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EFFECT OF UNCERTAINTY ON PREDICTION OF TOOL LIFE FOR MILLING ULTRAHIGH STRENGTH STEEL

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Introduction: Tool wear can affect surface quality of the work-piece and frequent tool changing leads to low machining efficiency. Estimation of tool life is thus an essential aspect considered in evaluating the performance of milling ultrahigh strength steel. The traditional method is to develop model of tool life using model-based approach. These models assume that tool life is deterministic [1]. Unfortunately, inherent uncertainties exist in the empirical constants. And tool life is generally considered a stochastic process because variation is inherent in every cutting process [2]. This work thus focuses on the effects of uncertainties of milling variables and contents of model on prediction.

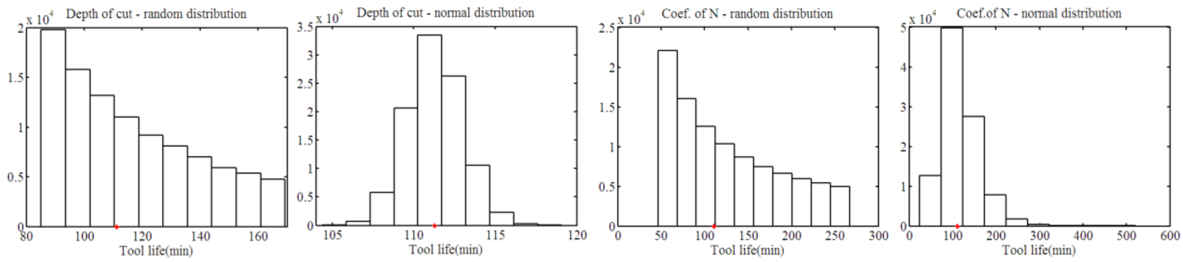
Method: The main milling parameters are depth of cut d_p (mm), width of cut d_e (mm), feed rate f (mm/min) and spindle speed N (rpm). Expression of tool life is obtained by least square method from previous work of authors [3].

$$\mathrm{T} = \left(\frac{19650}{Nf^{0.25}dp^{0.15}de^{0.1}}\right)^5 \tag{1}$$

Given point is [1100, 450, 3.5, 9.5] while T=111.2810. The number of trails is 10^5. Variation of depth of cut d_p is due to non-uniformity of cast iron work-pieces. In this work, depth of cut d_p is investigated and assumed following random distribution (The range is [2, 5]) and normal distribution (μ_{dp}=3.5, σ_{dp}=0.005) respectively while other ones are determined.

Uncertainty exists in empirical relationship due to the unknown factors. In addition, spindle speed N is most significant effect on tool life [2]. The coefficient of spindle speed N is thus investigated in this work. Coefficient of spindle speed N is assumed following normal distribution (μ_{coeN}=-1, σ_{coeN}=0.0001) and random distribution (The range is [-1.025, 1.025]).

Results and discussion: Effects of uncertainties of milling variable (depth of cut d_p) and constant (coefficent of spindle speed N) on prediction of tool life are shown in Figure 1. We can see that predicted values of tool life are not following random distribution for depth of cut d_p and coefficient of spindle speed N following random distribution (Figure 1 a) and Figure 1 c)). It shows a non symmetric distribution with a rather heavy right 'tail'. Tool lives are longer than life obtained by determined model (red point in Figure 1). However, for normal distribution (Figure 1 b) and Figure 1 d)), tool life is still following normal-liking distribution. It isn't quite different from distributions of the variable d_p and the constant of N.



a) b) c) d)

Fig. 1 Histograms of tool life for uncertianties of the variable d_p and the constant of N

Conclusion: Effects of uncertainties of milling variables and contents in exponential model developed by least square method on prediction are investigated in this work. Results show the uncertainties of milling variables and contents following random distribution obviously affect prediction. However, the uncertainties of milling variables and contents following normal distribution give rise to the almost same distribution of prediction of tool life. Therefore, it is better to avoid variables and constants following random distribution for developing exponential model. This is of course other topic.

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