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PREDICTION OF SURFACE ROUGHNESS AND METAL REMOVAL RATE INTO MAGNETIC ABRASIVE FINISHING FOR SILICON CARBIDE ABRASIVE

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Abstract
Magnetic abrasive finishing (MAF) is one of advanced method which play a major role in important applications (medical, rocket and aerospace parts , dies) .this paper was focused intoprediction of surface roughness and metal removal rate during intervening important parameters (mesh size ,concentration,gap between workpiece and poles).experiments show thatthe best surface roughness can be obtained when machining workpiece of low carbon steel by silicon carbide (Sic) was 0.007µm at concentration 33% SiC and maximum metal removal rate can be obtained 0.004gm at concentration (25% SiC and 75% Fe) the Minitab software version 17 was used to predict the surface roughness and metal removal rate which obtained good result and agreement with experimental values for surface roughness and metal removal rate when comparing between them reach to 98.66%.

Introduction
Finishing is among latest processes which are performed on the workpiece to achieve surface quality and dimensions. Magnetic Abrasive Finishing (MAF) process is one of important machining process mainly used to achieve surface finish by using magnetic poles ,usually (MAF) was finishing process used to enhance the surface layer and abrasive particles play important role in machining .the workpiece is kept between two poles and there is a gap filled with powder consist of abrasive from (SiC,Al2O3,B4C,TiC ….etc) mixed with Iron powder .S.C. [1] .

In MAF process , the workpiece is kept between the two poles of a magnet and the working gap between the workpiece and the magnet is filled with magnetic abrasive particles composed of ferromagnetic particles and abrasive powder.[2,3]

S. C. JAYSWA Letal (2005) study the effect of flux density , height of working gap, size of magnetic abrasive particles on magnetic abrasive finishing process with their effect on surface roughness and concluded that surface roughness value (Rmax) of the workpiece decreases with increase in flux density and size of magnetic abrasive particles. Surface roughness value (Rmax) decreases with decrease in working gap. Rmax value also decreases when the magnet has a slot as compared to the magnet having no slot. [4,5]

Saadkariem Shatheretal (2015) study the technological parameters (current ,working gap , abrasive in magnetic abrasive finishing (MAF) with regression analysis of variance (ANOVA) and concluded that the amplitude of pole geometry has significant effect on the surface roughness (Ra) which improved the surface roughness about 30% [6]

Jiang Guoetal (2017) study the influence of two types of abrasive (SiC,Al2O3) on MAF process size on polishing force and MRR, wear of magnetic abrasives, surface roughness and surface morphologies obtained using different types of magnetic abrasives ,experiments prove that higher MRR and low surface roughness by using SiC and smooth surface by Al2O3.[7,8]

Mehrdad Vahdatietal (2016) study the effect of magnetic abrasive process parameters on free form surfaces of parts made of Aluminiumis examined using controlled machine (CNC).The use of simple hemisphere for

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installation on the flat area of the magnets as well as magnets' spark in curve this condition can improve surface roughness up to 75% based on simulation results. In performed experiments, based on the ranges of the variables, improvement was reported up to 62%. Difference was 13% percent, which is acceptable [9,10]

Saad Kariem Shatheretal (2019) focused on the effect of mesh size and concentration ,gap dimension of abrasive of silicon carbide when added to Iron powder , they concluded that there are great influence on surface roughness and metal removal rate.[11]

Analysis of Application SiC Abrasives on surface roughness (Ra)

The analyses of application abrasive SiC on surface roughness (Ra) are listed in Table (2)
In the present work regression model has been developed and experimental results obtained were subject to analysis by using MINITAB-17 statistical software to evaluate the relationship between input and output process parameters. Based on the experimental findings of 12 runs the following regression models have been evolved a Regression Equation for surface roughness is given by

Eq (1) Ra (µm) = 0.088 + 0.00591 *wt% - 0.000348* mesh - 0.02033 *gap (mm) - 0.000152 (wt %)^2 ……… (1)

Where (R-sq) of regression model gets (98.66%) that represent our model better fits the data. More the value of R-sq, better the model fits our data and prediction of response is more accurate. The normal distribution probabilities for (Ra) to SiC-Fe abrasive powder is shown in Figure (3) .experimental procedure involve many steps to achieve experiments and usually started with preparing the powder of magnetic abrasive of silicon carbide (Sic) which mixed with glass binder or resin to machine work piece from low carbon steel which has the chemical composition as shown in table (1) at different percentage of abrasives (25,30,33% of SiC) mixed together with powder of Fe Then ,cutting conditions were used (abrasive concentration, mesh size , gap dimension) which can be shown in tables,(2, 3)

The work piece dimension (4 x 60 x 100 mm) was usedin experiments with the chemical composition as shown in table (1)

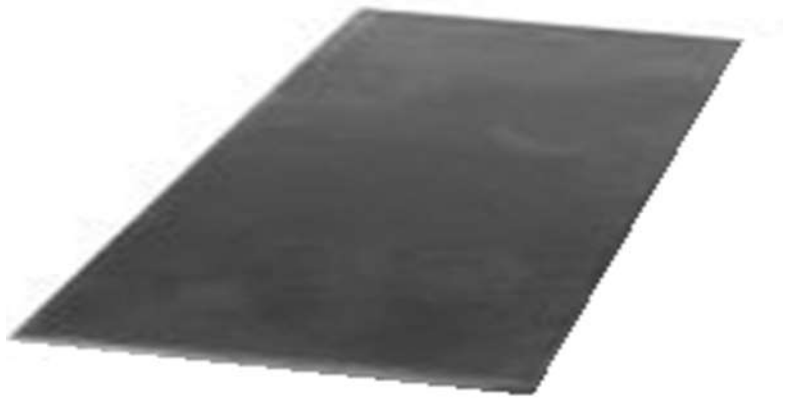

Figure (1) workpice

Table (1) chemical composition of workpiece

C %	Si%	Mn %	P%	S%	Cr%	Mo%	Ni%	Al%	Co%	Cu%	Ti%	V%	W%
0.0649	0.131	0.414	0.0194	0.0049	0.373	0.0028	0.0301	0.0210	0.0102	0.0111	0.0015	0.0026	0.0050

Pb%	Sn%	B%	Ca%	Se%	Sb%	Ta%	Fe%
0.0010	0.0010	0.0007	0.0005	0.0010	0.0081	0.0250	98.8697

Silicon carbide:Silicon Carbide (SiC) is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. Silicon carbide shown in Figure (2) is an excellent abrasive material. It has Low density, High strength, Low thermal expansion, High thermal conductivity, High hardness, excellent thermal shock resistance was used in experiments with different concentration (25% ,30%,33%) mixed with iron powder concentration 75% ,70% ,67% then added binder to the mixture and put into furnace at 250C° sintering process.

Figure (2) Abrasive of silicon carbide

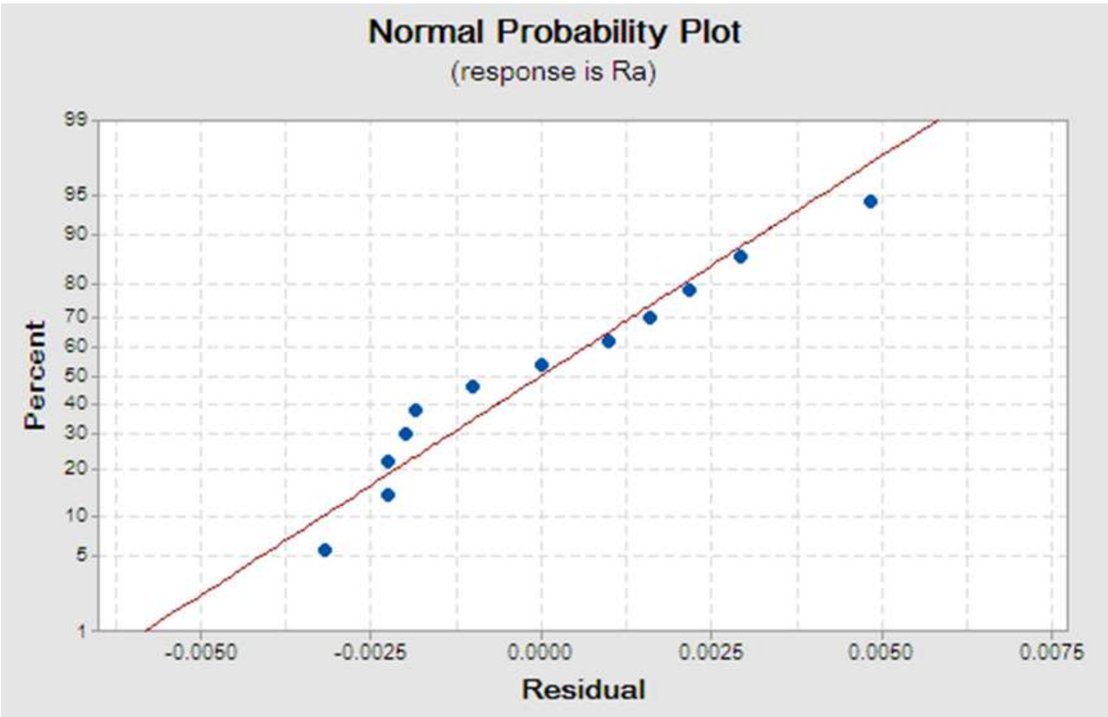

Figure (3) Plot of normal distribution probability for (Ra) to SiC-Fe abrasive powder

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Figure (4) machine of MAF process

Table (2) Theoretical and experimental Values of surface roughness at different concentration of SiC abrasive, mesh size and working gap for workoiece

No	Concentration of SiC abrasive %	Mesh size	Gap,mm	Surface roughness (Ra) before machining, μm	Surface roughness (Ra) after machining,μm	Theoretical Surface roughness (Ra)
1-	SiC 25% - Fe 75%	100	1.5	0.166	0.073	0.075
2-	SiC 25% - Fe 75%	100	2	0.170	0.068	0.065
3-	SiC 25% - Fe 75%	200	1.5	0.126	0.042	0.040
4-	SiC 25% - Fe 75%	200	2	0.146	0.028	0.030
5-	SiC 30% - Fe 70%	100	1.5	0.161	0.061	0.063
6-	SiC 30% - Fe 70%	100	2	0.135	0.051	0.052
7-	SiC 30% - Fe 70%	200	1.5	0.173	0.033	0.028
8-	SiC 30% - Fe 70%	200	2	0.132	0.017	0.018
9-	SiC 33% - Fe 67%	100	1.5	0.144	0.053	0.052
10-	SiC 33% - Fe 67%	100	2	0.121	0.044	0.041
11-	SiC 33% - Fe 67%	200	1.5	0.133	0.014	0.017
12-	SiC 33% - Fe 67%	200	2	0.162	0.007	0.008

As a result of the comparison between the experimental and theoretical Ra result, the Figure (3) below shows that there is an approach in data between them.

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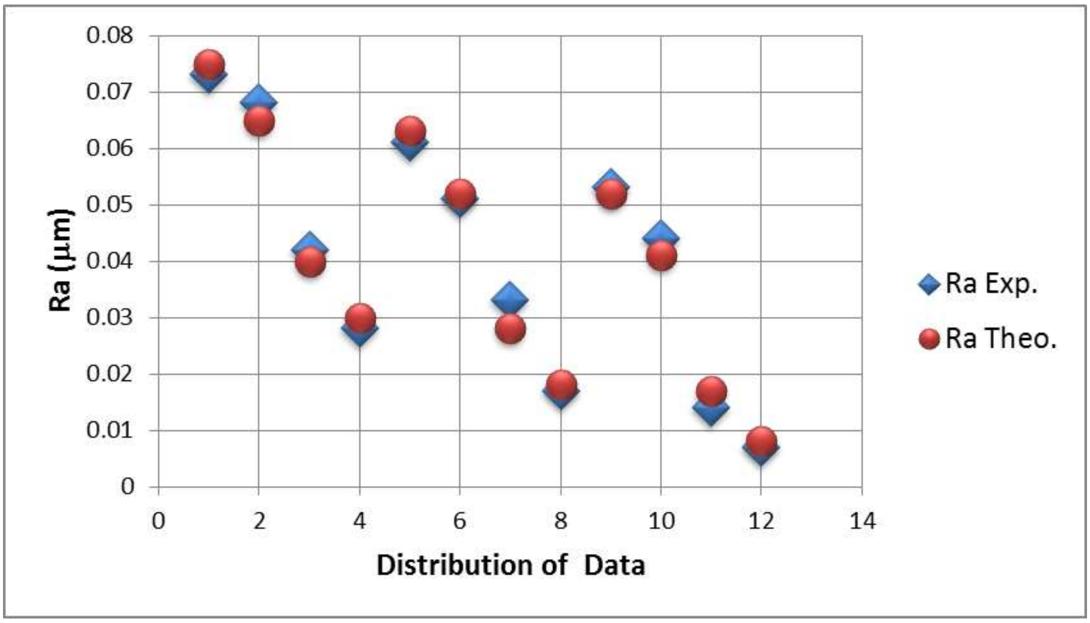

Figure (5)Comparison between Experimental and Theoretical Ra Data for SiC- Fe abrasive brush

Analysis of Application SiC Abrasives on MRR

The analyses of application SiC on MRR are shown in table (3)and
Values of MRR for different wt% of SiC abrasive, mesh size and working gap on (ASTM 415) low carbon steel
Based on the experimental findings of 12 runs the following regression models have been evolved

MRR (gm/min) = 0.00427 + 0.000317 wt% - 0.000012 mesh -0.001845 gap - 0.000006 (wt %)^2…….(2)

Where (R-sq) of regression model gets (98.93%) that represent our model better fits the data. The normal distribution probabilities for (MRR) to SiC -Fe abrasive powder

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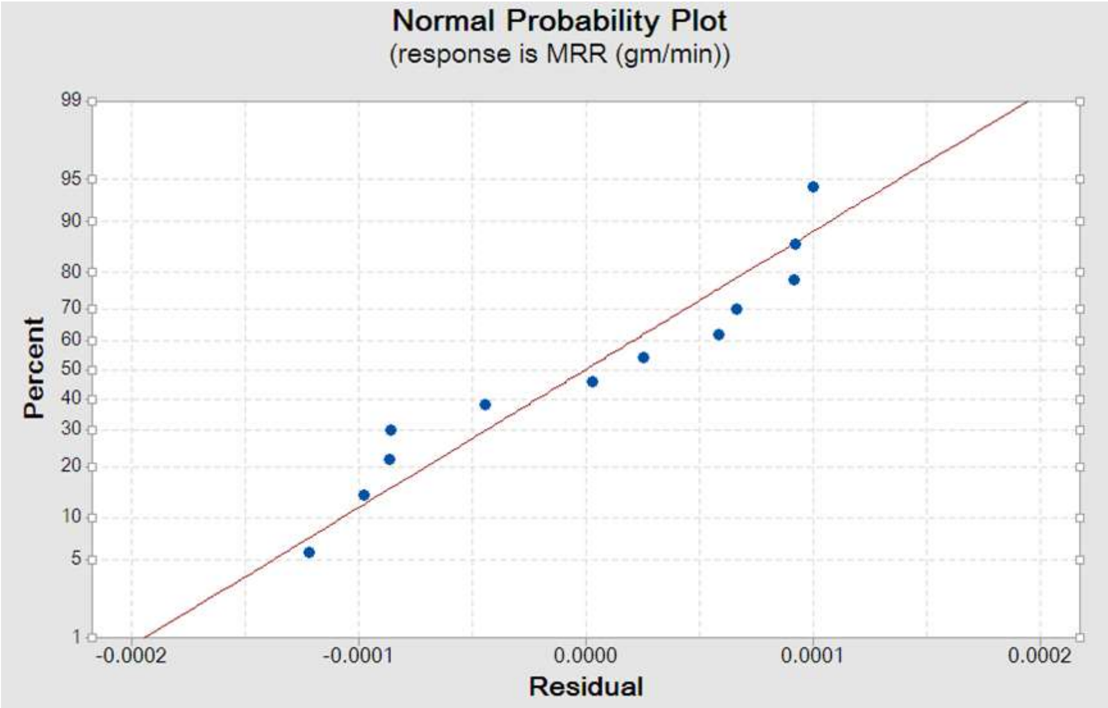

Figure (6)Plot of normal distribution probability for (MRR) to SiC-Fe abrasive powder

As a result of the comparing between the experimental and theoretical MRR result, the Figure (7) below showed that there is an approach in data between them.

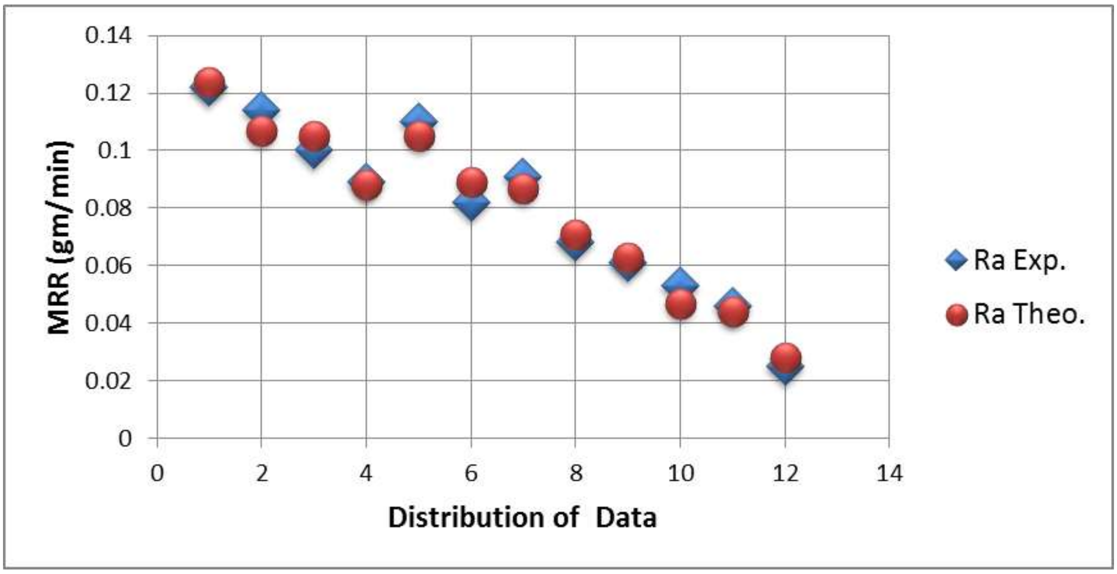

Figure (7) Comparison between Experimental and Theoretical MRR Data for SiC- Fe abrasive brush

Table (3) Theoretical and experimental Values of metal removal at different concentration of SiC abrasive, mesh size and working gap for work piece

No	Concentration of SiC abrasive	Mesh	Gap ,mm	Wt% before Machining(gm)	Wt% after machining,(gm)	ExperimentalMRRgm/min	Theoretical MRR
1-	SiC 25% - Fe 75%	100	1.5	175.158	175.03	0.0042	0.0044
2-	SiC 25% - Fe 75%	100	2	197.417	197.32	0.0032	0.0033
3-	SiC 25% - Fe 75%	200	1.5	194.182	194.09	0.0030	0.0030
4-	SiC 25% - Fe 75%	200	2	92.306	192.24	0.0022	0.0021
5-	SiC 25% - Fe 75%	100	1.5	165.515	165.39	0.0041	0.0040
6-	SiC 25% - Fe 75%	100	2	185.513	185.42	0.0031	0.0031
7-	SiC 25% - Fe 75%	200	1.5	172.093	172.01	0.0027	0.0028
8-	SiC 25% - Fe 75%	200	2	185.581	185.52	0.0020	0.0019
9-	SiC 33% - Fe 67%	100	1.5	176.727	176.61	0.0039	0.0038
10-	SiC 33% - Fe 67%	100	2	182.414	182.33	0.0028	0.0027
11-	SiC 33% - Fe 67%	200	1.5	176.456	176.38	0.0025	0.0026
12-	SiC 33% - Fe 67%	200	2	175.024	174.97	0.0018	0.0017

Surface roughness device: surface roughness device was used to measure the surface roughness (Ra) of machined surface shown in Figure (8).

Figure (8) surface roughness device

Weighting device: this device was used toweighed theworkpiece before and after machining by using MAF process.

Figure (9) device for weight

Result and discussion

According to tables (2,3) concluded that the maximum value of surface roughness was 0.073µm at concentration of abrasive 25 % Si and 75% Fe with gap 1.5mm, mesh size 100 while minimum surface roughness can be obtained 0.007µm at concentration 33% Si which related with mesh size and concentration of SiC abrasives and 67% Fe with gap 2mm , mesh size 200 and for metal removal rate maximum MRR was 0.004gm at concentration 25% Si and 75% Fe with gap 1.5mm,mesh size 100 and minimum metal removal rate was 0.0017gm at concentration 33% Si and 67% Fe ,gap 2 and mesh 200mm. Figure (6,7) show the maximum surface roughness at concentration 25% Si and the concentration 30% ,33% while Figure (9,10) gaps 1.5mm and concentration 25% ,30% causes rise of surface roughness more than (0.05 ,0.06 µm) and minimum surface roughness obtained at mesh 200 from 0.01-0.04µm so the value of metal removal rate while the maximum metal removal rate was at point 0.004gm and minimum was 0.002gm at concentration 33% and mesh 200.

Conclusions

From experiments and values of surface roughness and metal removal rate above can be concluded the following conclusions:

1. The mesh size and concentration of silicon carbide (SiC) abrasives have great significant on surface roughness and metal removal rate.
2. Also gap dimension between work piece and magnet has an effect
3. Minitab software 17 give good result for prediction the surface roughness and metal removal rate.
4. More than 98% percent agreement between experimental and theoretical values for surface roughness and metal removal rate.

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