Electrolytic vs Carbonyl Iron Powders

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Industrial Metal Powders (I) Pvt. Ltd. Pune (India)

Motivation

- Vast application of Diamond cutting tools (DCTs) in stone cutting industries.

Dressing Operation

Segments of circular saw

Applications Of DCT

Segments Of Gangsaw

Incentive

- Iron base DCTs occupies major part (nearly 50% by wt.)
- Imported and costly Carbonyl Iron traditionally being used in DCT.
- Carbonyl-iron (C-Fe) can be effectively replaced by Electrolytic Iron (E-Fe) due to its better sintered properties viz. Hardness, Sintered density ,Wear and Fracture Test etc.
- It is an opportunity to reduce material cost of DCT without affecting the properties.

Experimental Work

Experimental Process

- Hot-Press sintering of Electrolytic iron (E-Fe) and Carbonyl iron (C-Fe) powders.

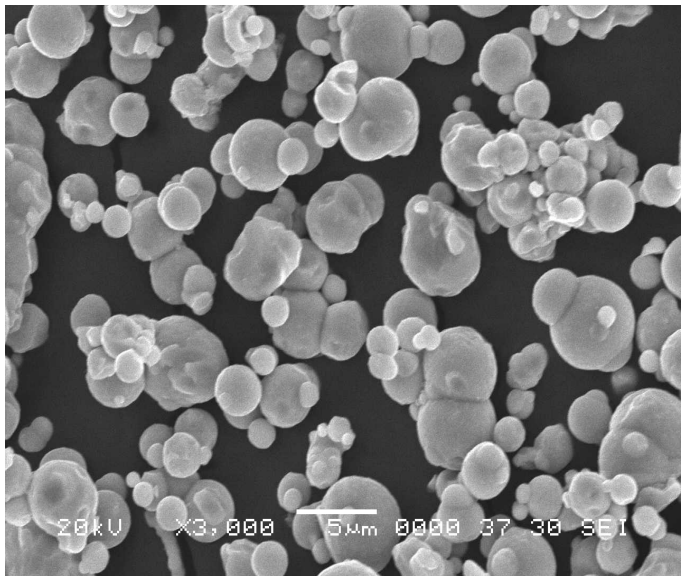
- Manufacturing of DCT using E-Fe and C-Fe.

Properties Of The Powders and Their sources

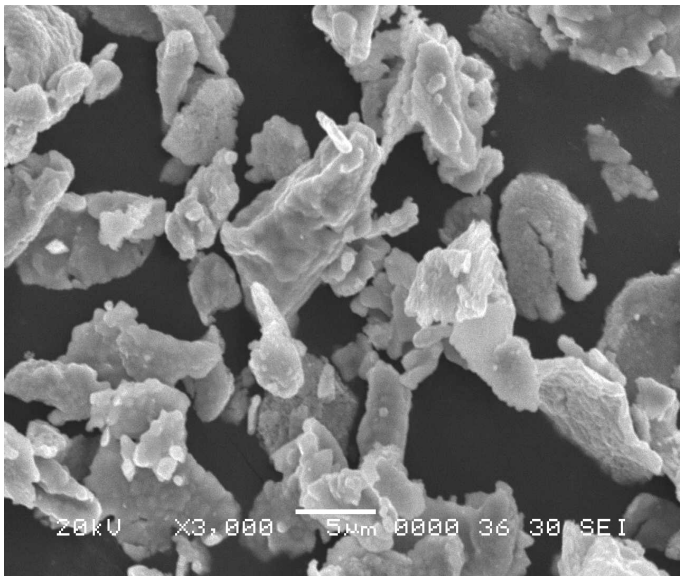
Sr. No.	Powder	Particle size (FSSS/ micron)	ASTM Sieve Size (mesh)	Apparent density (g/cc)	Make
1	**Electrolytic Iron (E-Fe)**	**2.4**	**2400**	**1.3**	**Industrial Metal Powders, Pune**
2	**Carbonyl Iron (C-Fe)**	**2.58**	**2400**	**2.6**	**Imported**
3	Electrolytic Copper	4.5	2400	1.20	Local
4	Cobalt	1.45	4800	1.40	Imported
5	Nickel	105	140	4.10	Imported
6	Fused Tungsten Carbide (FTC)	37 - 44	-325 + 400	6.07	Local
7	Aluminum	91	140	1.18	Local
8	Magnesium	52	270	0.64	Local

2380 grade imported diamonds of 50/60 mesh are used.

SEM Powder Morphology (3000X)



Carbonyl Iron



Electrolytic Iron

Hot-Press Sinterability

Of

Electrolytic Iron Powder (E-Fe)

And

Carbonyl Iron Powder (C-Fe)

Process Parameters For
Hot-Press sintering of Iron Powder

Cold pressing of powders in hydraulic press at 200 MPa pressure to form green compacts

Sintering at 850 ^{o}C for 3 min under 10 to 34 MPa in stepped manner

Characterization

Hardness	Density
(Rockwell B-scale)	(Archimedes Principle)

Hot-press sintering carried out at M/s Supercut, Mumbai.

Sintered Properties Of Iron Powders

Mixing in double cone blender

Mixing time 2 Hrs.

Without mechanical grinding

(no steel balls used during mixing)

Hot-press sintered at 850 ^{o}C for 3 min.

Parameters	E-Fe (TR grade)	C-Fe
Hardness (HRB)	83	64
Density (g/cc)	7.33	7.53
% Porosity	6.74	4.20

With mechanical grinding

(Steel balls used during mixing with ball to Powder ratio (10:1) by wt.)

Parameters	E-Fe (TR grade)	C-Fe
Hardness (HRB)	85	65
Density (g/cc)	7.46	7.54
% Porosity	5.08	4.04

Fabrication
Of
Diamond Cutting Tool (DCT)

Using E-Fe and C-Fe

Fabrication of DCTs using **Electrolytic Iron Powder** (E-Fe)

Tool	Matrix composition (wt. %)							
	E-Fe	Cu	Co	FTC	Ni	Al	Mg	Diamonds
A (DCT)	44.62	13.5	20	10	2	6	1	2.88
B (Dummy)	47.5	13.5	20	10	2	6	1	0

Fabrication of Diamond Cutting Tools (DCT) using **Carbonyl Iron Powder** (C-Fe)

Tool	Matrix composition (wt. %)							
	C-Fe	**Cu**	**Co**	**FTC**	**Ni**	**Al**	**Mg**	**Diamonds**
C (DCT)	44.62	13.5	20	10	2	6	1	2.88
D (Dummy)	47.5	13.5	20	10	2	6	1	0

Mfg. Of Diamond Cutting Tools By Hot-Press Sintering

Mixing of powders – ball milling

For 2 Hrs., powder to ball ratio (1:10) by wt.

Cold pressing at 200 MPa pressure in a hydraulic compaction machine

Sintering at 850 ^{o}C for 3 min under 10 to 34 MPa in stepped manner

Hot-press sintering carried out at M/s Supercut, Mumbai.

DCT made using Electrolytic iron powder

DCT using Carbonyl iron powder

Characterization of Diamond Cutting Tools

1. Hardness

- Hardness measured on B-scale (HRB) of Rockwell hardness tester with (1/16”) steel ball indenter at major load of 100 kg.

  (± 3HRB error)

2. Density

- Density measured by Archimedes principle by the following formula,

  (0.03 g/cc error)

$$\rho = \frac{ma}{(ma - mw)} \; x \; \rho w$$

Where,

ρ = density of sample (g/cc)

ρw = density of water (1g/cc)

m_a = mass of sample in air (gm)

m_w = mass of sample in water (gm)

3. Wear rate

- Wear test performed on pin on disc wear machine with following parameters

Parameter	
Sliding Distance (m)	3000
Sliding Speed(m/s)	2.34
Load (kg)	2
Pressure (MPa)	0.4
Counter surface Alumina Disc	Moh's Hardness 7

Properties Of Fabricated **Dummy** Tools

(without addition of diamonds)

Tool	850 °C			900 °C		
	Hardness HRB	Density (g/cc)	Wear Rate (mm^3/m)	Hardness HRB	Density (g/cc)	Wear Rate (mm^3/m)
B (E-iron)	103	7.13	4.126×10^{-4}	109	7.11	4.477×10^{-4}
D (C-iron)	106	7.56	10.3×10^{-4}	109	7.59	12.2×10^{-4}

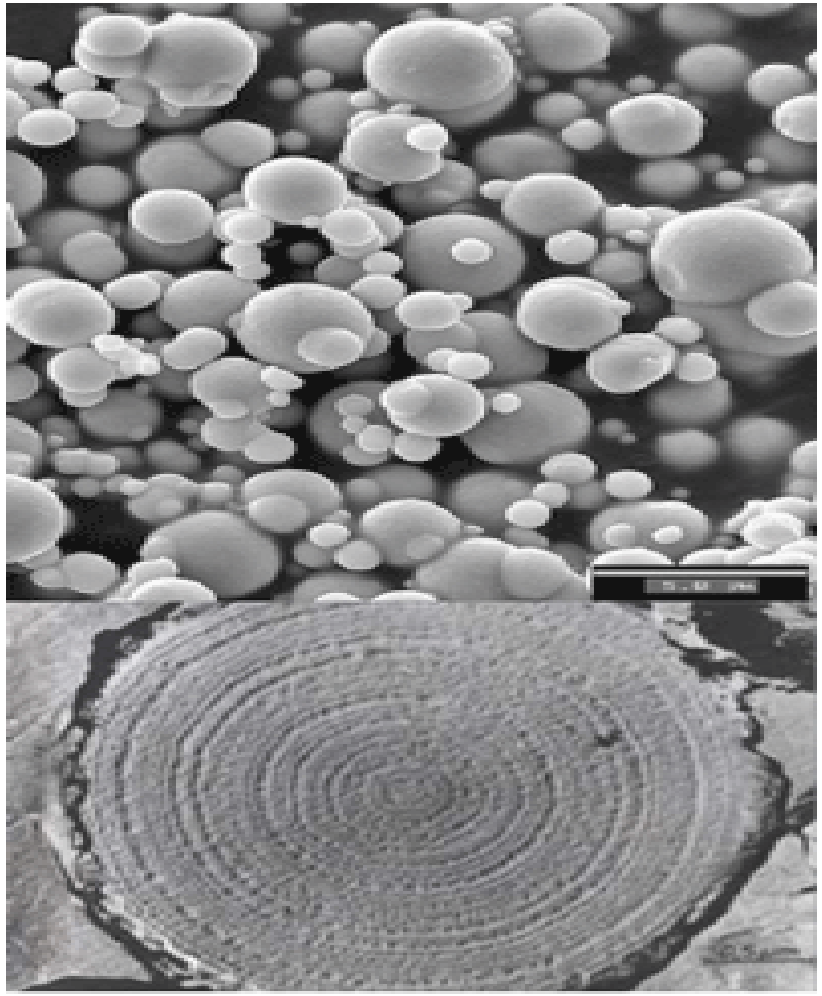
Properties Of Fabricated **Diamond** Cutting Tools
(addition of diamonds)

Tool	850 °C			900 °C		
	Hardness HRB	Density (g/cc)	Wear Rate (mm^3/m)	Hardness HRB	Density (g/cc)	Wear Rate (mm^3/m)
A (E-iron)	103	6.88	0.29×10^{-4}	102	7.04	3.551×10^{-4}
C (C-iron)	106	7.32	9.34×10^{-4}	107	7.36	5.20×10^{-4}

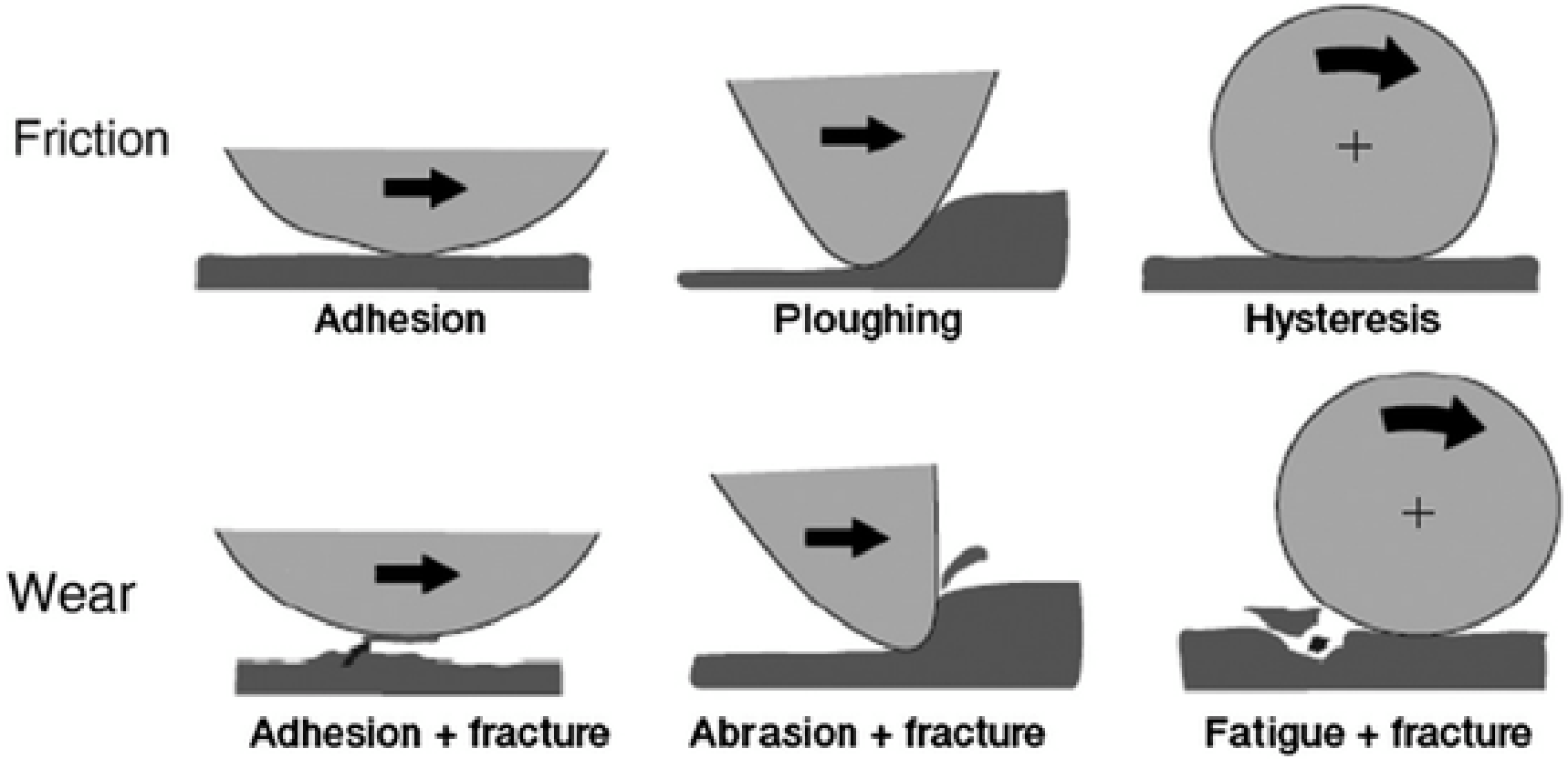
Significance of wear loss

- Low wear loss means more life to the diamond cutting tools.
- High wear loss less life more life to the diamond cutting tools.
- User of the tool is interested to maximize the life of the tools.
- High wear loss to carbonyl powder is due to onion like structure.

C-Iron: Onion like structure



Difference between Friction & Wear



Modes OF WEAR

TYPES	CONTRIBUTION
ABRASIVE	50 %
ADHESIVE	15 %
EROSION	8 %
FRETTING	8 %
CHEMICAL	5 %

Conclusions

- **Electrolytic iron exhibits higher hot-press hardness than carbonyl iron powder.**
- **Diamond Cutting Tools containing Electrolytic iron exhibits higher wear resistance.**
- **Electrolytic iron powder can replace carbonyl iron powder without affecting end properties of sintered diamond cutting tools and with improved wear resistance.**

!!! Thank you !!!

Question?

And

…Answers