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FPA 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 an extensively 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 eco-friendly 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 Nano solid boric acid with titanium dioxide (µm) suspended in lubricating oil in turning of EN 24 steel with carbide tool. SAE-40 is taken as base lubricants and boric acid solid lubricant of (50, 60 80, 538nm) particles 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. The Nano 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 usingFPA (flower pollination algorithm) is developed. For the prediction of output parameters of the lathe machining process is modelled 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 FPAgives the results which are well in agreement with experimental results.
Keywords: Turn machining, SAE-40 oil, Boric acid, Titanium dioxide, Minimum Quantity Lubrication (MQL), FPA **(**flower pollination algorithm).

1. INTRODUCTION

In the present work, an attempt has been made to modify the micro sized H_3BO_3 powder into Nano sized H_3BO_3 powder by usingHigh 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 flower pollination algorithm 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 modelled 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).

1.1Vamsi Krishna 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

1.2 Kamruzzamanb

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 to 500 ml/hour, which is an about three to four order of magnitude less than the amount commonly used in flood cooling condition.

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

1.4 Dr.S.V.Ramana et al (2010)

Canola 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, 50nm.The 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 micrometre range to achieve better machining results.

2. Experimental setup

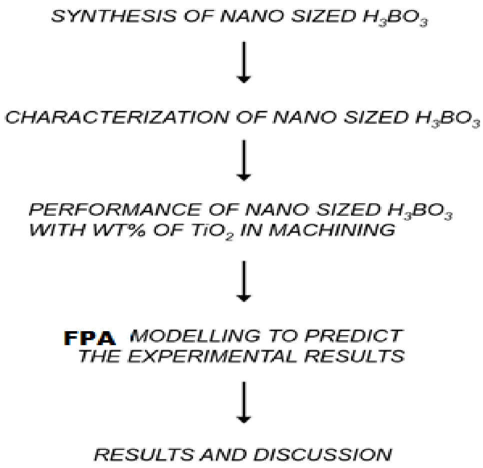
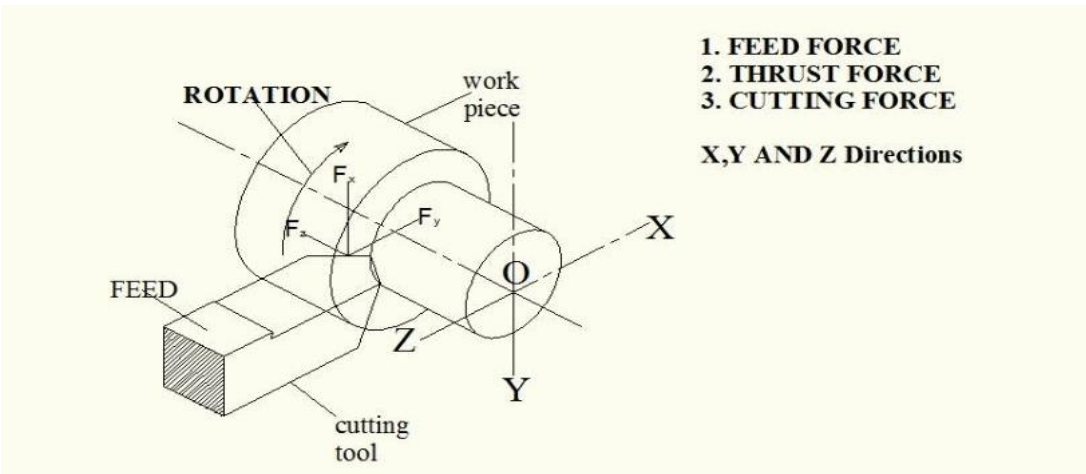


Fig. 1: Methodology



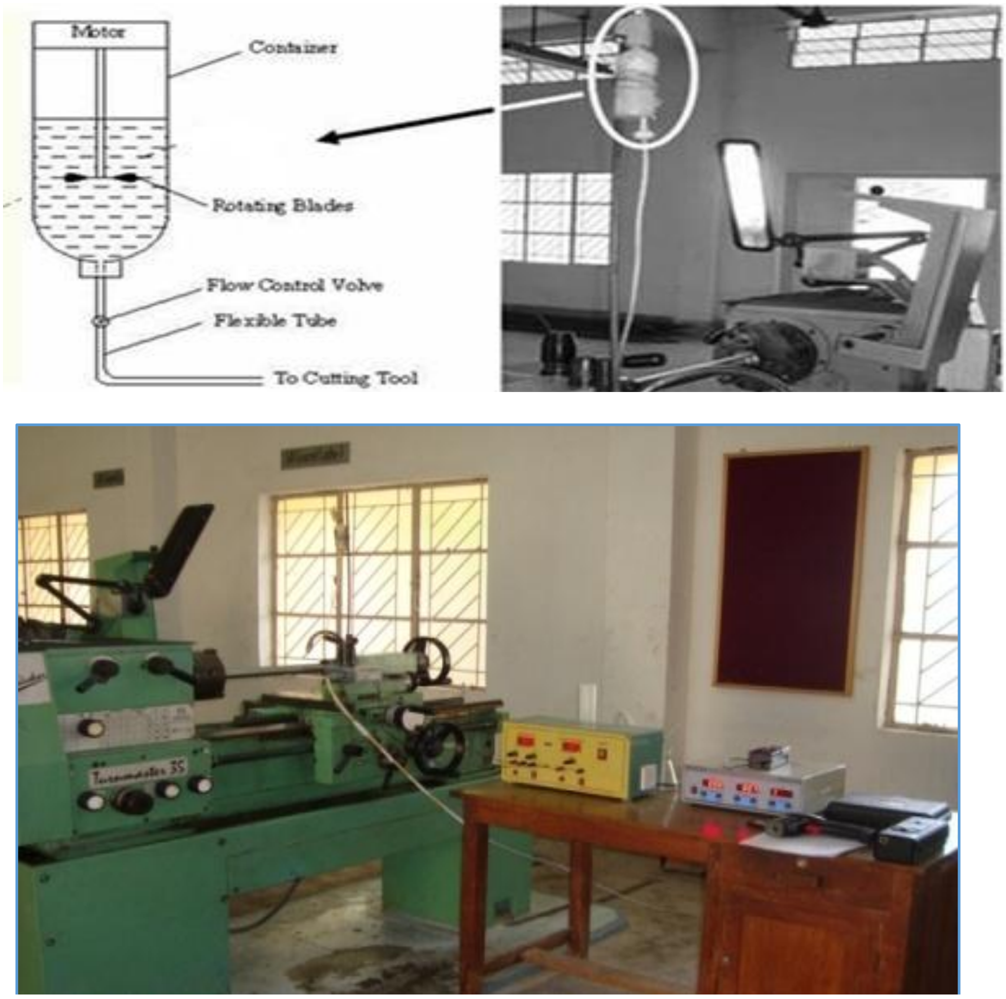


Fig. 2: Experimental setup showing flow regulation system and the location with reference to the lathe.

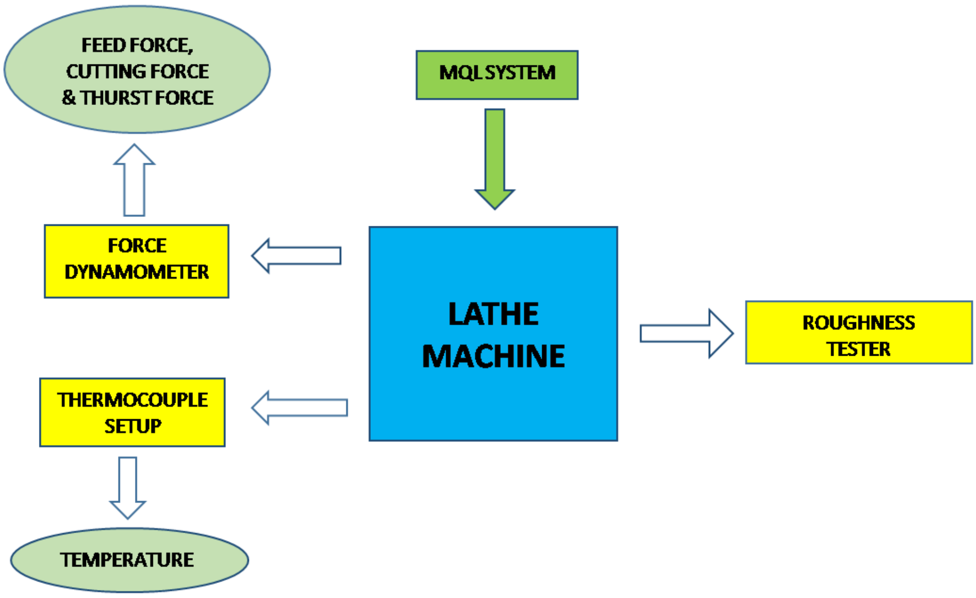


Fig. 3: Block diagram of the experimental setup.

Experimental setup for the turning process using MQL containing H3BO3 and TiO2 particles, where a) Cutting tool and workpiece indicating the feed, thrust, and cutting forces, b) Turning process, c) Setup comprising of the container (MQL solution at atmospheric pressure) in the left panel and its placement shown in the right panel (Fig. 2). The block diagram of the experimental setup is included where the force dynamometer for force measurement, thermocouple system for temperature and roughness tester for roughness measurement was made (Fig. 3).

For the development of predictive models we have adopted theFPA **(**flower pollination algorithm) for 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 modelled using two inputconstraints such as particle size of Boric Acid (50, 60, 80, 538nm) and weight percentage (1%, 3%, 5%, 7%) of Titanium Dioxide (100µm).

3. Study of the mechanical properties

H3BO3	Tio2	FF	Predicted	Error	X
538	1	184.5	183.0061	0.809702	1
538	1	183	183.0061	0.003333	2
538	3	168	170.3041	1.371488	3
538	3	171.5	170.3041	0.697318	4
538	5	150.5	157.6021	4.719003	5
538	5	152	157.6021	3.685592	6
538	7	145	144.9001	0.068897	7
538	7	147	144.9001	1.428503	8
80	1	183.5	169.5867	7.58218	9
80	1	181.5	169.5867	6.563802	10
80	3	156.5	152.7627	2.388051	11
80	3	157	152.7627	2.698917	12
80	5	148	135.9387	8.149527	13
80	5	147.5	135.9387	7.838169	14
80	7	130	119.1147	8.373308	15
80	7	129	119.1147	7.663023	16
60	1	176	169.0007	3.976875	17
60	1	177	169.0007	4.519379	18
60	3	155	151.9967	1.937613	19
60	3	147	151.9967	3.399116	20
60	5	135	134.9927	0.005407	21
60	5	135	134.9927	0.005407	22
60	7	120.5	117.9887	2.084066	23
60	7	118	117.9887	0.009576	24
50	1	141	168.7077	19.65085	25
50	1	140	168.7077	20.5055	26
50	3	144	151.6137	5.287292	27
50	3	143	151.6137	6.023566	28
50	5	121	134.5197	11.17331	29

50	5	120	134.5197	12.09975	30
50	7	115	117.4257	2.109304	31
50	7	116	117.4257	1.229052	32

Equation :-(a x +b y+ c x y+ d)
Coefficients

a	0.0248
b	-8.772
c	0.0045
d	176.015

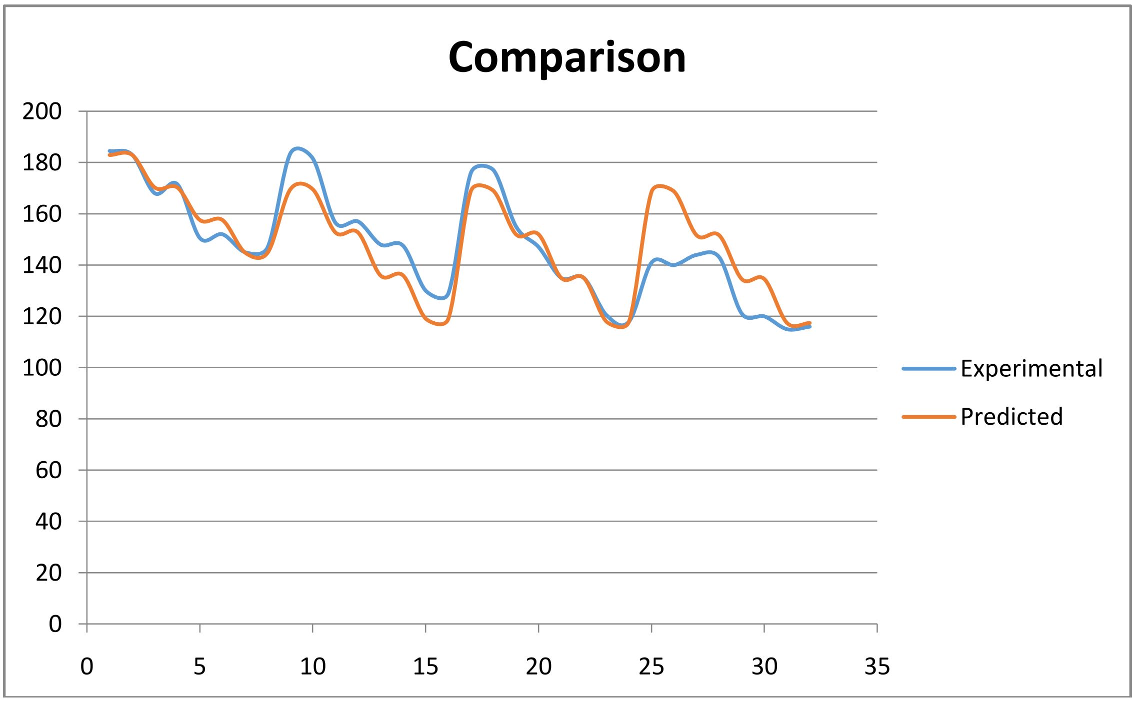


Fig. 3.1FEED FORCE

H3BO3	Tio2	TF	Predicted	Error	X
538	1	183	185.5137	1.37	1
538	1	182	185.5137	1.93	2
538	3	175	175.0555	0.03	3
538	3	176	175.0555	0.54	4
538	5	169	164.5973	2.61	5
538	5	169	164.5973	2.61	6
538	7	154	154.1391	0.09	7
538	7	154	154.1391	0.09	8
80	1	182	176.3995	3.08	9
80	1	182	176.3995	3.08	10

Coefficients

a	0.0162
b	-7.2197
c	0.0037
d	182.027

80	3	168	162.5521	3.24	11
80	3	169	162.5521	3.82	12
80	5	153	148.7047	2.81	13
80	5	154	148.7047	3.44	14
80	7	149	134.8573	9.49	15
80	7	150	134.8573	10.1	16
60	1	177	176.0015	0.56	17
60	1	176	176.0015	0	18
60	3	163	162.0061	0.61	19
60	3	161	162.0061	0.62	20
60	5	148	148.0107	0.01	21
60	5	146	148.0107	1.38	22
60	7	142	134.0153	5.62	23
60	7	143	134.0153	6.28	24
50	1	158	175.8025	11.27	25
50	1	158	175.8025	11.27	26
50	3	157	161.7331	3.01	27
50	3	154	161.7331	5.02	28
50	5	139	147.6637	6.23	29
50	5	139	147.6637	6.23	30
50	7	120	133.5943	11.33	31
50	7	126	133.5943	6.03	32

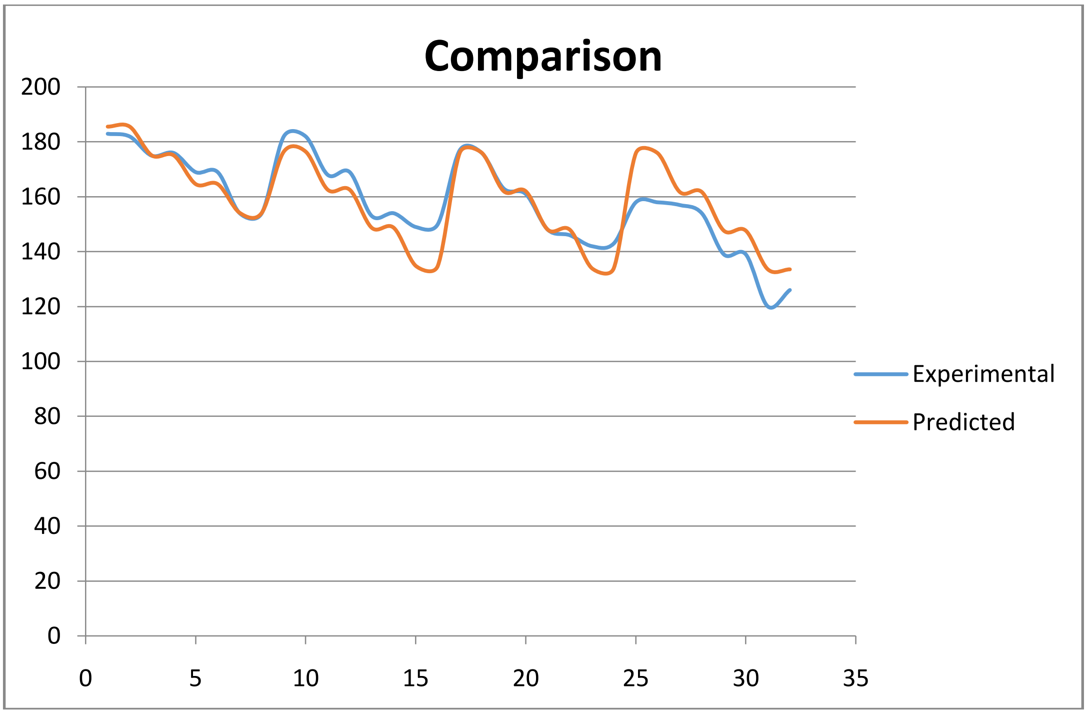


Fig.3. 2THRUST FORCE

H3BO3	Tio2	SR	Predicted	Error	X
538	1	2.2	2.3202	5.46	1
538	1	2.21	2.3202	4.99	2
538	3	2.18	2.0704	5.03	3
538	3	2.12	2.0704	2.34	4
538	5	1.9	1.8206	4.18	5
538	5	1.92	1.8206	5.18	6
538	7	1.68	1.5708	6.5	7
538	7	1.67	1.5708	5.94	8
80	1	2.19	1.7248	21.24	9
80	1	2.04	1.7248	15.45	10
80	3	2.05	1.5666	23.58	11
80	3	2.01	1.5666	22.06	12
80	5	1.48	1.4084	4.84	13
80	5	1.42	1.4084	0.82	14
80	7	1.39	1.2502	10.06	15
80	7	1.25	1.2502	0.02	16
60	1	1.68	1.6988	1.12	17
60	1	1.76	1.6988	3.48	18
60	3	1.55	1.5446	0.35	19
60	3	1.59	1.5446	2.86	20
60	5	1.42	1.3904	2.08	21
60	5	1.42	1.3904	2.08	22
60	7	1.43	1.2362	13.55	23
60	7	1.34	1.2362	7.75	24
50	1	1.57	1.6858	7.38	25
50	1	1.59	1.6858	6.03	26
50	3	1.43	1.5336	7.24	27
50	3	1.42	1.5336	8	28
50	5	1.31	1.3814	5.45	29
50	5	1.25	1.3814	10.51	30
50	7	1.02	1.2292	20.51	31
50	7	1.02	1.2292	20.51	32

	Coefficients
a	0.0014
b	-0.0711
c	-0.0001
d	1.6919

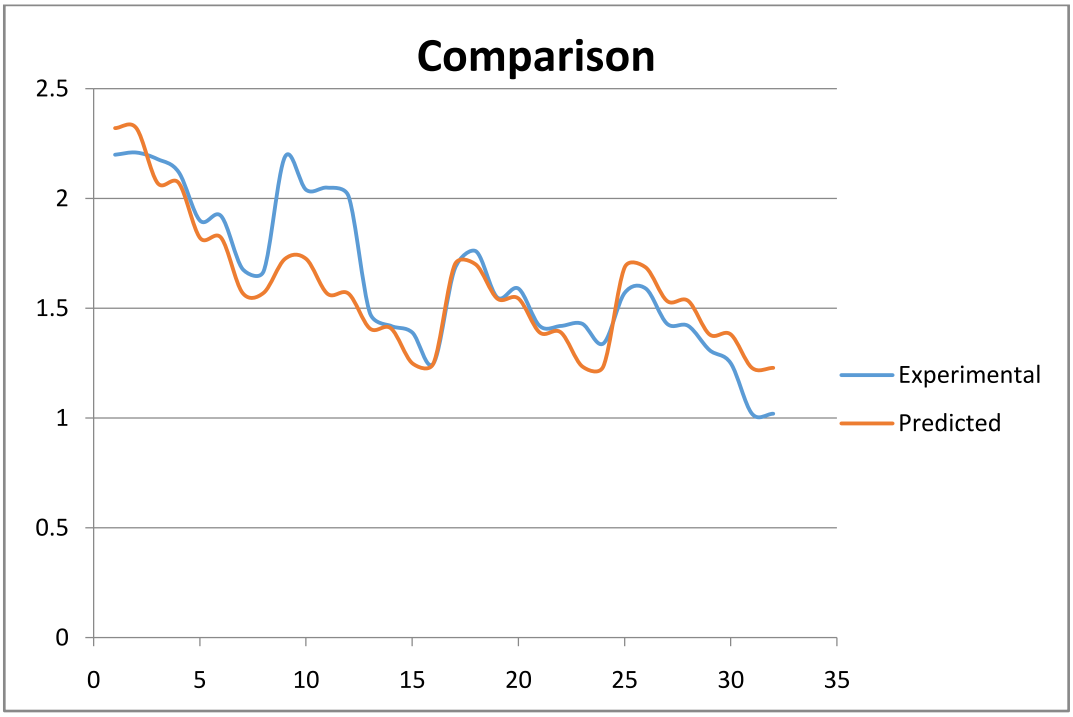


Fig. 3.3SURFACE ROUGHNESS

4. Flower Pollination Algorithm.

Every spices strive to protect and facilitate perpetuation of their own spices to increase their population without any change in their breed. Pollination is the art of transportation of pollen grains from one plant male anther to another female stigma. There are basically two different types of pollinators which help in pollination namely biotic and abiotic. The plants that need pollination from animals are usually bright in colour and have a strong odour to attract bees. The relationship between the flower and regular visiting bees gets developed and this mutualism is called as floral constancy Amaya Marquez. Another way is by the wind which collects pollens from one plant and transport to others globally.

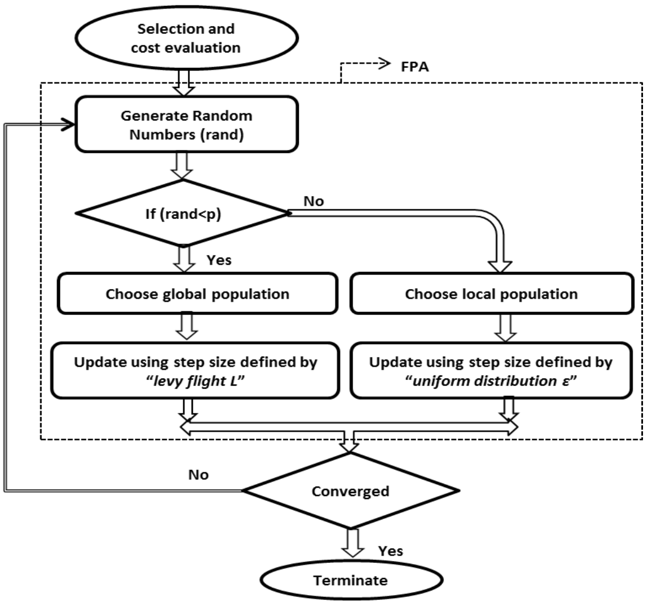


Figure 5.1 Working of FPA Flow chart.

5. Conclusions

The tribological behavior of the Nano crystalline H_3BO_3 with weight percentages of the TiO_2(μm) has been studied by using it as a lubricant in the machining of EN24Steel. It was observed that the forces (cutting forces), temperature (tool temperature) and surface roughness gets reduced with reduction in boric acid particle size (from 538nm to 50nm) and increasing weight percentage of Tio_2 (titanium dioxide from 1% to 7%).flower pollination algorithmhas been developed using the experimental results for predicting the surface roughness, temperature and forces (three forces). In this paper, flower pollination algorithmmodeling was used to validate with experimental results for given conditions. It has been found that results generated by the designed flower pollination algorithmare close to the experimental results with more accuracy. The accuracy of the developed model can be improved by increasing the more experimental datasets.

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