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INFLUENCE OF SILICON CARBIDE (SIC) ABRASIVE ON SURFACE ROUGHNESS AND METAL REMOVAL RATE DURING MAGNETIC ABRASIVE FINISHING

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KEYWORDS: Abrasive silicon carbide (SiC), MAF Process, Surface roughness, MRR, Mesh Size.

ABSTRACT
Magnetic abrasive finishing (MAF) was advanced method used to remove metal by magnet abrasive from work metal which has important applications in (medical,aerospace parts and dies) .this paper focused into the influence of abrasive of silicon carbide (SiC) into surface roughness and metal removal rate , other parameters were taken into consideration (gap between workpiece and poles ,mesh ,concentration) experiments prove that the best surface roughness can be obtained when machining workpiece of low carbon steel by silicon carbide (Sic) was 0.007µm at concentration 33% Si and 67% Fe with gap 2mm , mesh size 200 and maximum metal removal rate can be obtained 0.004gm at concentration 25% Si and 75% Fe with gap 1.5mm,mesh size 100 while maximum value of surface roughness was 0.073µm at concentration 25 % Si and 75% Fe with gap 1.5mm, mesh size 100.

INTRODUCTION
Magnetic Abrasive Finishing (MAF) process is one of nontraditional 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 as shown in Fig. (1) 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. JAYSWAL etal (2005) focused on 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]

Saad kariem Shather etal (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 Guo etal (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].

Principle of MAF
The principle of magnetic abrasive finishing (MAF) is based on magnet abrasive which consist of two types of powders mixed together with different percentage usually used (67-80% pure iron +20-33% abrasive Sic,Al2O3,WC).after mixed powder put into furnace to 250-450 C° (sintering process) then filled gap with powder to remove metal from part which machined.[9]

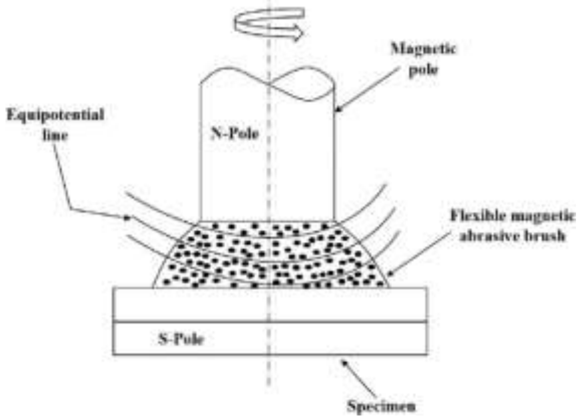

Figure (1) principle of MAF process [2]

ABRASIVE

There are different types of magnetic abrasive were used in MAF process , the common abrasive was tungsten, silicon carbide, aluminum oxide ,diamond which are mixed with iron powder at different concentration and mesh. The abrasive magnetic play important role in machining and finishing process to enhance the surface layer.[10]

In this paper silicon carbide was used as abrasive to enhance the surface layer.

EXPERIMENTAL PROCEDURE

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 as shown in Figure (4) to machine workpiece 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 was (4 x 60 x 100 mm) as shown in Figure (2).

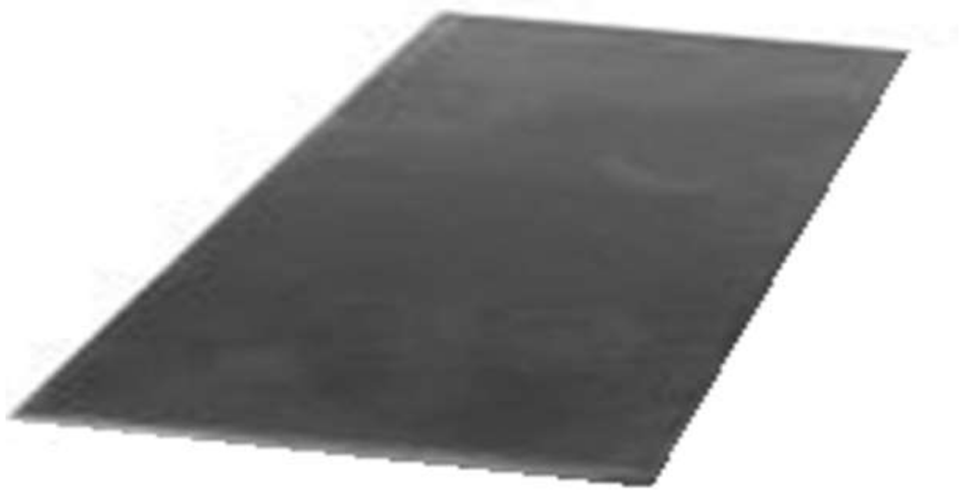

Figure (2) workpice

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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 (3) 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 250 C° sintering process.

Figure (3) Abrasive of silicon carbide

Figure (4) Type of binder

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Figure (5) machine of MAF process

Table (2) 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	Ra before machining, µm	Ra after machining, µm
1-	SiC 25% - Fe 75%	100	1.5	0.166	0.073
2-	SiC 25% - Fe 75%	100	2	0.170	0.068
3-	SiC 25% - Fe 75%	200	1.5	0.126	0.042
4-	SiC 25% - Fe 75%	200	2	0.146	0.028
5-	SiC 30% - Fe 70%	100	1.5	0.161	0.061
6-	SiC 30% - Fe 70%	100	2	0.135	0.051
7-	SiC 30% - Fe 70%	200	1.5	0.173	0.033
8-	SiC 30% - Fe 70%	200	2	0.132	0.017
9-	SiC 33% - Fe 67%	100	1.5	0.144	0.053
10-	SiC 33% - Fe 67%	100	2	0.121	0.044
11-	SiC 33% - Fe 67%	200	1.5	0.133	0.014
12-	SiC 33% - Fe 67%	200	2	0.162	0.007

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

No	Concentration of SiC abrasive	Mesh	Gap ,mm	Wt% before Machining(gm)	Wt% after machining,(gm)	MR,gm	MRR,gm/min
1-	SiC 25% - Fe 75%	100	1.5	175.158	175.03	0.128	0.0044
2-	SiC 25% - Fe 75%	100	2	197.417	197.32	0.097	0.0033
3-	SiC 25% - Fe 75%	200	1.5	194.182	194.09	0.092	0.0030
4-	SiC 25% - Fe 75%	200	2	92.306	192.24	0.066	0.0021
5-	SiC 25% - Fe 75%	100	1.5	165.515	165.39	0.125	0.0040
6-	SiC 25% - Fe 75%	100	2	185.513	185.42	0.093	0.0031
7-	SiC 25% - Fe 75%	200	1.5	172.093	172.01	0.083	0.0028
8-	SiC 25% - Fe 75%	200	2	185.581	185.52	0.061	0.0019
9-	SiC 33% - Fe 67%	100	1.5	176.727	176.61	0.117	0.0038
10-	SiC 33% - Fe 67%	100	2	182.414	182.33	0.084	0.0027
11-	SiC 33% - Fe 67%	200	1.5	176.456	176.38	0.076	0.0026
12-	SiC 33% - Fe 67%	200	2	175.024	174.97	0.054	0.0017

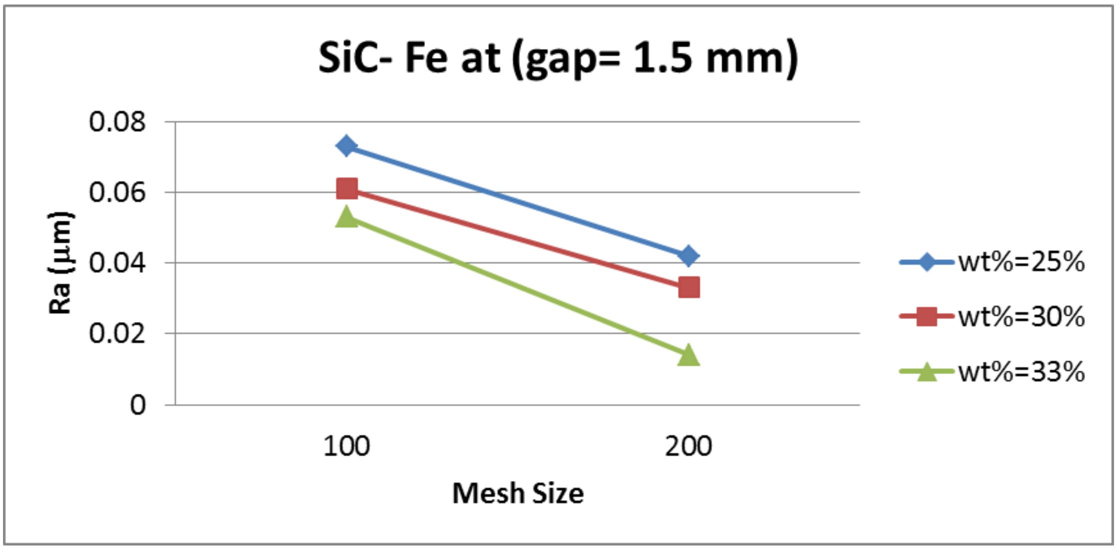

Figure (6) Relationship between mesh size and surface roughness at gap 1.5mm

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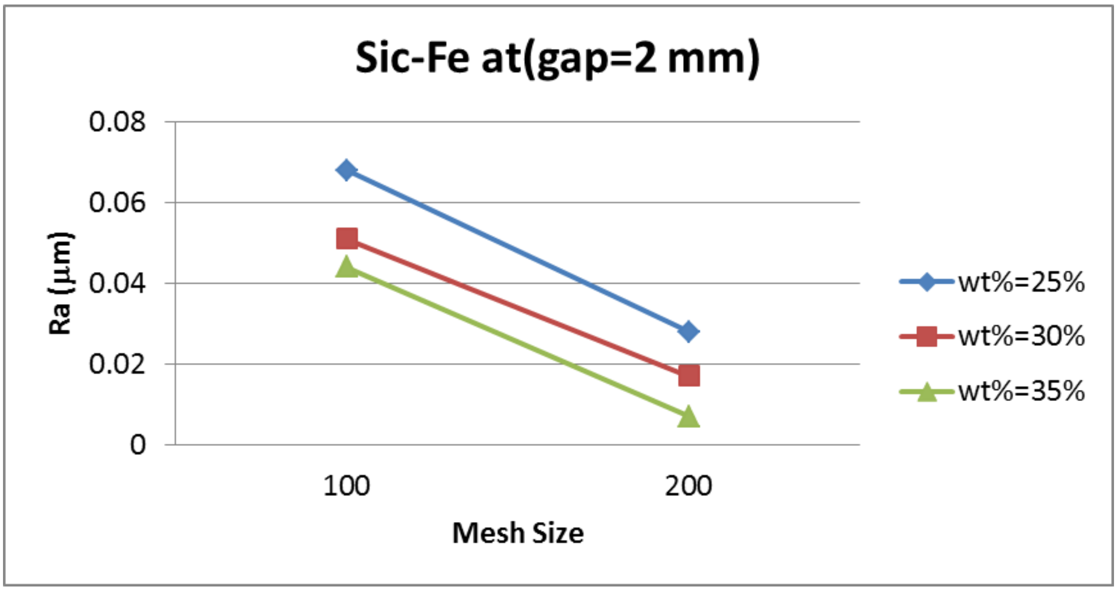

Figure (7) Relationship between mesh size and surface roughness at gap 2mm

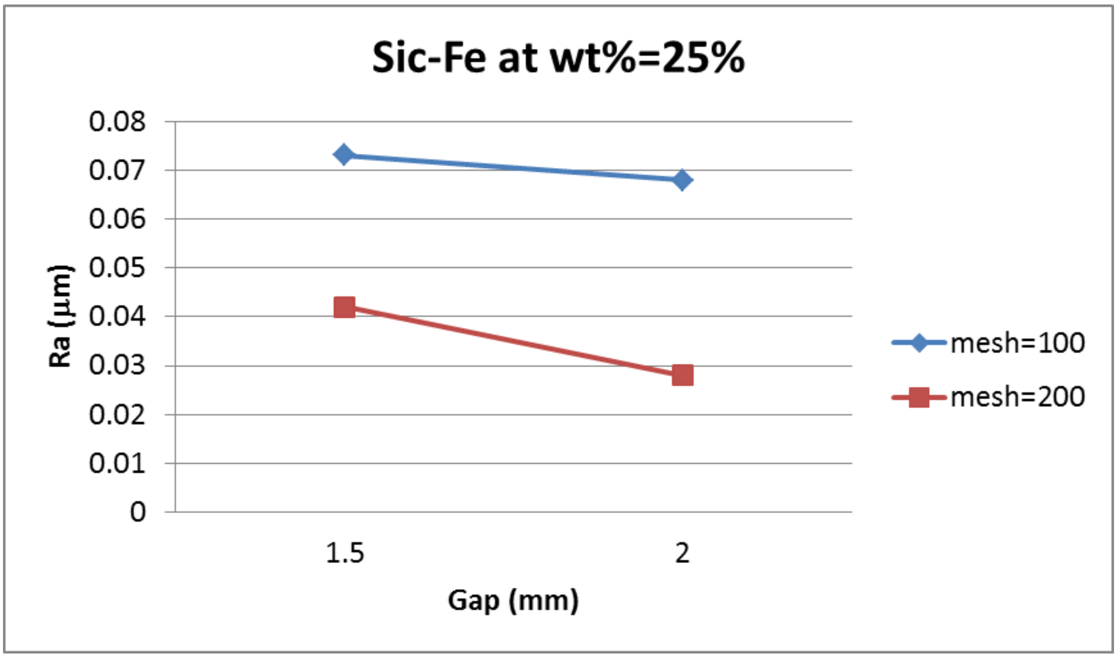

Figure (8) Relationship between gap size and surface roughness at 25% Si

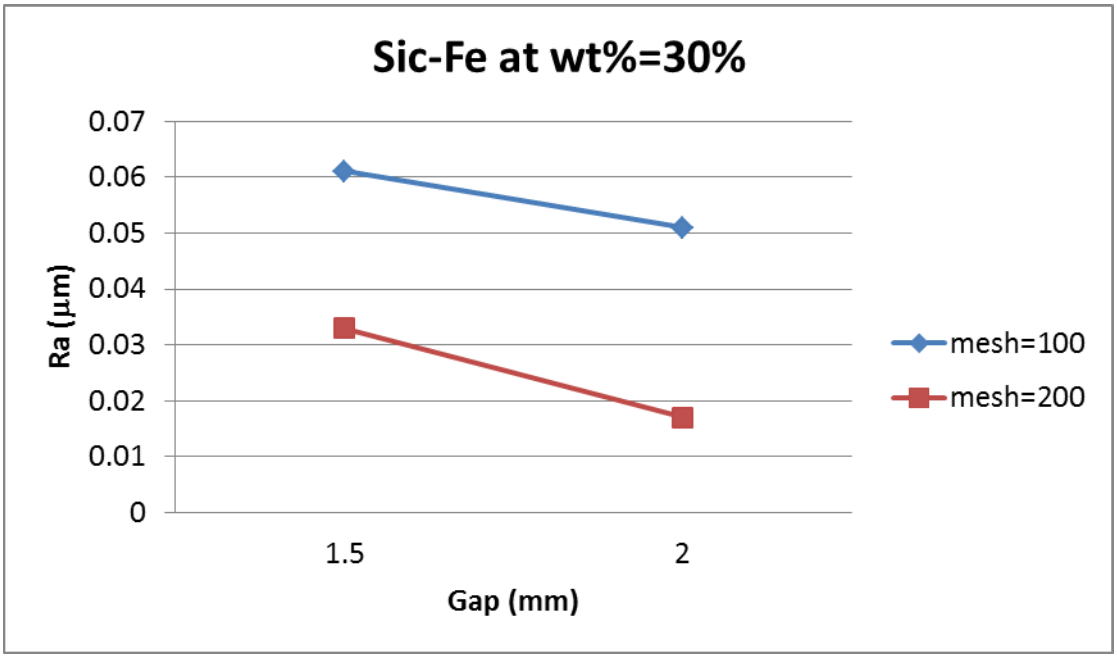

Figure (9) Relationship between gap size and surface roughness at 30%Si

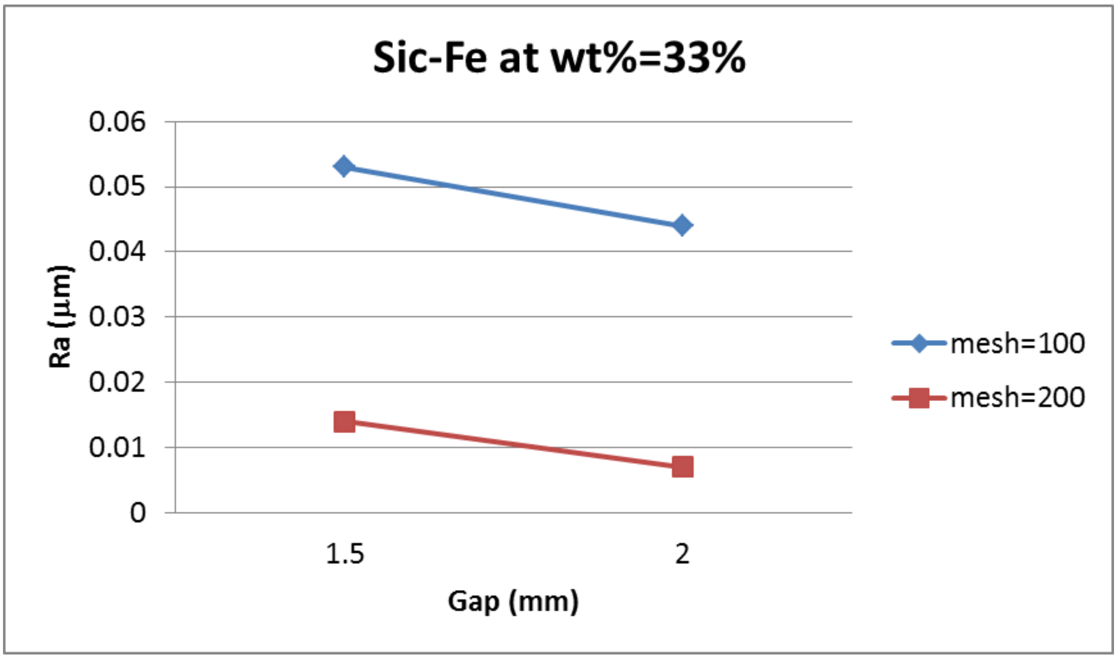

Figure (10) Relationship between gap size and surface roughness at concentration 33% Si

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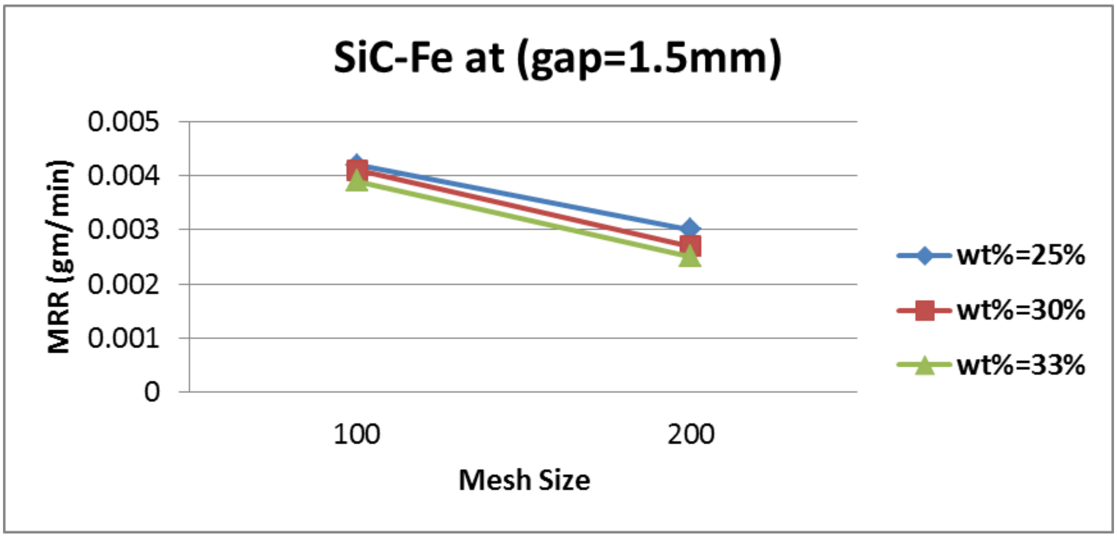

Figure (11) Relationship between mesh size and surface roughness at gap 1.5 mm

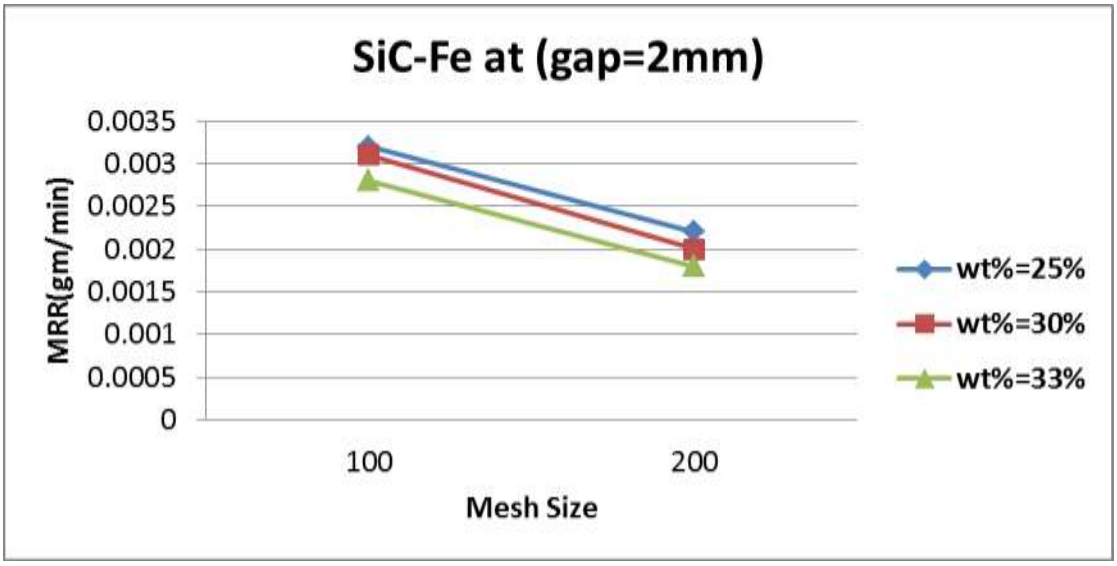

Figure (12) Relationship between mesh size and surface roughness at gap 2mm

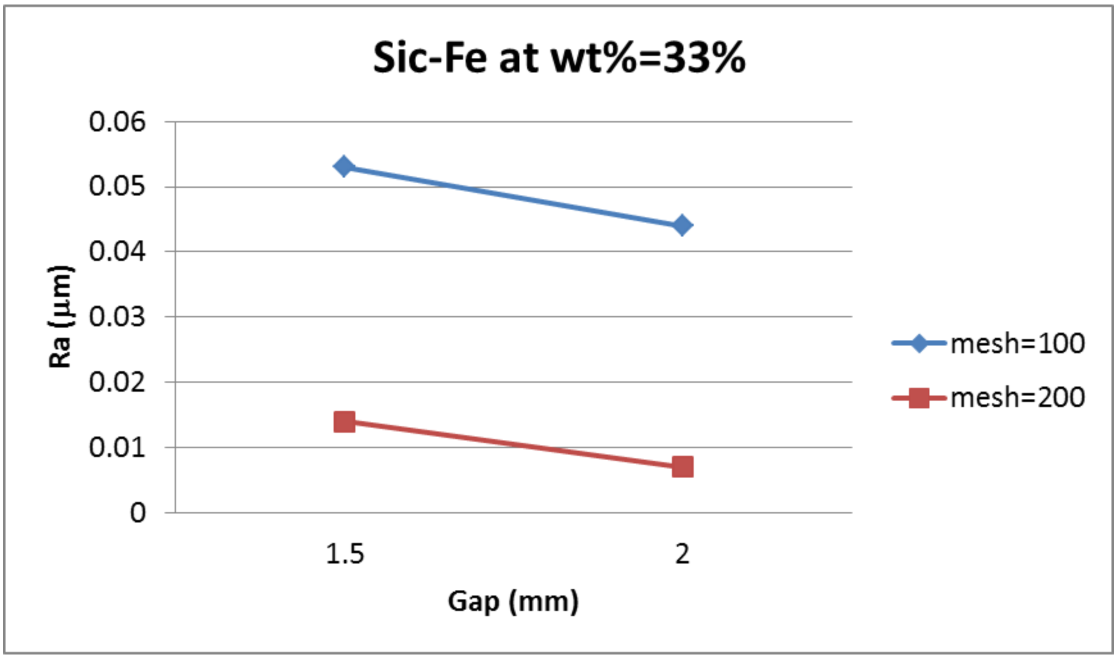

Figure (13) Relationship between mesh size and surface roughness at concentration 33% Si

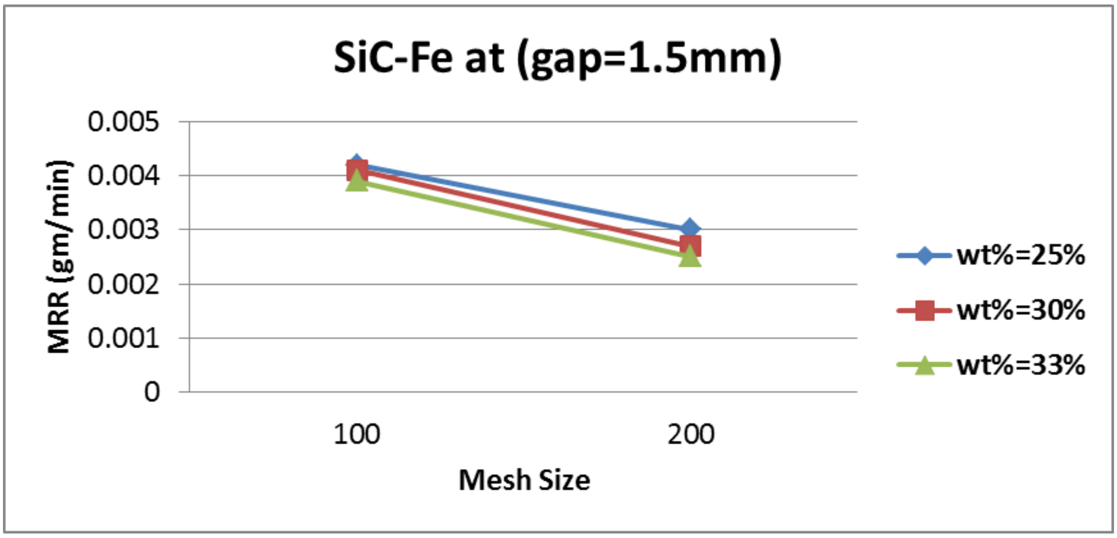

Figure (14) Relationship between mesh size and metal removal rate at gap 1.5mm

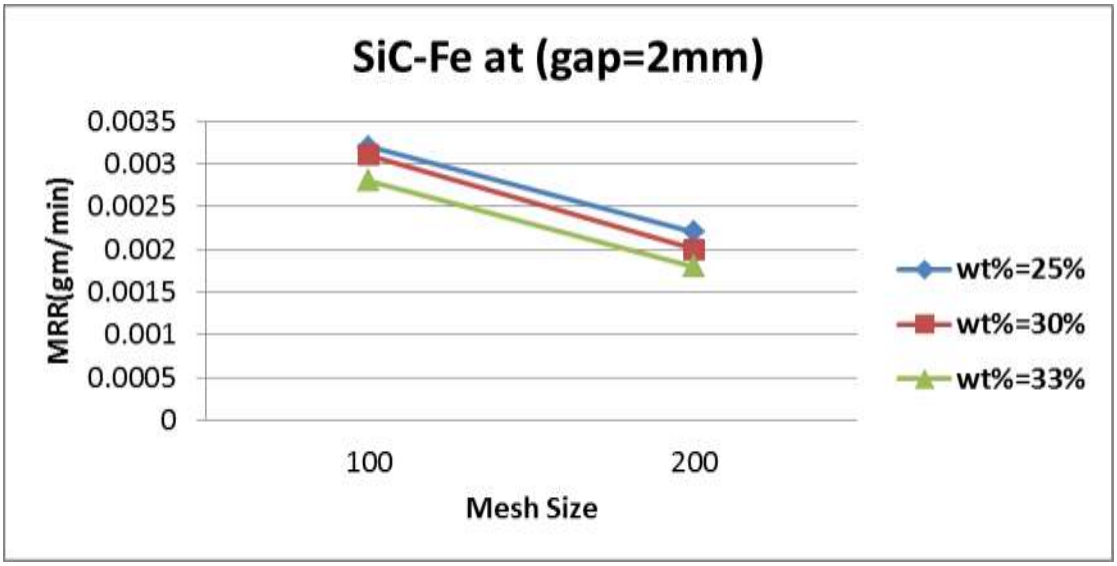

Figure (15) Relationship between mesh size and metal removal rate at gap 2mm

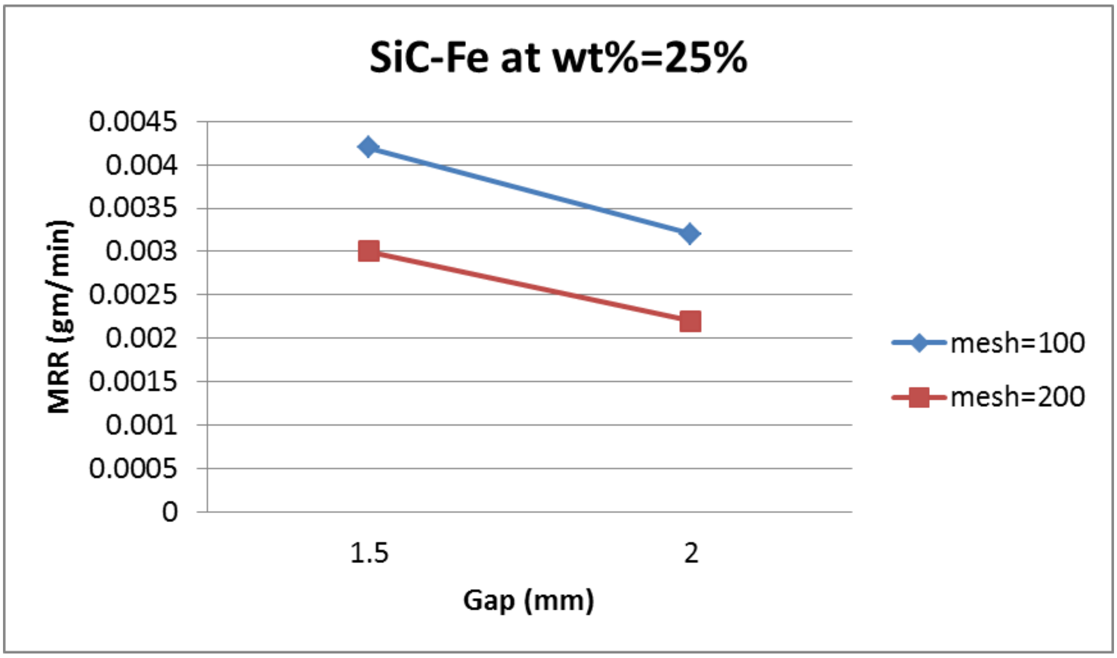

Figure (16) Relationship between gap size and metal removal rate at concentration 25% Si

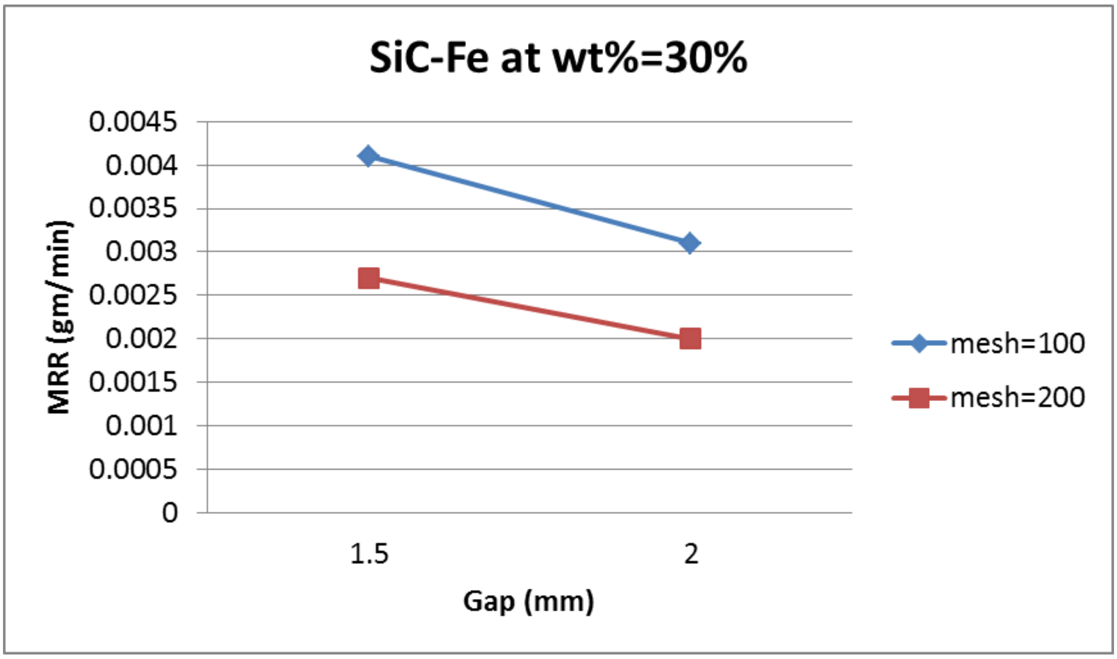

Figure (17) Relationship between gap size and metal removal rate at concentration 30% Si

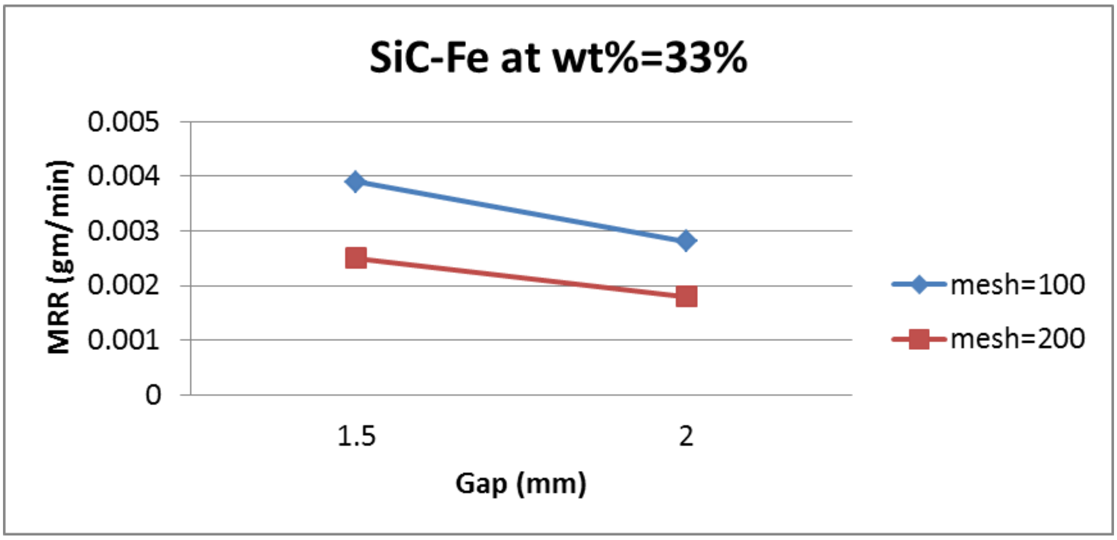

Figure (18) Relationship between gap size and metal removal rate at concentration 33% Si

SURFACE ROUGHNESS DEVICE

Surface roughness device was used to measure the surface roughness (Ra) of machined surface shown in Figure (19)

Figure (19) surface roughness device

WEIGHTING DEVICE

This device was used to weighed the workpiece before and after machining by using MAF process (MR).

Figure (20) device for weight

RESULT AND DISCUSSION

From experiments and 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 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 0.01-0.04 µm so the value of metal removal rate from Figure (14 ,15,16,17) shows the maximum metal removal rate was at point 0.004gm and minimum was less than 0.002gm at concentration 33% and mesh 200.

CONCLUSIONS

From all experiments and Figures above can be concluded the following conclusions:
1- The best surface Roughness was at maximum concentration 33% Si abrasive.
2-The maximum surface roughness was obtained by low concentration of Si abrasive 25% and low size of mesh and gap.
3-Maximum metal removal rate (MRR) was obtained from small gap, mesh and low concentration of Si abrasive.

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