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OPTIMIZATION OF MACHINING PARAMETERS ON S.G.CAST IRON DURING WIRE EDM PROCESS A REVIEW

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***Abstract* - Now a day's Electric Discharge Machining (EDM) is one of the most efficiently employed non-traditional machining processes for cutting hard materials, to geometrically complex shapes that are difficult to machine by conventional machines. S.G. Cast iron material has various industrial applications such as machinery, internal combustion engines, pumps and compressors. In the present work, an experimental investigation has been carried out to study the effect of voltage, current and various machining parameters like material removal rate, electrode wear and surface roughness in S.G. Cast iron. The materials used for the work were machined with different electrode materials such as copper, copper-tungsten and graphite. From in this Project output parameters such as material removal rate, electrode wear and surface roughness can be studied.**

Index Terms: **Electric Discharge Machining (*EDM), Optimization, Machining, S.G.Cast iron***

I. INTRODUCTION

Spheroidal graphite (SG) cast iron was discovered in the 1948. However, «lf coke (which is high in would have been accepted as the normal form of iron, with flake graphite iron only being discovered much later as an accident of adding S and O. This seems to have been close to the situation in China where spheroidal graphite irons were produced over 2000 years ago. The term Cast iron refers to an alloy of iron containing more than 2.0 percentage of carbon. The brittle behavior associated sulfur) had not been used for melting iron and if high purity ores had been used, then ductile iron with the cast iron is an outdated and widely held misconception which implies all cast irons are brittle and none of them are ductile in nature. Ductile iron is one form of cast iron which is ductile and it offers the designer a unique combination of high strength, wear resistance, fatigue resistance, toughness and ductility in addition to good castability, machinability and damping properties. Unfortunately these properties of SG iron are not widely well known because of the misconception about its brittle behavior.

SG iron is an alloy of iron and carbon having nodules or spheroids of graphite embedded in a ferrite-pearlitic matrix. The nodules are compact spheres and are sharp and regular. The graphite occupies about 10-15% of the total material volume and because graphite has negligible tensile strength, the main effect of its presence is to reduce the effective cross-sectional area, which means that ductile iron has tensile strength, modulus of elasticity and impact strength proportionally lower than that of a carbon steel of otherwise similar matrix structure.

II. EDM

Electrical Discharge Machining, commonly known as EDM is a non-conventional machining method used to remove material by a number of repetitive electrical discharges of small duration and high current density between the work piece and the tool. EDM is an important and cost-effective method of machining extremely tough and brittle electrically conductive materials. In EDM, since there is no direct contact between the work piece and the electrode, hence there are no mechanical forces existing between them. Any type of conductive material can be machined using EDM irrespective of the hardness or toughness of the material.

Electric discharge machining (EDM) (sometimes also referred to as spark machining, spark eroding, burning, die sinking or wire erosion) is a manufacturing process whereby a desired shape is obtained using electrical discharges (sparks). Material is removed from the work piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the 'tool' or 'electrode', while the other is called the work piece-electrode, or 'work piece'.

Figure: Basic Elements of an EDM system

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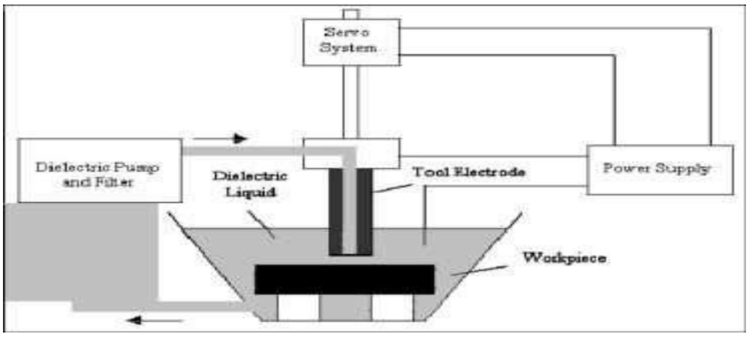
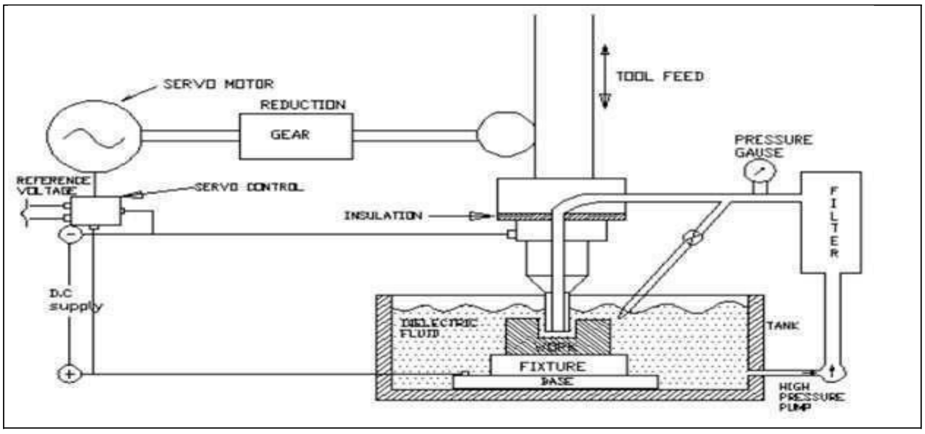


When the distance between the two electrodes is reduced, the intensity of the electric field in the volume between the electrodes becomes greater than the strength of the dielectric (at least in some point(s)), which breaks, allowing current to flow between the two electrodes. As a result, material is removed from both the electrodes. Once the current flow stops (or it is stopped depending on the type of generator), new liquid dielectric is usually conveyed into the inter-electrode volume enabling the solid particles (debris) to be carried away and the insulating proprieties of the dielectric to be restored. Adding new liquid dielectric in the inter-electrode volume is commonly referred to as flushing. Also, after a current flow, a difference of potential between the two electrodes is restored to what it was before the breakdown, so that a new liquid dielectric breakdown can occur.
Electrical discharge machining is a machining method primarily used for hard metals or those that would be very difficult to machine with traditional techniques. EDM typically works with materials that are electrically conductive, although methods for machining insulating ceramics with EDM have also been proposed. EDM can cut intricate contours or cavities in pre-hardened steel without the need for heat treatment to soften and re-harden them. This method can be used with any other metal or metal alloy such as titanium, inconel etc.
EDM is often included in the 'non-traditional' or 'non-conventional' group of machining methods together with processes such as electrochemical machining (ECM), water jet cutting (WJ, AWJ), laser cutting and opposite to the 'conventional' group (turning, milling, grinding, drilling and any other process whose material removal mechanism is essentially based on mechanical forces).

Principle of EDM:

In this process the material is removed from the work piece due to erosion caused by rapidly recurring electrical spark discharge between the work piece and the tool electrode. There is a small gap between the tool and the work piece. The work piece and tool both are submerged in dielectric fluid, commonly used are EDM oil, deionized water, and kerosene.

Figure: Experimental setup



Limitations of EDM:

a. The work piece has to be electrically conductive so that electric sparks can be generated.
b. The measure of the gap that is the distance between the electrode and the workpiece is not always easily predictable, especially in case of complex geometries.
c. The material removal rate is rather low in case of EDM; hence it is limited to the production of certain sections.
d. The electrical parameters used in the EDM process have to be optimized for best results.

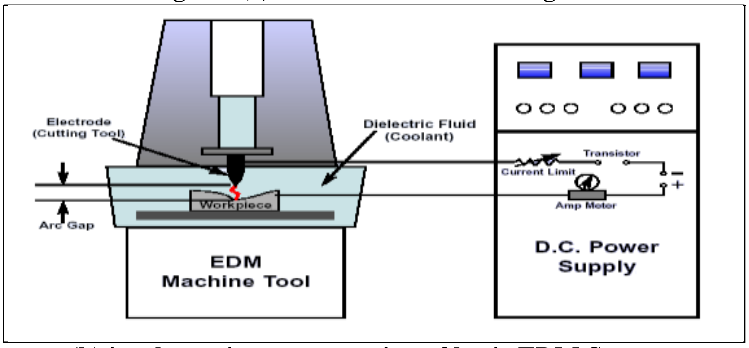
III. OPERATION OF ELECTRO DISCHARGE MACHINING (EDM)

EDM is a thermo-electrical material removal process, in which the tool electrode shape is reproduced mirror wise into a work material, with the shape of the electrode defining the area in which the spark erosion will occur. As shown on Figure 2.2(a) and figure 2.2(b), the EDM is accomplished with a system comprising two major components:

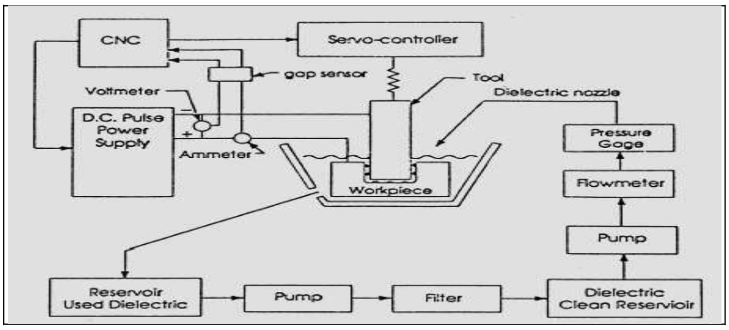
1) Machine tool
2) Power supply

The machine tool holds a shaped electrode, which advances into the work material and produces a high frequency series of electrical spark discharges. The sparks are generated by a pulse generator, between the tool electrode and the work material, submerged in a liquid dielectric, leading to metal removal from the work material by thermal erosion or vaporization.

Figure: (a) is the illustration and figure



(b) is schematic representation of basic EDM System.



Electrode:

EDM electrode materials and components consist of highly conductive and/or arc erosion-resistant materials such as graphite, copper or copper graphite. EDM is an acronym for electric discharge machining, a process that uses a controlled electrical spark to erode metal. EDM electrode materials include components made from brass, copper and copper alloys, graphite, molybdenum, silver and silver tungsten and also the moly combinations.

EDM electrodes are manufactured in variety of forms such as coated wire, tube shaped, or bar stock, depending on the EDM electrode materials used and the application. A brass electrode is easy to machine and can also be die cast or extruded for use in special applications. However, brass is not as wear-resistant as other EDM electrode materials, such as copper or tungsten, so it is typically used to make EDM wire. Copper is a common base material because it is highly conductive and strong. A copper tungsten electrode is used in resistance welding electrodes and in circuit breakers. A copper zirconium diboride electrode is similar to a copper tungsten electrode, but has much higher erosion resistance and is more expensive to produce. A tellurium copper electrode is easy to machine and is useful in applications that require an electrode with a fine finish.

Flushing:

Flushing is important because it removes eroded particles from the gap for efficient cutting. Flushing also enables fresh dielectric oil flow into the gap and cools both the electrode and the work piece. Improper flushing causes erratic cutting, thus prevents the electrode from cutting efficiently. It is then necessary to remove the attached particles by cleaning the work piece. Dielectric fluid is used as flushing to assist in the removal process of particles from the work area hence giving better surface finish [9].

There are five types of flushing fluid that usually use in system in EDM; [10]. Two of the types of flushing are;

1) Pressure flushing
2) Through electrode

Wire-EDM Technology:

This logical dimension is depending on the chosen technology, which is finally machine dependent. Since the logical diameter of the tool is technology and machine dependent, therefore the offset paths of the final part can only be determined if the selected technology and machine is known. Furthermore there is no "analytical approach" to determine the logical radius of the wire Gabor Erdos (2004). It is determined based on experiments. Beside the logical diameter of the wire, there are many factors that determine the offset. In wire EDM there are basically three type of working mode:

• Roughing
• Finishing
• Surface finishing

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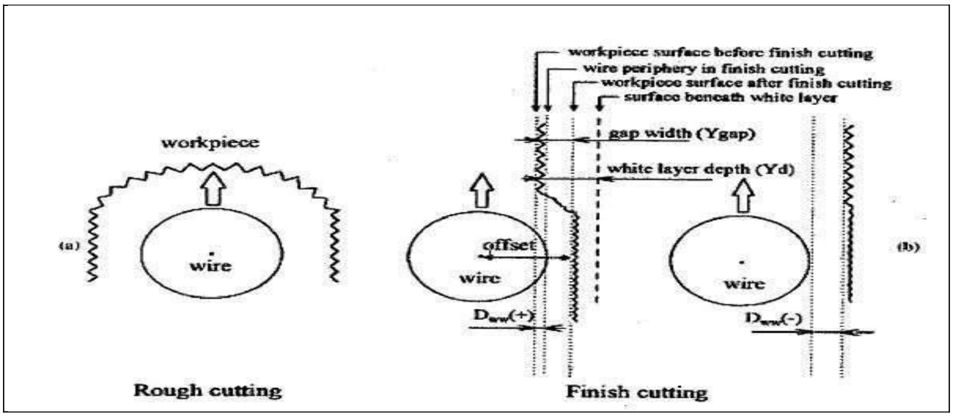
Figure: A schematic plan view of (a) a rough (b) finish,



The number of working modes required to manufacture the same part on deferent machines is also machine dependent. The same part might require 1 roughing, 2 finishing and 3 surfaces finishing on one machine and 1 roughing 3 finishing 1 surface finishing working step on another machine.

The technological parameters- which are principally the settings of the generator- used for these manufacturing steps are also different and proprietary to the machine builders. This implies that it is rather difficult to define global working steps like in milling, because the definition of the technology of these working steps varies from machine to machine.

IV. EXPERIMENTAL PROCEDURE

The experimental procedure for the project work can be listed as:

1) Specimen preparation
2) Surface finish
3) Chemical composition
4) Microstructure

Specimen Preparation:

Figure: Specimen Preparation

Specimen – Rectangular Block of 300*100*28

Specimen	C%	MN %	SI %	S %	P %	MG %
BLOCK	3.3	0.46	2.65	0.088	0.088	0.091

5	Current	3 amps
6	Water Pressure ($W_{p)}$	1bar
7	Wire Feed (WF)	2mm/min
8	Wire Tension (WT)	7
9	Servo Voltze (SV)	20v

10	Servo Feed (SF)	2100
11	Machining Time	52 min

Specimen – Rectangular Block (2 nd machining process)

1. Diameter of wire : 0.25 mm
2. Type of wire: copper with brass coating wire.
3. Desired shape to be made from rectangular block: Rectangular rod of length 10 mm.

S.No	Parameter	Value
1	Pulse on Time (Ton)	130
2	Pulse off Time (Toff)	56
3	Wire Power (I_p)	230
4	Wire gap (V_p)	2
5	Current	3 amps
6	Water Pressure ($W_{p)}$	1
7	Wire Feed (WF)	2
8	Wire Tension (WT)	7
9	Servo Voltz (SV)	20
10	Servo Feed (SF)	2100
11	Machining Time	32 min

Specimen – Rectangular Block (3 rd machining process)

1. Diameter of wire : 0.25 mm
2. Type of wire: copper with brass coating wire.
3. Desired shape to be made from rectangular block: Rectangular rod of length 10 mm.

S.No	Parameter	Value
1	Pulse on Time (Ton)	131
2	Pulse off Time (Toff)	60
3	Wire Power (I_p)	230
4	Wire gap (V_p)	2
5	Current	5 amps
6	Water Pressure ($W_{p)}$	1
7	Wire Feed (WF)	2
8	Wire Tension (WT)	7
9	Servo Voltze (SV)	20
10	Servo Feed (SF)	2100
11	Machining Time	26 min

V. RESULTS AND DISCUSSIONS

EDM Output Results:

Table: Machining Time Results

S.NO	1stMachining process in mins	2ndMachining process in mins	3rdMachining process in mins
1	52	26	20

MRR= depth of cut * cross sectional area
Machining time

MATERIAL REMOVAL RATE RESULTS:

S.NO	1^{st}Machining process in mm^3/min	2^{nd}Machining process in mm^3/min	3^{rd} Machining process in mm^3/min
1	12.02	17.08	20.16

% of Tool Wear:

S.N	1^{st} cut piece	2^{nd} cut piece	3^{rd} cut piece
1	4	6	8

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SURFACE ROUGHNESS RESULTS:

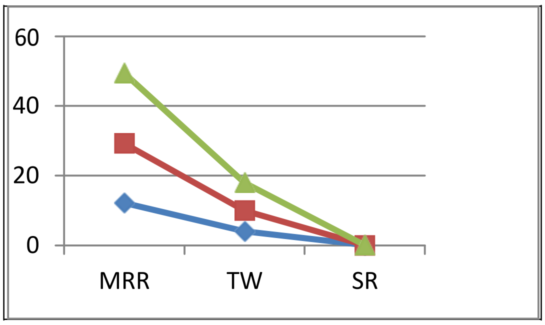
S.No	1st cut piece	2nd cut piece	3rd cut piece
1	0.022	0.0283	0.0281

OUT PUT RESULTS:

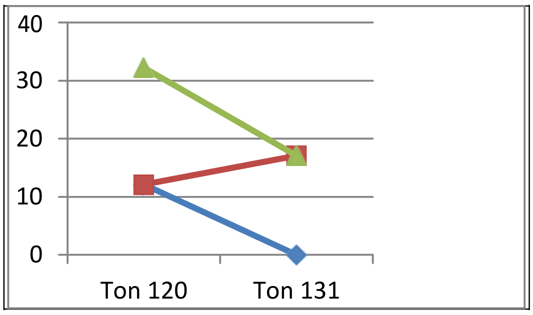
	1st cut piece	2nd cut piece	3rd cut piece
MRR	12.02	17.08	20.16
TOOL WEAR	4	6	8
SURFACE ROUGHNESS	0.022	0.0283	0.0283

Note:
1. Machining time is continuosly decreases from specimen 1st cut to 3rd cut
2. The material removal rate is continuosly Inecreases from specimen 1st cut to 3rd cut
3. Tool wear is continuosly increases specimen 1st cut to 3rd cut
4. Surface roughness is continuosly increases 1st cut to 3rd cut

Comparison of Output Results :

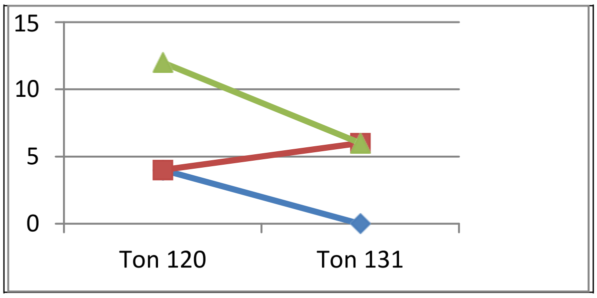


Pulse on time



PULSE ON TIME VS MRR

PULSE ON TIME VS TW:



CHEMICAL COMPOSITION RESULTS:

1st Machining piece- Square of side 10mm and length 23.7mm

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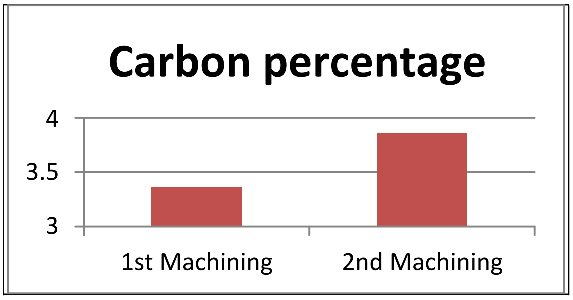
Specimen	C%	MN %	SI %	S %	P %	MG %
1st Machining	3.36	0.28	2.20	0.014	0.023	0.019

2nd Machining piece- Square of side 10mm and length 23.7mm

Specimen	C%	MN %	SI %	S %	P %	MG %
2nd Machining	3.86	0.36	2.65	0.088	0.088	0.091

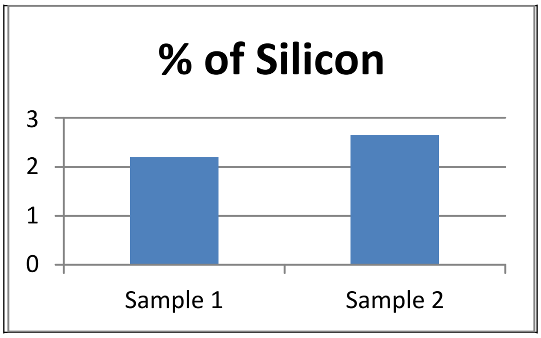
Copper comparison:

S.NO	Sample	% of C
1	1st machining	3.36
2	2nd machining	3.86



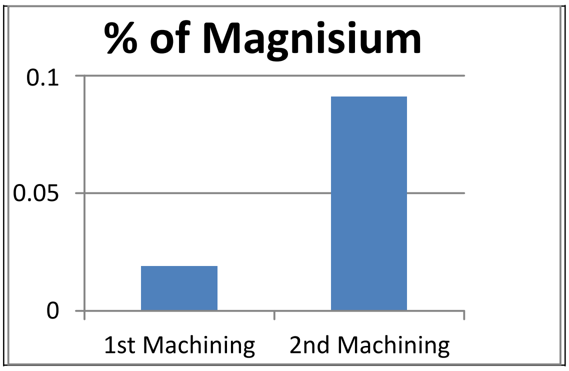
SILICON COMPARISM:

S.NO	Sample	% of Si
1	1st machining	2.20
2	2nd machining	2.65



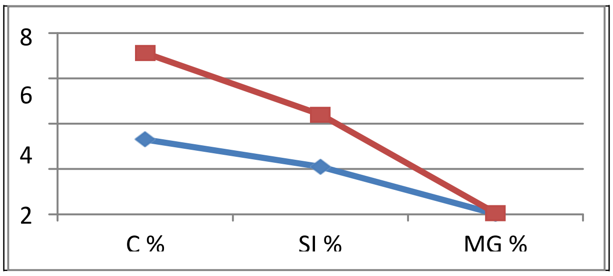
MEGNISIUM COMPARISM:

S.NO	Sample	% of Mg
1	1st machining	0.019
2	2nd machining	0.091



CHEMICAL COMPOSITION COMPARISION:

S.NO	% of Content	1st Machining	2nd Machining
1	C	3.36	3.86
2	SI	2.20	2.65
3	MG	0.019	0.091



VI. CONCLUSIONS

The two different compositoned SG Cast Iron is used in this project above results are observed conculded as follows

1. Machining time is continiously decreases from 1st machining to 3rd Machining.
2. Due to increase in Wire Diameter and current Machining time Decreases.
3. The material removal rate is continiosly Inecreases from 1st machining to 3rd Machining.
4. Due to increse of current Material Removal rate increses.
5. Tool wear is continiosly increases from 1st machining to 3rd Machining.
6. Surface roughness is continiosly increases from 1st machining to 3rd Machining.

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