Influence of boron carbide on surface roughness and metal removal rate during magnetic abrasive machining process

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Abstract:

Magnetic abrasive finishing (MAF) is one of advanced finishing process which has special applications in medical equipment, dies, cutting tools , aerospace. This paper was focused on boron carbide (B_4C) with iron powder which mixed together to perform finishing process into magnetic abrasive finishing . experiments show that boron carbide enhanced the surface roughness from (0.15-0.088) µm at concentration 25% boron carbide and 75% iron powder ,mesh100, gap 1.5mm and the best value of surface roughness was 0.011µm while the concentration 33% boron carbide and 67% iron powder , mesh 200, gap 2mm otherwise the maximum value of metal removal rate obtained 0.0045 gm/min at concentration 25% boron carbide and 75% iron powder , mesh 100, gap 1.5mm.

Keyword: **boron carbide, magnetic finishing , surface roughness, metal removal rate**

Introduction:

Today the advanced machining process has great influencing in industrial life and their applications The magnetic abrasive Finishing (MAF) process which is a highly developed to improve the surface layer of work material and highly quality of product in industries require excellent surface finish when comparing with super finishing, grinding, polishing and buffing are used to modify the surface texture produced by manufacturing process. [1,2,3]

Yahya (2010) studied the magnetic abrasive powder used 33%Fe and 67% Quartz of (250µm mesh size). the lubricant type SAE 20W was used as a binder for the powder contents. taguchi method was used for designing the experiments and the optimal values of the selected parameters were found that the most significant parameter is the working gap followed by the supplied current. Working stroke and the feed rate found to have a small effect on the change in workpiece roughness. Linear Regression analysis gives an accepted rapprochement with the experimental data. the obtained data show that the values of ΔRa increase with increasing the supplied current while it decreases with increasing the values of the working gap, stroke and the feed rate.[4]

Actul Babbae etal (2017) study the influence of boron carbide (B_4C) on surface roughness using brass metal and their experimental results showed that rotational speed was the most significant parameter on change in surface roughness then the minimum surface roughness (Ra) achieved was 0.061 mm for initial value of 0.544 mm.[5]

Pranita A.Deshpande etal (2016) focused on the benefits of MAF which can be used for both external and internal surfaces. The difference between internal and external surfaces of finishing process. magnetic abrasive finishing (MAF) is capable of altering the surface texture of workpieces with complicated geometries made of hard materials with little cost compared to other texturing technologies such as high precision grinding. Magnetic abrasive finishing (MAF) is a finishing process that utilizes the manipulation of an abrasive and magnetic particle mixture with a magnetic field.[6,7]

Dr.Saad Kariem Shather etal (2019) focused on silicon carbide and 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 .[8]

Sri Ram Murthy etal (2019) focused on boron carbide and their mechanical properties

Due to its high hardness, corrosion resistance which is used as an abrasive in polishing and lapping applications, and also as a loose abrasive in cutting applications such as water jet cutting. [9]

Also saad kariem shather (2020) studied the combined abrasive from (silicon carbide and boron carbide) to enhance the surface roughness and metal removal rate instead of single abrasive, the surface roughness of work material enhanced from 1.58µm to1.05µm and the metal removal rate was enhanced from 0.050gm to 0.077gm.[10]

Experimental procedure:

The abrasive of boron carbide (B_4C) was used which mixed with iron powder at different percentages and sintered at furnace 250 C° to perform powder.

Preparation of Magnetic Abrasive Powder:

Powder from boron carbide was selected and prepared to use in experiments with grain size (50,100,150,200,250,300 µm) using sieving device which mixed with iron powder at different percentage as below:

- 25% B_4C + 75% Fe
- 30% B_4C +70% Fe
- 33% B_4C +67% Fe

Figure (1) boron carbide

Sintering and Heating:

There are several methods which have been used to fabricate bonded type magnetic abrasives, including sintering, attrition milling (mechanical alloying), and chemical reactions, The mixture is then heated to a temperature slightly below the melting temperature of iron. which heated to 250°C over a period of two hours.

Magnetic pole:

Magnetic pole was prepared to perform experiments during mechanical machining with six grooves as shown in Figure (2)

Figure (2) magnetic pole with six grooves

During machining the work piece was fixed on the table of milling machine by clamps when the machine is turned on, each piece is fixed in the slot of the fixture in such a way that the centre of the work piece coincides with the centre of the north pole of the magnet, then the gap is filled with ferromagnetic abrasive powder.

After 30 min of MAF measuring, achieved for the weight of the workpiece and surface roughness from the same random points that calculated before.

Figure (3) Magnetic abrasive machine

Work material : The work material was low carbon steel and the chemical composition shown in table (1)

Table (1) the chemical composition of low carbon steel and finishing the symbols which required to perform the goal of research

	Wt%	mesh	gap	Ra (µm) (before)	Ra (µm) (after) experimental	Ra (µm) theoretical

C%	Si%	Mn %	P%	S%	Cr %	Mo %	Ni%	Al%	Co%	Cu%	Ti%
0.0 649	0.1 31	0.4 14	0.01 94	0.00 49	0.3 73	0.00 28	0.03 01	0.02 10	0.01 02	0.01 11	0.0 015

V%	W%	Pb%	Sn%	B%	Ca%	Se%	Sb%	Ta	Fe
0.002 6	0.00 50	0.00 10	0.00 10	0.0007	0.00 05	0.00 10	0.00 81	0.02 50	98.86 97

Table (2) The surface roughness before and after machining

1	B_4C 25% + Fe 75%	100	1.5	0.156	0.088	0.093
2	B_4C 25%+ Fe 75%	100	2	0.164	0.081	0.087
3	B_4C 25% + Fe 75%	200	1.5	0.136	0.069	0.063
4	B_4C 25% + Fe 75%	200	2	0.139	0.065	0.058
5	B_4C 30% + Fe 70%	100	1.5	0.141	0.071	0.072
6	B_4C 30%+ Fe 70%	100	2	0.155	0.069	0.066
7	B_4C 30% +Fe 70%	200	1.5	0.152	0.041	0.042
8	B_4C 30% + Fe 70%	200	2	0.154	0.037	0.037
9	B_4C 33% + Fe 67%	100	1.5	0.162	0.059	0.057
10	B_4C 33% + Fe 67%	100	2	0.131	0.056	0.052
11	B_4C 33% + Fe 67%	200	1.5	0.160	0.028	0.027
12	B_4C33% + Fe 67%	200	2	0.157	0.011	0.022

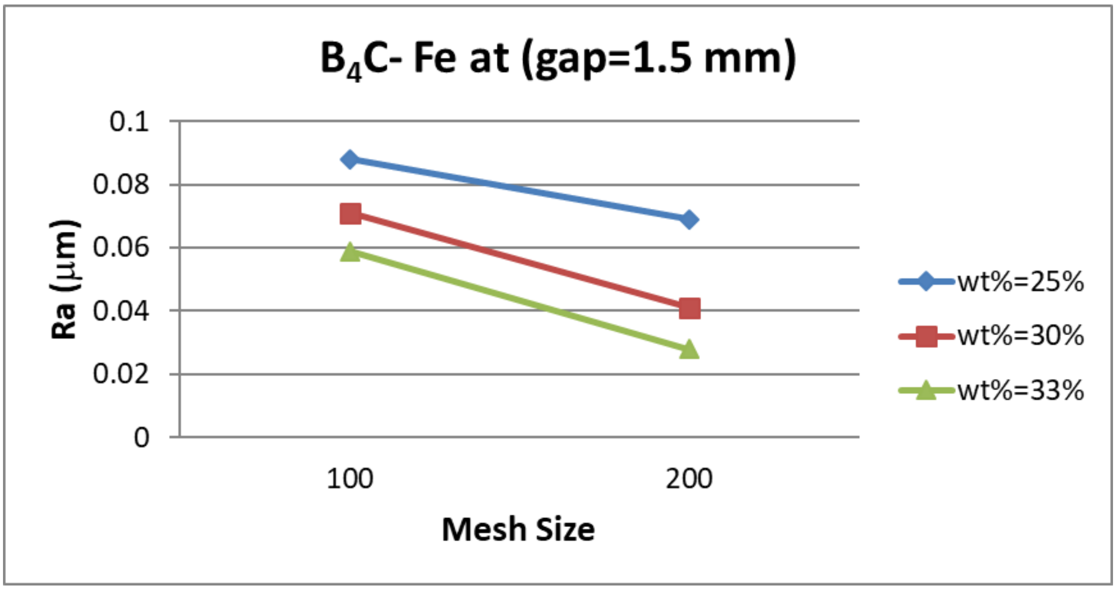

Fig (4) Effect of Mesh size and weight percent of B4C-Fe abrasive powder on Ra at gap=1.5 mm

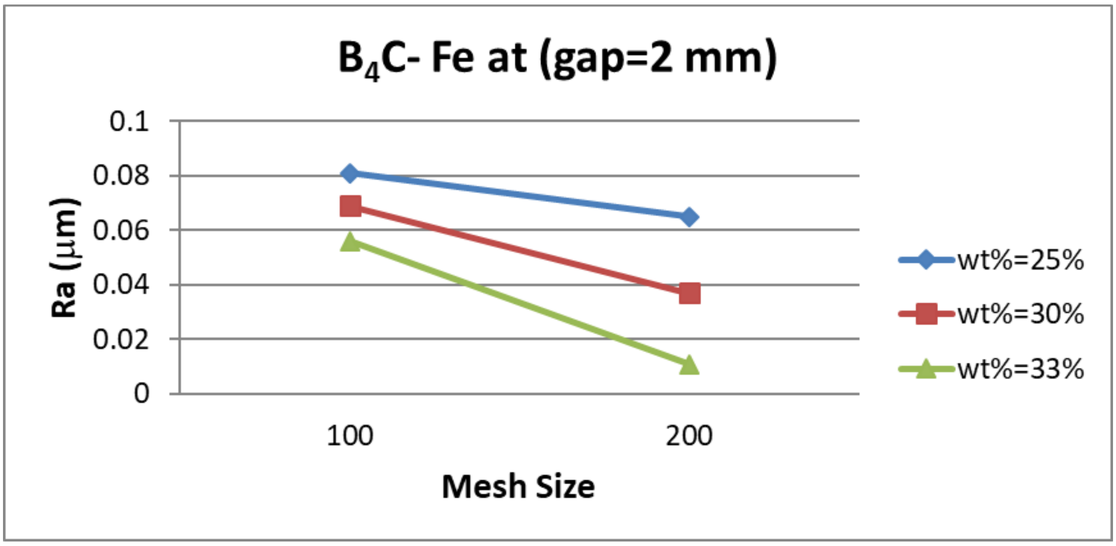

Fig (5) Effect of Mesh size and weight percent of B4C-Fe abrasive powder on Ra at gap=2mm

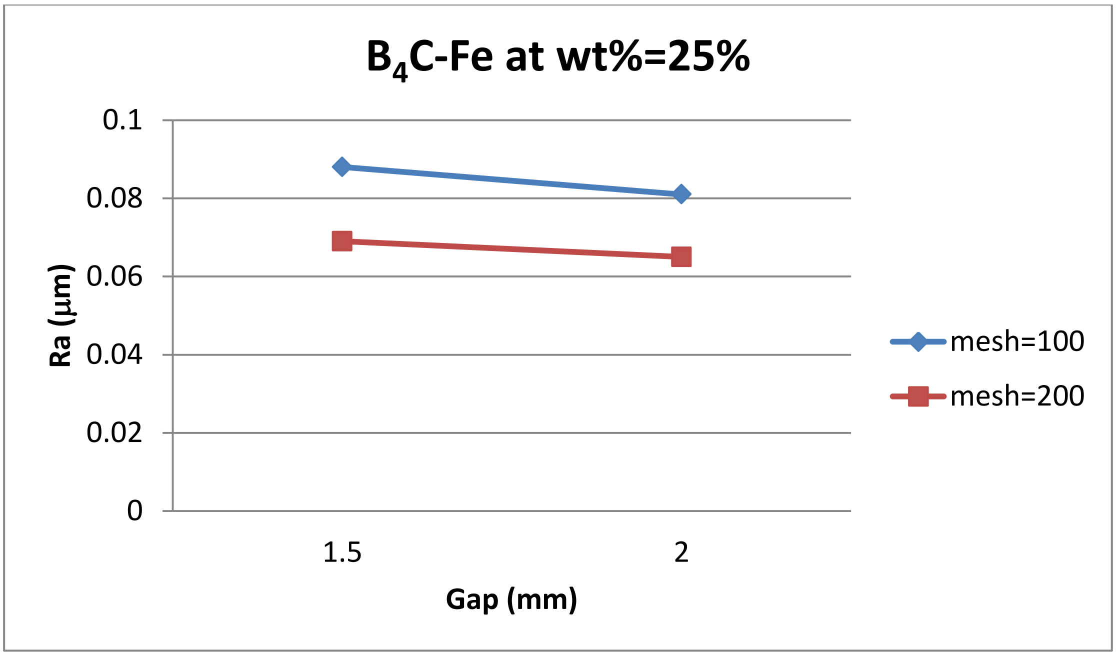

Fig (6): Effect of gap of B_4C-Fe abrasive powder on Ra at wt%=25

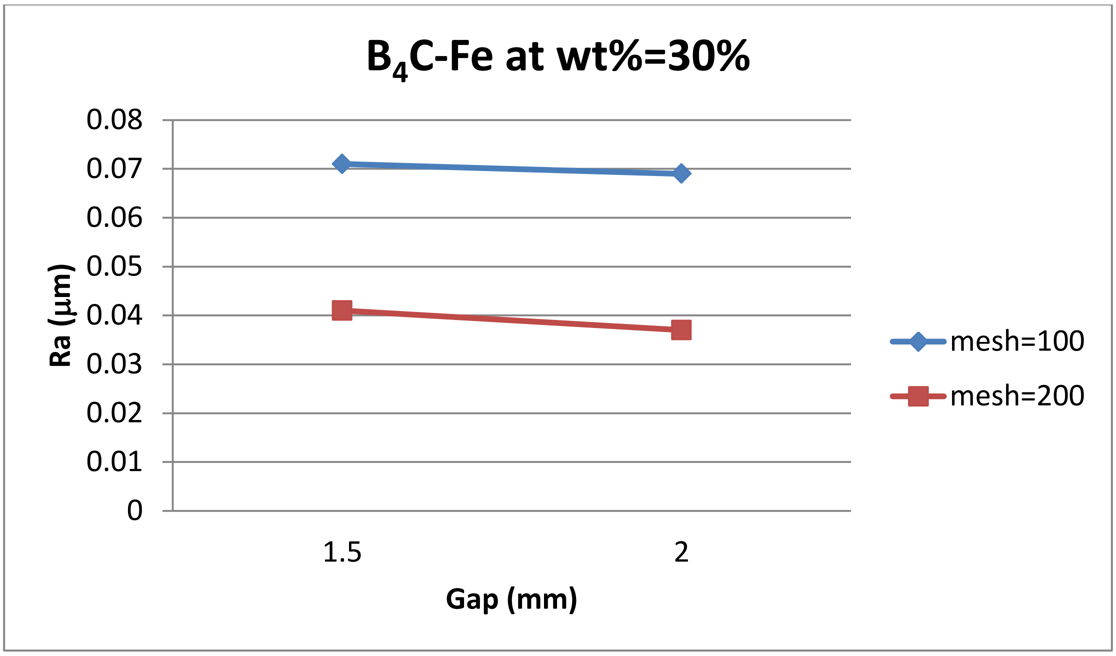

Fig (7): Effect of gap of B_4C-Fe abrasive powder on Ra at wt%=30

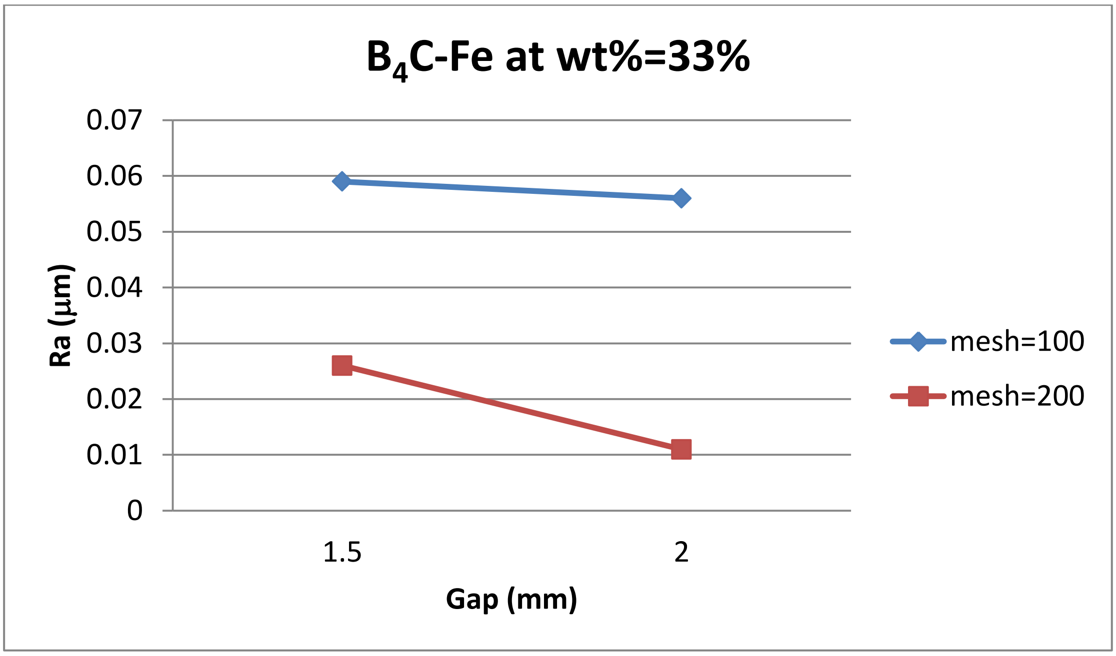

Fig (8) Effect of gap of B_4C-Fe abrasive powder on Ra at wt%=33

Table (3) Values of MRR for different wt% of B_4C abrasive, mesh size and working gap on (ASTM 415) low carbon steel

No.	Wt%	Mesh size	Gap (mm)	Wt (gm) before	Wt (gm) after	MR (gm)	MRR (gm/min)	MRR (gm/min) Theo.
1	25% B_4C + 75% Fe	100	1.5	171.895	171.76	0.135	0.0045	0.0043
2	25% B4C +75% Fe	100	2	181.315	181.21	0.105	0.0035	0.0036
3	25% B4C +75% Fe	200	1.5	177.484	177.39	0.094	0.0031	0.0033
4	25% B4C +75% Fe	200	2	197.086	197	0.086	0.0028	0.0026
5	30%B4C+70%Fe	100	1.5	268.399	268.27	0.129	0.0043	0.0041
6	30%B4C+70%Fe	100	2	236.409	236.31	0.099	0.0033	0.0034
7	30%B4C+70%Fe	200	1.5	251.008	250.92	0.088	0.0029	0.0031
8	30%B4C+70%Fe	200	2	233.19	233.11	0.08	0.0026	0.0024
9	30%B4C+70%Fe	100	1.5	246.845	246.72	0.125	0.0041	0.0038
10	33%B4C+67%Fe	100	2	209.429	209.34	0.089	0.0029	0.0031
11	33%B4C+67%Fe	200	1.5	198.741	198.66	0.081	0.0027	0.0028
12	33%B4C+67%Fe	200	2	208.722	208.65	0.072	0.0024	0.0021

Figure (9) Weight device

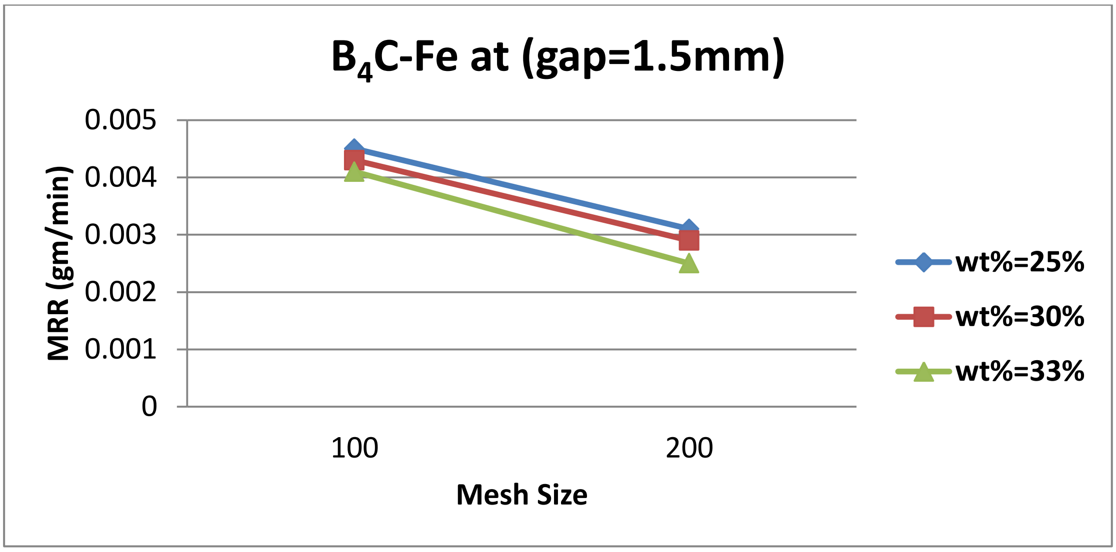

Fig (10) Effect of Mesh size and weight percent of B_4C -Fe abrasive powder on MRR at gap=1.5 mm

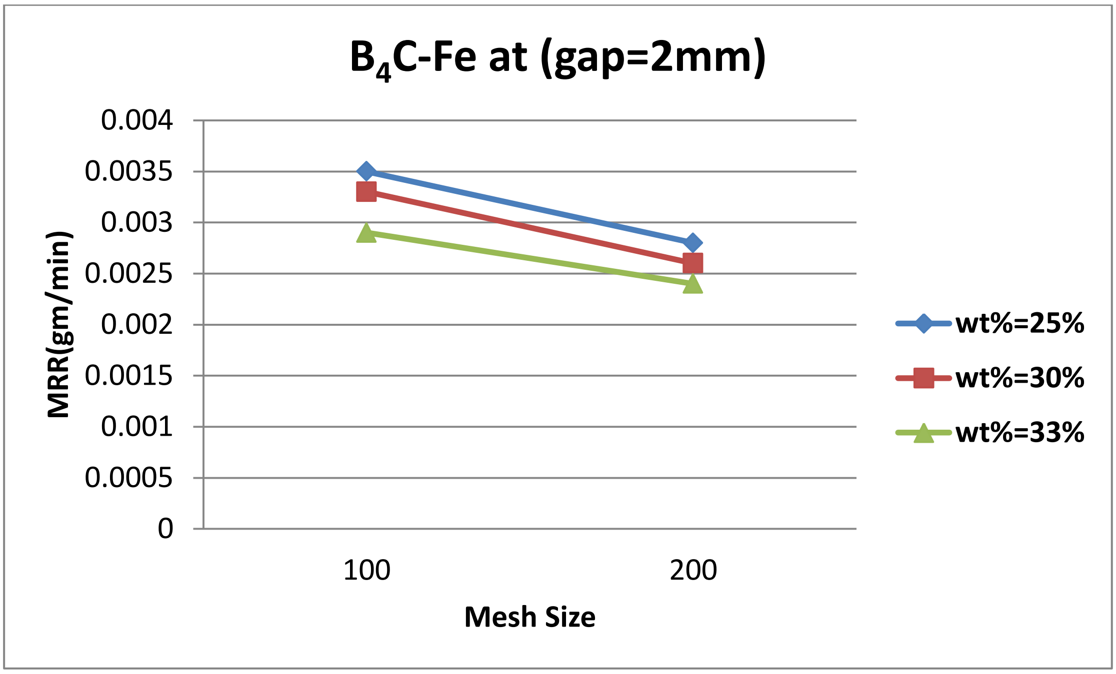

Fig (11) Effect of Mesh size and weight percent of B_4C -Fe abrasive powder on MRR at gap=2 mm

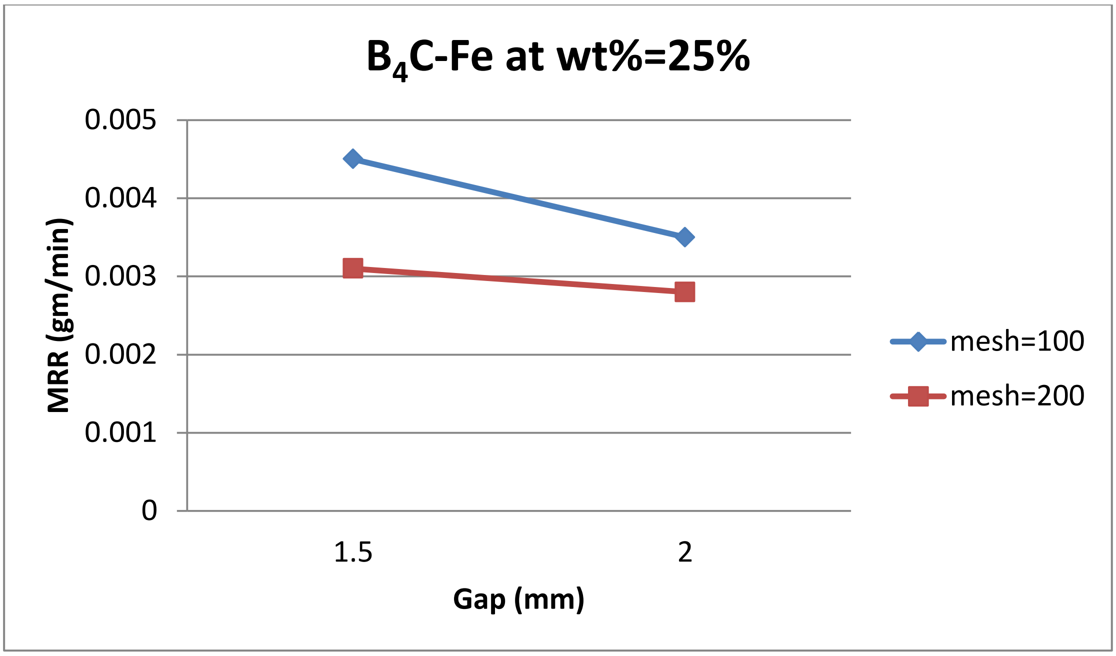

Fig (12) Effect of gap of B_4C -Fe abrasive powder on MRR at wt%=25

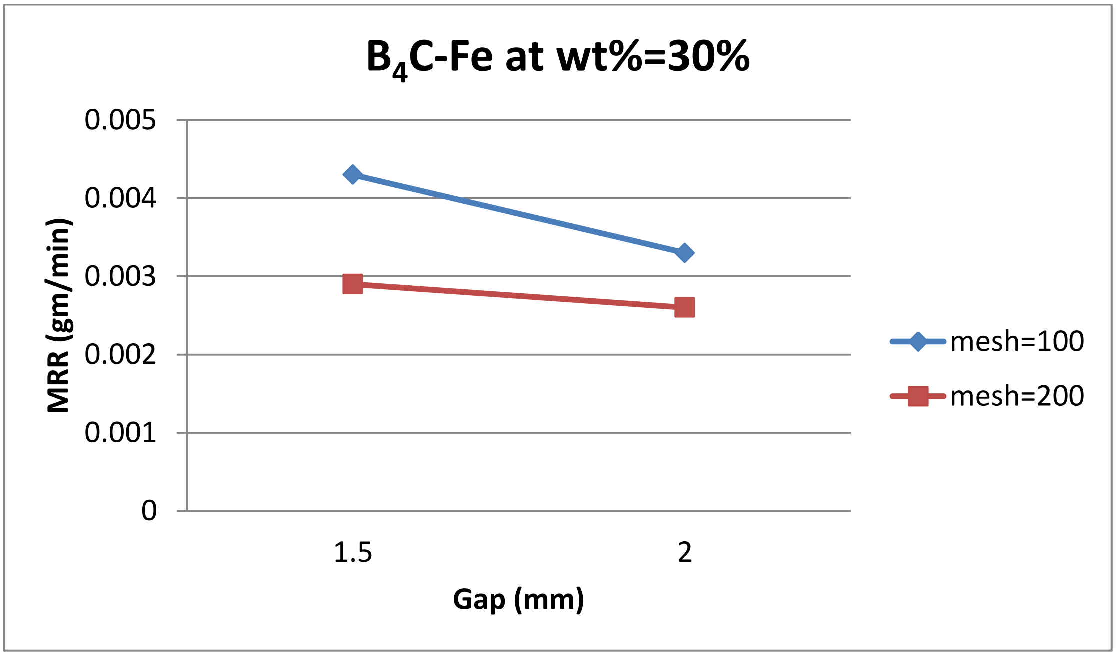

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Fig (13) Effect of gap of B_4C -Fe abrasive powder on MRR at wt%=30

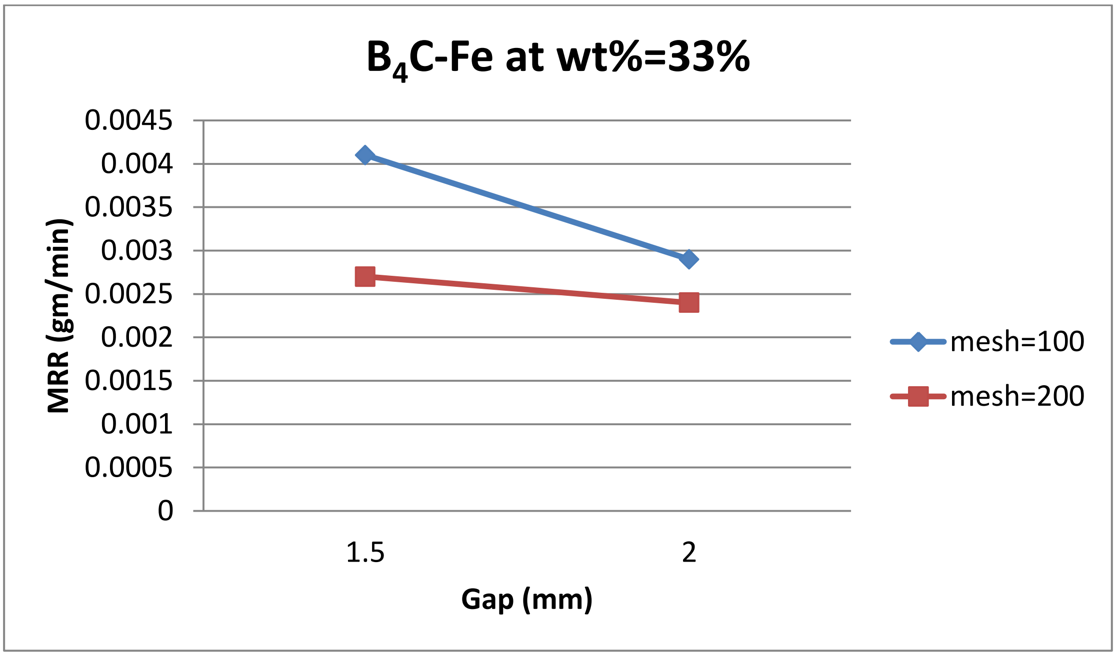

Fig (14) Effect of gap of B_4C-Fe abrasive powder on MRR at wt%=33

Result and discussion:

From table (2) and Figures (4,5) represent the relationship between the surface roughness and the mesh size at gap and increasing percentage of carbide lead to enhance surface roughness so at 25% boron carbide and 75% iron powder which is less than 0.08µm while the percentage of boron carbide 33% the surface roughness is 0.04 µm at gap 1.5mm , the same for Figure (6) the surface roughness was 0.06µm , percentage 25% , gap was 2mm and the surface roughness was less than 0.022µm , mesh 100 ,200 . Also Figures (7,8,9) shown the percentage of boron carbide (25%) , gap =1.5, mesh=100 and the surface roughness were0.088 and 0.069 while gap 2mm,mesh=200 the surface roughness were 0.069 and 0.063 µm. then at the percentage 30% boron carbide, gap=1.5mm , mesh 100 the surface roughness were 0.071, 0.072µm while the mesh 100 , gap=2 the surface roughness were 0.069 and 0.066µm so the same can be shown for percentage 33% , gap =1.5 , mesh 100 the surface roughness were 0.059 and 0.057µm while the mesh 200 , gap=2mm the surface roughness were 0.011 and 0.022µm respectively.

For metal removal rate (MRR) the table (3) and Figures (10,11,12,13,14) shows that the relationship between the gap , mesh , percentages and metal removal rate so for percentage 25% of boron carbide , mesh 100, gap=1.5mm the metal removal rate (MRR) was 0.0045gm/min while mesh 200,gap=2 the metal removal rate (MRR) was 0.0028gm/min also for 30% percentage of boron carbide ,gap =1.5mm obtained metal removal rate 0.0043 g/min and for 200 mesh ,gap=2mm the metal removal rate 0.0026 gm/min then the percentage 33% , gap=1.5mm the metal removal rate was 0.0027g/min and for gap=2mm, mesh 200 the metal removal rate was 0.0029g/min.

Conclusions:

From all above can concluded the following points:

1- Boron carbide has great impact in surface roughness and metal removal rate.
2- Mesh and percentage of born carbide have more significant than other parameters in magnetic abrasive finishing process.
3- Small size of gap influence in surface roughness and metal removal rate.

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