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Research Article

Fuzzy Inference System Modeling to Predict Performance of H_3BO_3 (nm) and Tio_2 (µm) as Lubricants in Machining

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Abstract

Now a day's turning is a widely used metal removal process in manufacturing industry that involves generation of high cutting forces and temperature. Lubrication becomes critical to minimize the effects of these forces and temperature on cutting tool and workpiece. Development of lubricants that are ecofriendly is acquiring importance. For this a specific study on the application of MQL (Minimum Quantity Lubricants) as lubricating oil in turning operation is going on. In the present work a specific study on the application of nanosolid boric acid with titanium dioxide (µm) suspended in lubricating oil in turning of AISI 1040 steel with carbide tool. SAE-40 is taken as base lubricants and boric acid solid lubricant of (50, 60 80, 538nm) particlses size and titanium dioxide (100µm) with different weight percentages taken as suspensions. Variations in cutting forces, tool temperatures and surface roughness are studied For this Boric acid nano particles were prepared by using High Energy Ball Milling. Ball milling which was carried out for the total duration of 15 hours. The sample was taken out after every 5 hours of milling for characterizing. Thenano structured boric acid particle size measurement was done by X-Ray Diffractometer which was supported by the XRD Scherer's formula. It was found that the particle size got reduced from 538nm to 63nm for the period of 15 hrs. In present work, the obtained results were predicted by using Mamdani Fuzzy Inference System Modeling. For the prediction of output parameters of the lathe machining process is modeled using two input variable parameters such as particle size of boric acid (nm) and weight percentage of titanium dioxide (µm). Then the model predictions are compared with a set of reliable experimental data available, and it is found So that proposed fuzzy model gives the results which are well in agreement with experimental results.

Keywords: *modeling, prediction, lubricants, XRD.*

1. Introduction

In the present work, an attempt has been made to modify the micro sized H_3BO_3 powder into nanosized H_3BO_3 powder by using High Energy Ball Mill, and characterized for its crystallite size by using X.R.D. In the present work, machining experiments were conducted to verify the performance of nano-sized H_3BO_3 particles with different weight percentages of TiO_2 (µm)particle suspensions in SAE40 oil. It was found that the performance of this mixture is enhanced in terms of reduction in forces, tool temperature and surface roughness. An attempt is made to develop Mamdanifuzzy inference method for the prediction of output parameters such as the cutting force, the thrust force, and the feed force, the temperature, the surface roughness of the lathe machining process is modeled using two input parameters such as particle size of Boric Acid (50, 60, 80, 538nm) and weight percentage (1%, 3%, 5%, 7%) of Titanium Dioxide (100µm)

Pasam*et al* investigated the performance of the boric acid as the solid lubricant in the machining of hardened steel. The size of the particle is varied in the micron range and tested its performance by mixing it with SAE 40 oil.

The results were stated to improve the machining performance with decrease in the particle size of boric acid Kamruzzaman Minimum quantity lubrication (MQL) Sumaiya, Islama, Mohammad suggested the minimum quantity lubrication method to combine the advantages of both dry machining and wet machining. Refers to the use of cutting fluids of only a minute amount typically of a flow rate of 50 to500 ml/hour, which is an about three to four order of magnitude less than the amount commonly used in flood cooling condition.

Dhar*et al*. used the minimum quantity lubrication technique in turning process of medium carbon steel and concluded that, in some cases, a mixture of air and soluble oil has been shown to be better than the overhead flooding application of soluble oil. This would not only reduce the environmental hazards but also reduce the operating costs of the machining process

The review of the literature suggests that minimum quantity lubrication provides several benefits in machining.

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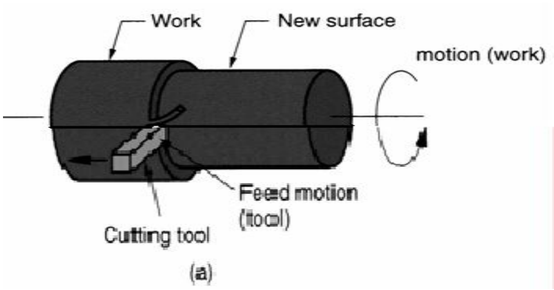
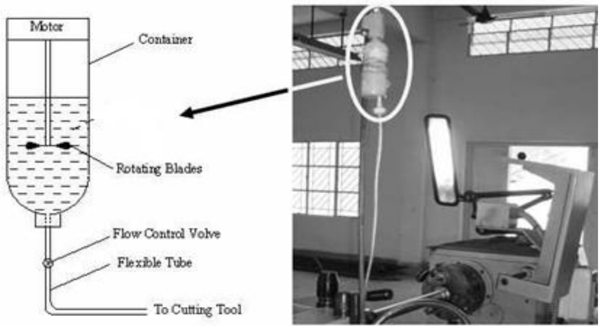
Therefore, it appears that MQL, if properly employed, not only provides environment friendliness but can also improve the machinability characteristics.

Ramana*et al (2010)*studiedCanola oil containing different weight proportions of boric acid was used as lubricants.The weight percentage of nano boric acid was varied in 7%, 4%, 2%, 0.5% steps and particle size used were 538, 80, 60, 50nmThe machining parameters like cutting velocity, feed rate, and depth of cut were kept constant. The cutting force increased when the particle size was reduced from 538 to 50nm.The size of particles should be maintained in micrometer range to achieve better machining results.

2. Experimentation





Block diagram of the Experimental setup

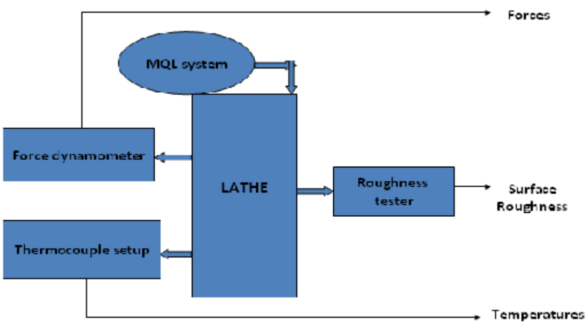


Table 1.5 Experimental and Predicted values of Feed Force

Experimental

FF	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538 nm	185	169	151	146
80 nm	**184**	**157**	**149**	**129**
60 nm	**176.6**	**150**	**133**	**118**
50 nm	**139.5**	**142**	**121**	**112**

Predicted

FF	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538nm	182	171	153	148
80nm	182	158	148	130
60nm	176	148	135	119
50nm	139	144	121	115

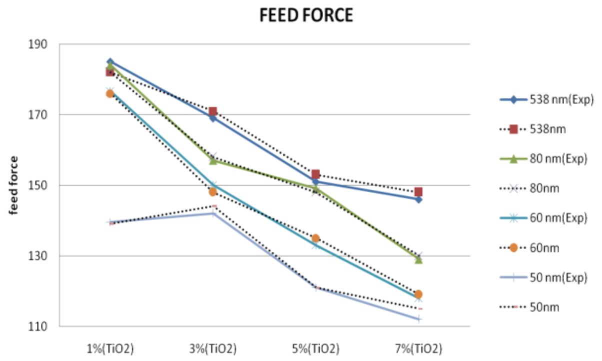


Table 1.6 Experimental and Predicted values of Cutting Force

Experimental

CF	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538nm	147	135	128	121
80nm	143	135	125	118
60nm	132	125	115	104
50nm	118	104	99.6	96.1

Predicted

CF	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538 nm	149	136	129	122
80 nm	147	135	124	116
60 nm	132	125	114	106
50 nm	119	104	101	94

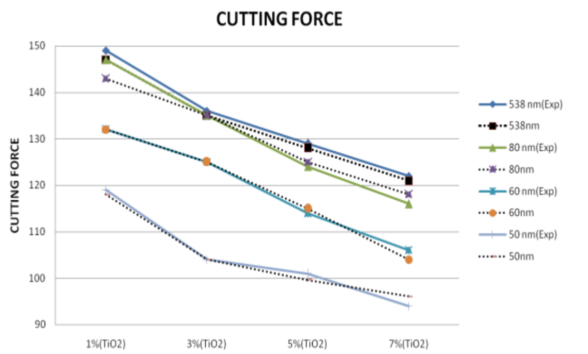


Table 1.7 Experimental and Predicted values of Thrust Force

Experimental

TF	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538 nm	184	175	169	153
80 nm	182	167	153	149
60 nm	177	163	148	142
50 nm	158	157	139	124

Predicted

TF	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538nm	182	176	169	154
80nm	182	169	154	150
60nm	176	161	146	143
50nm	158	154	139	126

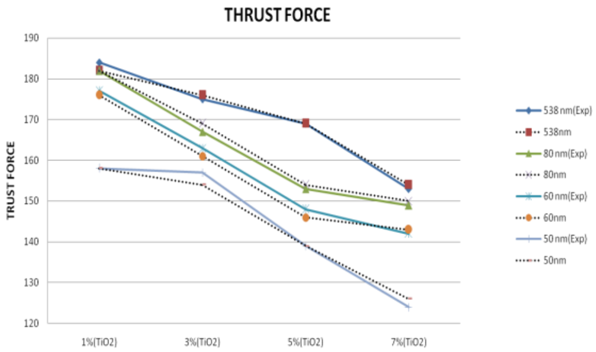


Table 1.8 Experimental and Predicted values of Temperatures

Experimental

tem	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538 nm	194	172	164	146
80 nm	184	165	151.2	137
60 nm	176.6	168.4	156.4	133.2
50 nm	139.5	133	127.8	121.2

Predicted

tem	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538nm	191	176	167	148
80nm	185	167	148	139
60nm	176	167	158	130
50nm	139	130	130	124

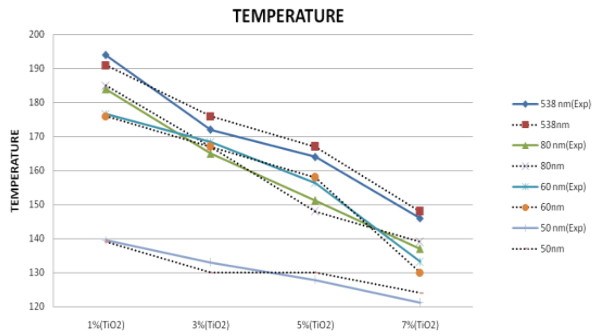


Table 1.9 Experimental and Predicted values of Surface roughness values

Experimental

SR	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538 nm	2.26	2.19	1.97	1.66
80 nm	2.17	2.07	1.46	1.31
60 nm	1.69	1.56	1.43	1.24
50 nm	1.56	1.41	1.24	0.92

Predicted

SR	1%(TiO2)	3%(TiO2)	5%(TiO2)	7%(TiO2)
538nm	2.21	2.12	1.92	1.67
80nm	2.04	2.01	1.42	1.25
60nm	1.76	1.59	1.42	1.34
50nm	1.59	1.42	1.25	0.971

3 Numerical results and discussion

The results obtained by the experimental work and fuzzy model are very closely matching and maximum error found is of the order2%. It was observed that the cutting forces, tool temperature and surface roughness is reduced with reduction in boric acid particle size (from 538nm to 50nm) and increasing weight percentage of titanium dioxide (from 1% to 7%). The fuzzy model has been developed with the experimental results for predicting the surface roughness, temperature & three forces.

4. Conclusions

By high-energy ball milling the size reduction of boric acid achieves from 5.6 microns to 63nm for the period of 15 hours.

The nano structured boric acid particle size measurement was done by X-Ray Diffractometer which was supported by the XRD Scherer's formula.

The XRD of H3BO3 sample reveals that the required phase is present with a little amount of impurities. The tribological behavior of the nano crystalline H3BO3 with weight percentages of TiO2(µm) has been studied by using it as a lubricant in the machining of AISI 1040 steel. It was observed that the cutting forces, tool temperature and surface roughness is reduced with reduction in boric acid particle size (from 538nm to 50nm) and increasing weight percentage of titanium dioxide (from 1% to 7%).

The fuzzy model has been developed with the experimental results for predicting the surface roughness, temperature & three forces. In this paper, Mamdani FIS Modeling was used to validate with experimental results for given conditions. It has been found that results generated by the designed fuzzy model are close to the experimental results with 98% accuracy.

The accuracy of the developed model can be improved by increasing the more fuzzy sets of the output variables.

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