contribution of chill thickness is 92.68% is determined by statistical analysis. Chill thickness is main parameter over pouring time, pouring temperature and chill distance is effect on shrinkage defect .future scope in this direction is to determine other chill material to minimize shrinkage defect.

5]. **Varprasad Bh et al [5],** present day the metal cutting industry is concentrated on quality and productivity of machine tool during turning. So in present work to develop model and predict tool wear of aini d3 hardened steel using response surface methodology. Different parameter like feed, speed and depth of cut are investigated using counter plots and surface plots. ANOVA is used for check mathematical model. Flank wear is considered for AINI d3 steel tool. On the experiment optimum process parameter like speed, feed and depth of cut to achieve lower tool wear rate to 0.148mm. Depth of cut is main parameter considered in flank wear, speed and feed is little effect on total variation.

6]. **Nexhat Qehaja et al [6],** Surface quality during machining is generally measured as a surface roughness and it is caused by many machining parameter like speed, feed, depth of cut, rake angle, cutting edge angle, nose radius, cutting time. In this paper surface roughness model were developed by response surface methodology to investigating this process parameter. RSM is most useful technique for relationship between output variable and input parameter and it is time and cost saving technique. On study and analysis in this paper feed rate is most influencing cutting parameter followed by nose radius and cutting time.

## 3. RESPONSE SURFACE METHOD

Response surface method was introduced by G.S.P box and K.B Wilson in 1951. The main idea of RSM is to use a sequence of design experiment to obtain an optimal result. Mathematical model can be developed by use of various modelling method for define the desired output variables to specify relationship between output parameter and input variables at minimum number of experiment. Response surface methodology is useful to solve this problem. RSM shows functional relationship between independent variable and response variable. RSM is most helpful to construct model which provides a mathematical representation for most of the statistical based investigation. The application of RSM in design optimization aimed at reducing cost of expensive method of analysis

 

## 4. TAGUCHI METHOD

Calculates the selected response characteristic for each factor level combination For each factor, calculates the average of the response characteristic at each level of the factor. For example, you selected S/N ratios and your design includes factor A, which has 2 levels (1 and 2) and 4 measurements at each level. Calculates the mean of the 4 S/N ratios at level 1 and the mean of the other 4 S/N ratios at level 2. For each factor, calculates the delta value, which is the absolute value of the average response characteristic at the low level subtracted from the average response characteristic at the high level. If the factor has more than two levels, subtracts the level with the lowest average response characteristic from the level with the highest average response characteristic to obtain the delta vale. Calculates the rank, which is the order of the delta values from high to low. The factor with the highest delta value is assigned rank 1; the factor with the next highest delta value is assigned rank 2, and so on.

## 5. FACTORIIAL METHOD

Minitab uses two methods to analyze standard deviations (s) of the repeat or replicate measurements: Method S and Method M. Both methods are based on a linear model with a log link function: ln(s) = Ag, where A is the design matrix and g is a vector of parameters to be estimated. One advantage to using the log link function is the fitted values are always positive. Method S uses least squares estimation and method M uses maximum likelihood estimation (MLE). The methods produce equivalent results in the saturated model, when the number of parameters equals the number of data points. For the least squares estimation, uses weighted least squares regression. If there are an equal number of repeats or replicates, the weights are equal.

## 6. WHY SELECT RSM ?

| **Factor** | **RSM** | **Taguchi** |
|---|---|---|
| Accuracy | High | Low |
| Complexity | Easy | Hard |
| No of run | Less | More |
| Cost | Less | More |
| Time | Less | More |
| No of runs | Less | More |

I. RSM gives relationship between process parameter but in Taguchi and Factorial method factor interaction is not accounted.
II. Factorial method is impossible to conduct due to increasing number of factor for model development as comparison with Response Surface Method.
III. Cost, time and labour incentive are also high in factorial method so RSM is best for develop mathematical model as comparison with other DOE method.
IV. The RSM technique seems to be more promising in predicting the response via mathematical modelling over the Taguchi technique,.[11]

## 7. CONCLUSION

RSM gives very low average error towards experimental validation and mathematical model. It will easily help to determine optimum condition because desirability criterion available in RSM. Relationship between interaction and square term of parameter are more clearly predicted in RSM. Taguchi method is generally used in linear term only. RSM can help to visualize effect of parameter on responses in entire range more specified while in Taguchi method gives

 

average value of response at given level of parameter. On study of all research paper most significant process parameter which is effect on machining process is speed, feed, depth of cut and nose radius. Also response surface method is best as compare to other method because it is easiest and time saving and cost saving technique.

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