INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATIONS AND ROBOTICS
ISSN 2320-7345

SOFT COMPUTING APPROACH TO MODEL FOR PREDICTING SURFACE ROUGHNESS IN ELECTRICAL DISCHARGE DIAMOND GRINDING PROCESS

Bhagwan Kumar Mishra[1], S.K.Jha[2], A.P.Burnwal[3] and Uzunyan M.D[4]

[1]bhkmishra.me@gmail.com, [2]skjha63@rediffmail.com, [3]apburnwal@yahoo.com
[1]M.tech student, Department of Production Engineering, B.I.T. Sindri, Dhanbad-828123, Jharkhand, India
[2] Department of Production Engineering, B.I.T. Sindri, Dhanbad-828123, Jharkhand, India
[3]Department. of Mathematics, GGSESTC, Bokaro-827013, Jharkhand, India
[4]Department of Material Cutting, Kharkov State Polytechnic University, Kharkov (Ukraine)

Abstract: - There is growing need among the manufacturers to model process performance in electrical discharge diamond grinding process using soft computing technique (SCT). This paper presents an application of SCT for modelling surface roughness in electrical discharge diamond grinding process. The design of grinding factors is based on a full factorial design of experiment. Electric discharge diamond grinding operation is widely used in modern manufacturing industry because of its high level of accuracy for micro-finishing of shaft, pin material compare to conventional grinding operation. The design factors (Traverse feed, Wheel speed and Cross feed) are selected based on experimental design methodology. Full factorial design method is applied for taking three factors at four levels each and a total 64 number of possible combination of these parameters are done. SCT has been tested with the experimental data and found to be satisfactory. The proposed SCT model is efficiently used for predicting surface roughness in electrical grinding operation

Keywords*:* Grinding parameter, SCT, Artificial neural network, EDDG

1. Introduction

Today’s manufacturing industries are very much concerned about the quality of their products. Manufacturing industries are focused on producing high quality products in time at minimum cost. Surface finish is one of the crucial performance parameters that have to be controlled within suitable limits in a grinding process. Therefore, prediction or monitoring of the surface roughness of machined components has been an important area of research. Electrical discharge diamond grinding is characterized by its complexity, nonlinearity and sensibility to a large number of input factors e.g. normal pressure, regulating wheel speed and diamond concentration that influence system stability and output performance. The most important quality characteristics for the input factor like Normal pressure, regulating wheel speed and diamond concentration of electrical discharge diamond grinding process are surface roughness. The enhancement of such complex process efficiency requires model based process simulation, which is a powerful tool for evaluating the performance of complex systems. Empirical models, such as the regression analysis model, the fuzzy logic model, and the soft computing technique, have, generally, shown satisfactory prediction accuracy, particularly useful for the on-line response evaluation and control. In many cases, data from design of experiment (DOE) were used to establish the regression models or to develop the fuzzy rule sets or to soft computing network. For better performance researchers have done a lot of work on surface roughness modelling in electrical discharge diamond grinding operation. Aguiar et al. (2008) predicted surface roughness in grinding using artificial neural network. Shrivastava et al. (2011) developed an Intelligent Modelling of Surface Roughness during Diamond Grinding of Advanced Ceramics by two different approaches multiple regression analysis (MRA) and artificial neural network (ANN) and compared the same. They found that ANN gave more accurate result. From the above literature, very little work has been done for modelling of centerless grinding process. This paper applied artificial neural network for modelling surface roughness in centerless grinding process.

1.1 Work piece Materials

Hard metals are composite engineering materials with unique combination of strength, hardness, and toughness. Therefore, they are widely used in the cutting tools industry and other applications where good wear resistance is required. Currently, there are two groups of hard metals available, namely cemented carbides (usually referred to as WC-Co composites) and cermets, comprising a non-metallic refractory compound(ceramic) and metallic binder of a much lower melting point, hence the name cermets. Commercially there are two kinds of cermets: Titanium carbide-based (TiC-based) cermets and titanium carbonitride-based (Ti(C,N)-based) cermets. A cermet is a composite material composed of ceramic (cer) and metallic (met) materials. Cermets are ideally designed to have the optimal properties of both a ceramic, such as high temperature resistance and hardness. As tribological materials, TiCN-based cermets have received greater attention due to their lower density, higher cutting speeds, and extended tool life with superior surface finish, as well as their chemical stability at elevated temperature. In last few decades, TiCN-based cermets are being developed as cutting inserts and are considered as an alternative to WC-Co cermets. While the microstructure development in TiCN-based cermet materials is relatively well understood their tribological and machining properties have been neither extensively nor systematically investigated.

Tool Material properties:

KHT-16(Titanium carbonitride-based cermets) Composition of tool material is (Ti CN-84%, Ni-12% & Mo-4%).

Properties:
Density- 5.8x10^-3 Kg/M^3
Hardness (HRA)-89 to 90
Elastic limit in bending-1.1 to 1.2 GPa

2. Application of SCT:

In recent times, engineers have very well accepted S.C.Technique such as Fuzzy set theory, neural networks, Evolutionary computing Probabilistic computing chaotic Theory etc. For carrying out various numerical solution analyses. In last three decades there technique has been successfully applied in various engineering problem independently as in hybrid form.

SCT has become an accepted information analysis technology in many disciplines such as civil sector, military sector, Business (marketing, real state), Electrical Engineering, Chemical Engineering, Mechanical Engineering, Medical and health care industry , wireless communication , food industry (product development, quality control), Weather fore casting, pattern recognition, image processing, Economic forecasting, metrology, stock market, manufacturing(process control, quality control), Grinding system etc.

3. Experimental procedure and M/C setup:

An universal grinding machine , Russian model 3D642E , was modified to meet the requirements of EDDG with the attachment of the positive pole of the power supply to the wheel and the negative pole to the electrically conducting work material . Specially designed small sized pulse power generator was used as the source of power supply. Among two basic configurations by which EDDG can be performed. We adopted the one, in which work piece itself acts as the dressing electrode (i.e., the grinding and dressing zones are combined) . The salient features of this set-up is that due to spark-induced thermal softening of the work, there is a reduction in grinding forces and power , as well as enhanced wheel performance due to continuous in-process dressing and declogging of the wheel[10]. The wheel used is designated as 12A2-45° AC6 ,100/80 M1-01 – 100 , where 12A2-45° is the dimension of cup type wheel, AC6 means synthetic diamond with average strength = 6N, 100/80 USSR mesh refers to the grit dimension = 90 microns , M1-01 denotes the metal bond, and 100 refers to the diamond concentration of 100% . Based on the preliminary tests the following cutting parameters were defined: wheel speed (V_c)=25m/s and the contact pressure (P_A) = 0.8 MPa which is equal to the normal force (F_n) of 4 kg (40 N). The electro-discharge pulse parameters were : technological current (I_{avg}) = 5 A , frequency of electric pulses (f) = 22 kHz , filling factor (n_{ff})= 2. Any test conditions deviating from these basic test parameters are detailed in the respective legends in the diagrams. Tap water with small amount of soda as dielectric fluid was used. At the beginning of each grinding test the diamond wheels were dressed using a separate copper electrode. This was done for about 20 s at the grinding speed to be used in the experiments. During EDDG, the work piece was pressed against the rotating grinding wheel with a constant contact pressure (P_A). This adjustable pressure caused the normal grinding force component (F_n). During the grinding process, the wheel was oscillated to ensure that abrasive layer wears uniformly. This movement resulted in a radial force component (F_R) ,which varied in direction and magnitude and is usually neglected because of its insignificance . Rotation of the grinding wheel to provide a peripheral speed (V_c) resulted in the tangential force component (F_t) . Grinding was carried out on the 10mm x 5mm surface.

Figure 3.1

two basic configurations by which EDDG can be performed[9] we adopted the one , in which work piece itself acts as the dressing electrode (i.e, the grinding and dressing zones are combined) .

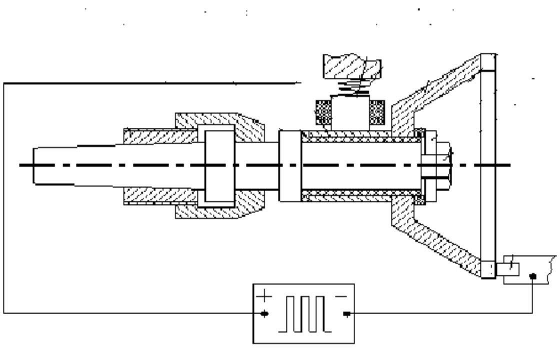


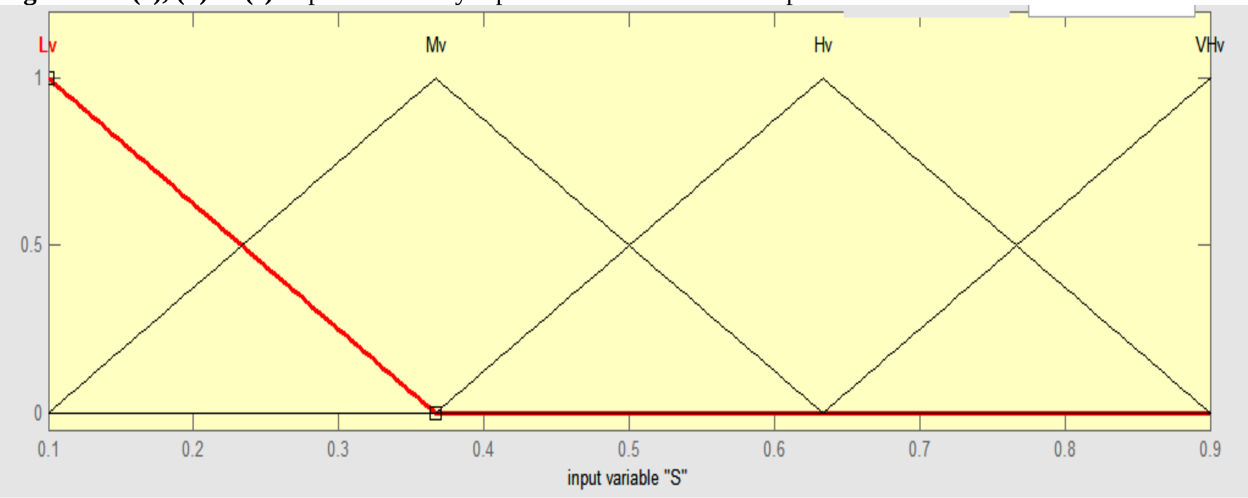
Figure no 3.2

For measurement of surface roughness,the Measurement Set-up (HOMMELWERKE C8000) was used.

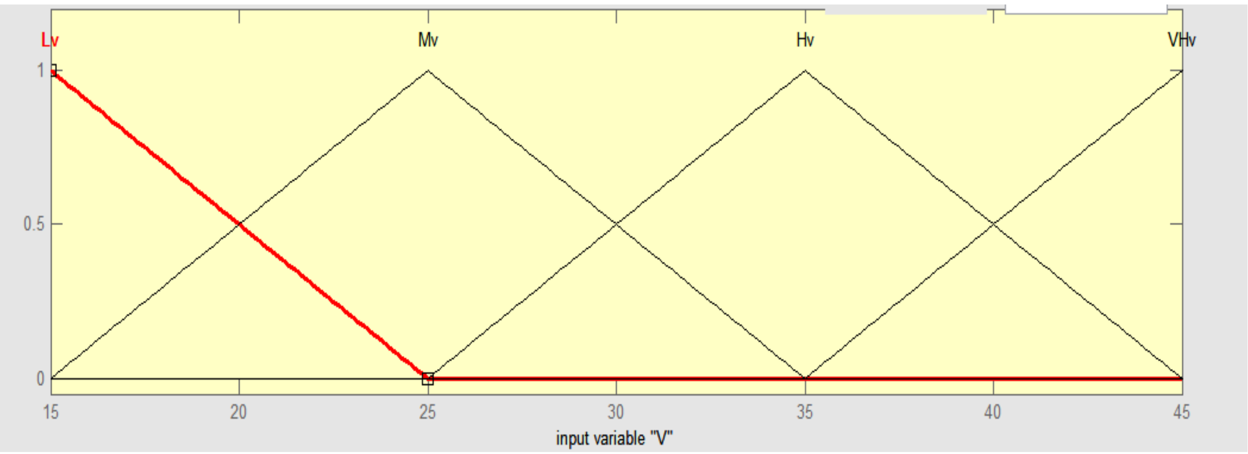
Table 1: Input process parameters and their levels

EDDG process parameter	Parameter Designation	Low	Medium	High	Very high
Traverse feed(mm/double stroke)	S	0.1	0.3	0.6	0.9
Wheel speed , m/sec.	**V**	15	20	35	45
Cross feed(mm/stroke)	**C_f**	0.36	0.38	0.43	0.5

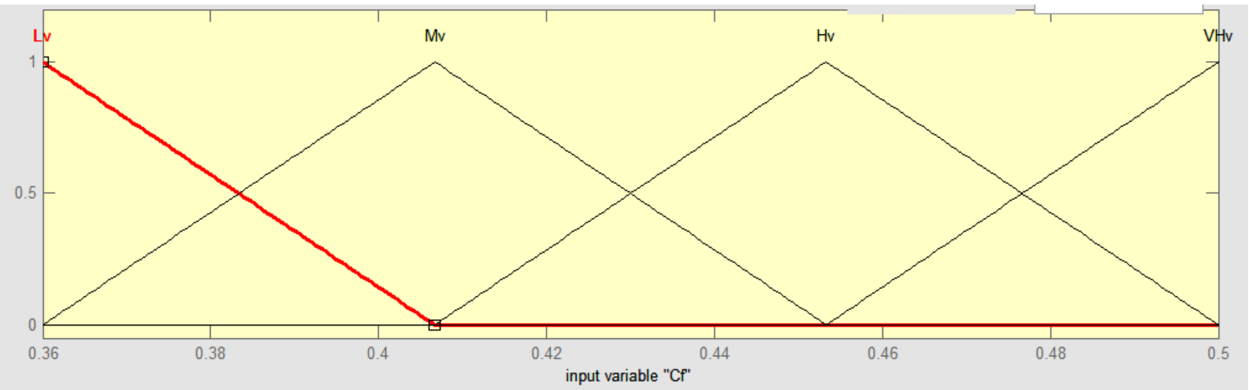
Figure 3.3: (a), (b) & (c) Represents Fuzzy input variable Vs Membership Function



3.3(a) Normal pressure (P_n) Vs Membership Function



3.3 (b) Wheel Speed (V) Vs Membership Function



3.3 (c) Grit Size Vs Membership Function

Table 2: Fuzzy Rule Base:

NO.	S	V	C_f	Ra	NO.	S	V	C_f	Ra
1	Lv	Lv	Lv	Lv	33	Hv	Lv	Lv	Lv
2	Lv	Lv	Mv	Lv	34	Hv	Lv	Mv	Mv
3	Lv	Lv	Hv	Mv	35	Hv	Lv	Hv	Hv
4	Lv	Lv	VHv	Mv	36	Hv	Lv	VHv	Hv
5	Lv	Mv	Lv	Lv	37	Hv	Mv	Lv	Mv
6	Lv	Mv	Mv	Lv	38	Hv	Mv	Mv	Mv
7	Lv	Mv	Hv	Mv	39	Hv	Mv	Hv	Hv
8	Lv	Mv	VHv	Hv	40	Hv	Mv	VHv	Hv
9	Lv	Hv	Lv	Lv	41	Hv	Hv	Lv	Mv
10	Lv	Hv	Mv	Mv	42	Hv	Hv	Mv	Hv
11	Lv	Hv	Hv	Mv	43	Hv	Hv	Hv	Hv
12	Lv	Hv	VHv	Hv	44	Hv	Hv	VHv	VHv
13	Lv	VHv	Lv	Lv	45	Hv	VHv	Lv	Hv
14	Lv	VHv	Mv	Mv	46	Hv	VHv	Mv	Hv
15	Lv	VHv	Hv	Hv	47	Hv	VHv	Hv	Hv
16	Lv	VHv	VHv	VHv	48	Hv	VHv	VHv	VHv
17	Mv	Lv	Lv	Lv	49	VHv	Lv	Lv	Mv
18	Mv	Lv	Mv	Mv	50	VHv	Lv	Mv	Mv
19	Mv	Lv	Hv	Mv	51	VHv	Lv	Hv	Hv

20	Mv	Lv	VHv	Hv	52	VHv	Lv	VHv	Hv
21	Mv	Mv	Lv	Mv	53	VHv	Mv	Lv	Mv
22	Mv	Mv	Mv	Mv	54	VHv	Mv	Mv	Mv
23	Mv	Mv	Hv	Mv	55	VHv	Mv	Hv	Hv
24	Mv	Mv	VHv	Hv	56	VHv	Mv	VHv	VHv
25	Mv	Hv	Lv	Mv	57	VHv	Hv	Lv	Hv
26	Mv	Hv	Mv	Mv	58	VHv	Hv	Mv	VHv
27	Mv	Hv	Hv	Hv	59	VHv	Hv	Hv	Hv
28	Mv	Hv	VHv	VHv	60	VHv	Hv	VHv	Hv
29	Mv	VHv	Lv	Mv	61	VHv	VHv	Lv	Hv
30	Mv	VHv	Mv	Hv	62	VHv	VHv	Mv	Hv
31	Mv	VHv	Hv	Hv	63	VHv	VHv	Hv	VHv
32	Mv	VHv	VHv	VHv	64	VHv	VHv	VHv	VHv

Rule Base Solution:

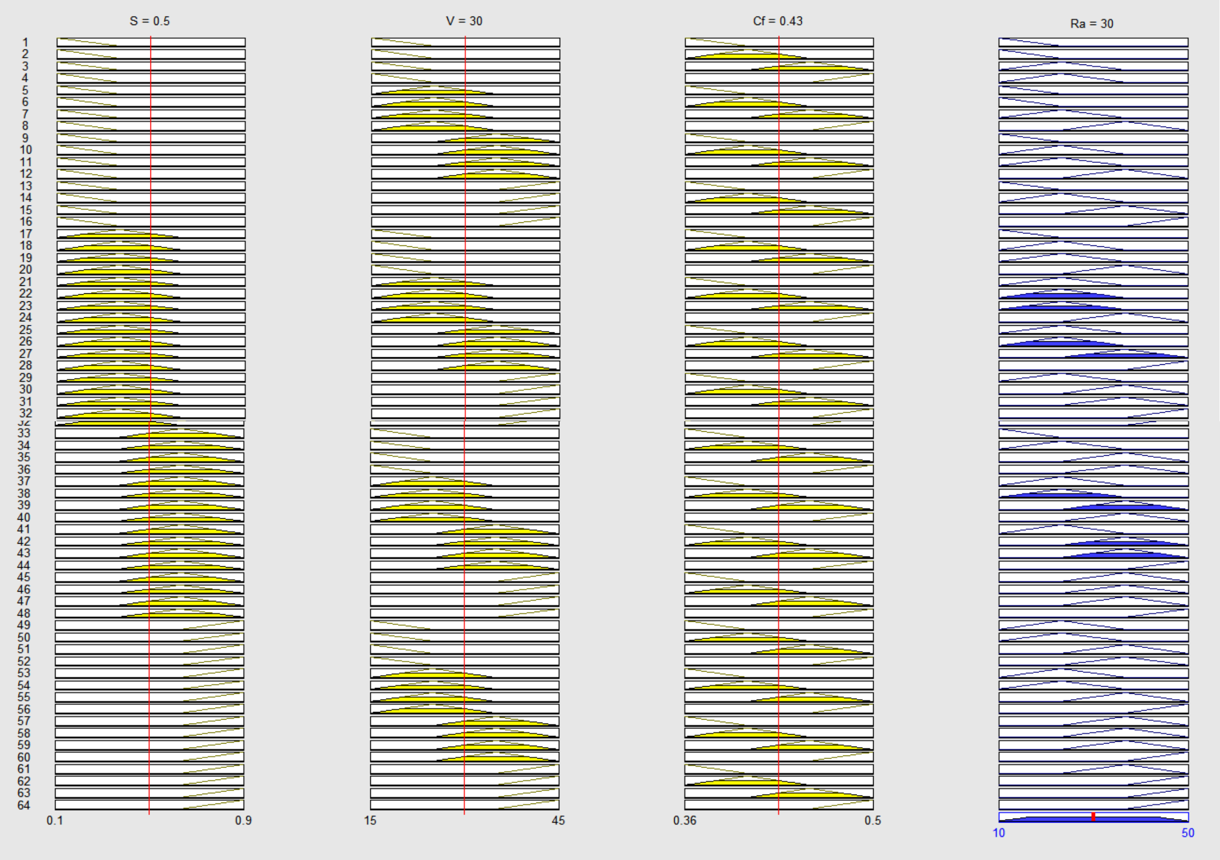


Figure 3.4 (a): Represent dependencies of output variable on the input variables.

Low and medium achievement in any of linguistic variable cannot be compensated by high or very high achievement of linguistic values of another variable. Therefore, out of 64, only 35 solutions are accepted otherwise very less useful in practical life.

Surface base solution:

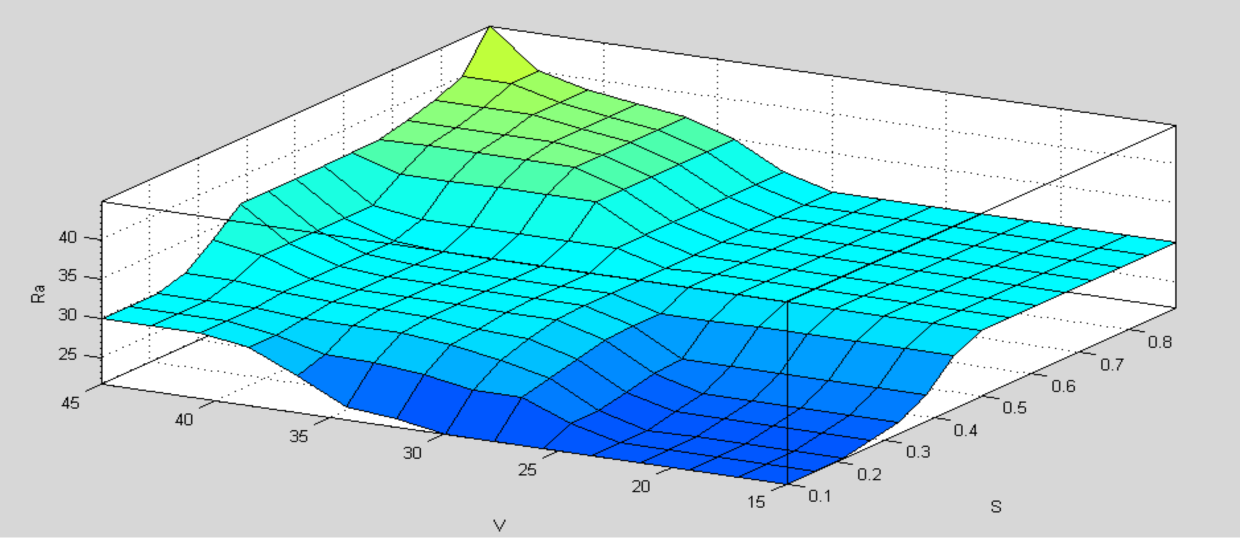


Figure 3.4(b): Plot between Pn, V, & Ra

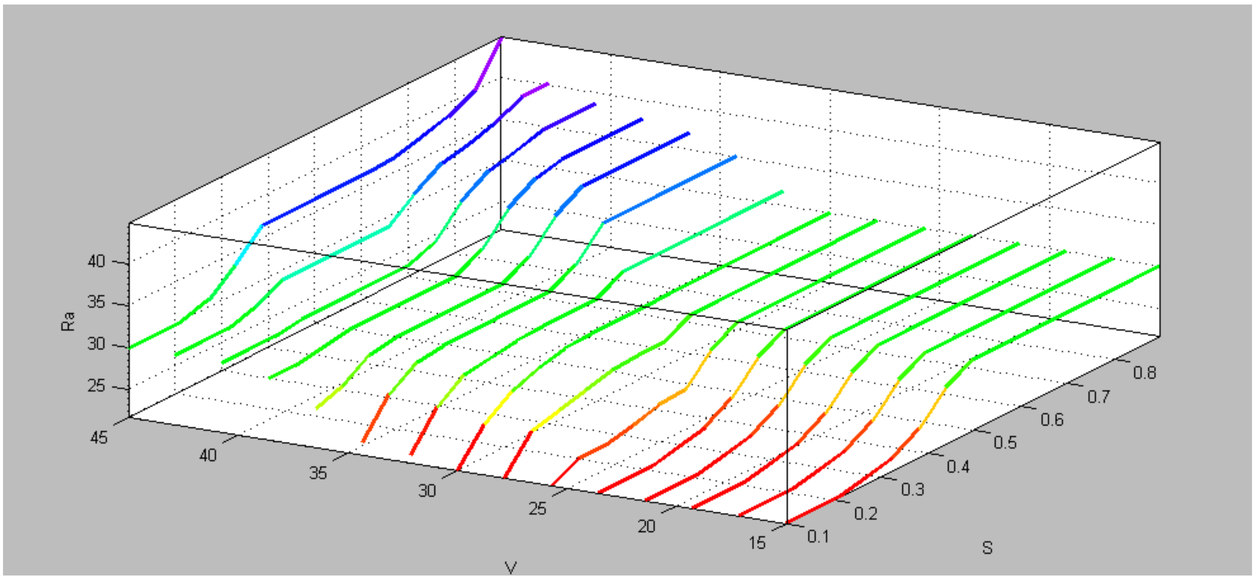


Figure 3.4(c): Plot between Pn, V, & Ra

4. Conclusions

The neural network based surface roughness prediction methodology has been adopted using various important parameters like Wheel speed, Normal pressure and Grit size influencing the surface roughness. It has been observed that neural network could well learn the pattern and could be used for future prediction of surface roughness. The predicted surface roughness from the present neural network model is very close to the measured experimentally, thus showing the efficacy of neural network for predicting surface roughness in electrical discharge diamond grinding(EDDG). Future work can be done using response surface modelling and compared the results to infer the best alternatives for modelling surface roughness in EDDG operation.

Acknowledgement:

The authors wish to thank colleagues from the Material Cutting Department of Kharkov State Polytechnic University, Kharkov (Ukraine) for their support and cooperation during the course of this work.

REFERENCES

[1] Augier, P.R. Cruz, E.D.C. Paula, W.C.F. and Bianchi C.E. (2008), “Predicting Surface Roughness in Grinding using Neural Networks”, Advances in Robotics, Automation and Control, CC BY-NC-SA 3.0 license.
[2] Brinksmeier, H. K. Toe, N. and Czenkusch, C. (1998), “Modeling and optimization of grinding processes”, Journal of Intelligent Manufacturing, Vol. 9, pp.303-314.
[3] Zhou S., Gartner J. R., Howes T.D.(1996), “On the Relationship between Setup Parameters and Lobing Behavior in Centerless Grinding”, CIRP Annals - Manufacturing Technology ,Vol. 45(1), pp 341346.
[4] Shin, Li, H. Y.C. (2007), “A time domain dynamic simulation model for stability prediction on infeed centerless grinding processes”, ASME Journal of Manufacturing Science and Engineering, vol. 129(1), pp. 539-550.
[5] Kim, H.Y. Kim, S.R. Ahn, J.H. and Kim, S.H. (2011), “Process monitoring of centreless grinding using acoustic emission”, Journal of Material Processing Technology, Vol. 111, pp.273-278.
[6] Kwak, J.S. and Ha, M.K. (2004), “Neural network approach for diagnosis of grinding operation by acoustic emission and power signals”, Journal of Materials Processing Technology, Vol. 147(1), pp.65–71.
[7] Kumar, S. and Choudhury, S.K. (2007), “Prediction of wear and surface roughness in electro-discharge diamond grinding”, Journal of Materials Processing Technology”, Vol. 191, pp.206–209.
[8] Mamun, A.A. and Dhar, N.R. (2012), “Numerical Modeling of Surface Roughness in Grinding under Minimum Quantity Lubricants (MQL) using Response Surface Method (RSM)”, Global Journal of Researches in Engineering Mechanical and Mechanics Engineering, Vol. 12(5).
[9] Mukhopadhyay, C.K. Jayakumar, T. Venugopal, S. Mannan, S.L. and Raj, B. (2005), “A review of the application of acoustic emission techniques for monitoring forming and grinding processes”, Journal of Materials Processing Technology, Vol. 159(1), pp.48-61.
[10] Shrivastava, P.K. and Dubey, A.K. (2011), “Intelligent Modeling of Surface Roughness during Diamond Grinding of Advanced Ceramics”, Proceedings of the World Congress on Engineering, Vol. I, WCE 2011, London, U.K.
[11] Lotfi A. Zadeh (1994), “Fuzzy Logic, Neural Networks and Soft Computing”, Communication of the ACM, 37(3), pp77-84.
[12] [Santosh Kumar Das, Sachin Tripathi and A.P.Burnwal, “Some Relevance Fields of Soft Computing Methodology,” International Journal of Research in Computer Applications and Robotics, Vol-2 Issue-6, June 2014, pp 1-6.
[13] Burnwal. A.P, Abhishek Kumar and Santosh Kumar Das, “Survey on application of Artificial Intelligence Techniques”, International Journal of Engineering Research and Management, Vol-01, No-05, Aug-2014, pp 215-219
[14] Burnwal. A. P. Abhishek Kumar and Santosh Kumar Das, “Assessment of fuzzy set theory in different Paradigm”, International Journal of Advanced Technology & Engineering Research”, Vol.3, Issue 3, (May-2013), 16-22, ISSN No: 2250-3536.
[15] Santosh Kumar Das, Sachin Tripathi, and A. P. Burnwal. "Intelligent Energy Competency Multipath Routing in WANET." Information Systems Design and Intelligent Applications. Springer India, 2015. 535-543.
[16] Santosh Kumar Das, Sachin Tripathi, and A. P. Burnwal. "Fuzzy based energy efficient multicast routing for ad-hoc network." Computer, Communication, Control and Information Technology (C3IT), 2015 Third International Conference on. IEEE, 2015.
[17] Santosh Kumar Das, Sachin Tripathi, and A. P. Burnwal. "Design of fuzzy based intelligent energy efficient routing protocol for WANET." Computer, Communication, Control and Information Technology (C3IT), 2015 Third International Conference on. IEEE, 2015.
[18] Kumar Das, S., Kumar, A., Das, B., Burnwal, A.P., “Ethics of Reducing Power Consumption in Wireless Sensor Networks using Soft Computing Techniques”. International Journal of Advanced Computer Research, 3(1-8), (2013)
[19] Santosh Kumar Das, Bappaditya Das and A. P. Burnwal, “Intelligent energy competency routing scheme for wireless sensor networks”, International journal of research in computer applications and robotics, Vol.2, Issue.3, (Mar-2014), 79-84, ISSN 2320-7345.