International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

Optimization of Wire Cut Electro Discharge Machining Process Parameters for HCHCr-D3 Steel

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Abstract:

In this paper wire cut electro discharge process parameters are optimized. Process parameters considered for the study are pulse on time, pulse off time and current. High Carbon high Chromium (HCHCr-D3) steel is high tensile strength alloy which is mostly used in cold dies and tooling application that where high degree and dimensional accuracy is required. HCHCr-D3 alloy steel plate of rectangular shape has been used for machining operation. Performance of wire cut electro discharge machine (WEDM) with a molybdenum wire has been measured by material removal rate (MMR) and surface roughness (SR).

Keywords: Optimization, Material Removal Rate, Surface Roughness.

1.1 GENERAL

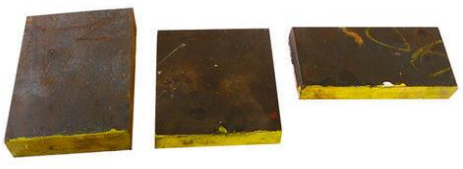
In recent times, industries which manufacture tools, dies, molds and metal-workings, are in need of materials which have high resistance, high wear and tear, hardness, strength and toughness. Hence development of new materials like titanium, inconel, ceramics, zirconium, stainless steel, carbides and many other high strength temperature resistant alloys are widely used in automobile, aerospace, medical, defence, tool and die manufacturing industries. For such materials, machining by conventional process is difficult and sometimes impossible. Thus, non-conventional processes are applied instead of traditional methods for extremely hard and brittle materials [1]. One such non-conventional process is wire cut electrical discharge machining (WEDM). Manufacturing process is modern manufacturing scenario. The WEDM utilizes the wire which acts as a tool upon passing current so as to erode the work material by the generation of sparks between the work and tool. The work piece and tool are partially or completely immersed in a dielectric fluid in order to remove the material by erosion and avoid over heating of the material. The gap between work piece and wire is usually ranges from 0.015-0.05 mm and is maintained constant by computer numerical control (CNC) system [2]. The process is mainly used in mould and dies making, aerospace and automotive industries [3]. Higher productivity with minimum cost is motive of almost all the industries. With increasing demand for quality product as well as for higher productivity, WEDM need to be performed more efficiently. Thus one of the most interesting and investigating areas is the modelling and optimization of process parameters to achieve a high quality product with the reduction of manufacturing cost [4].

1.2 Selection of Material

HCHCr-D3 steel material is used as work piece in this research work. Size available in round, flat and square shape. The application of this material mainly used in mould and dies making, aerospace and automotive industries Literature study indicates that research can be conducted to evaluate effect of process parameters like Pulse on time, Pulse off Time and Current of WEDM on material removal rate (MMR) and surface roughness (SR). Material HCHCr steel item code is D3.Chemical composition of HCHCr-D3 Steel is shown in Table 1

Composition	C	Si	Mn	Cr
Percentage	2-2.35 %	0.6%	0.6%	11-13.50%

Table Chemical Composition of HCHCr-D3 Steel



HCHCR D2 tool steel & Cu Electrode 6mm & 8mm.

1.3 Levels of Input Parameters

Three levels for each parameter has been selected for optimization. Selecting more than 3 levels would have needed more experiments to be conducted. Selecting less than 3 levels is not justified for investigation of effect of parameters for first time. Table shows three levels of input parameters selected for optimization study.

Sr. No	Level 1	Level 2	Level 3
Pulse on time (µs)	28	32	36
Pulse off time (µs)	7	9	11
Current (A)	2	4	6

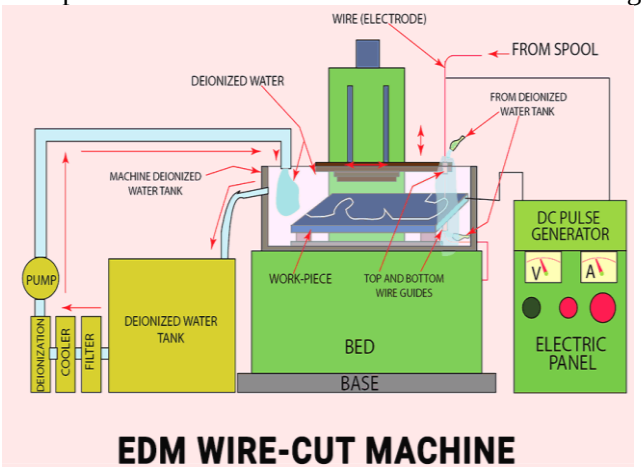
Table 2 Levels of Input Parameters

1.4 WORKING OF EDM

In EDM workpiece and tool electrode are completely submerged in a dielectric fluid like Kerosene oil, EDM grade oil, transformer oil, distilled water etc., generally tool is made negative connected to negative polarity called cathode and workpiece is made positive when connected to positive polarity called anode. Unwanted material is machined with the help intermittent electric discharge due to break down of dielectric strength at sufficient high voltage. Due to these intermittent discharge between the gap of 10.5 to 125.7 µm, which occurs after every pulse on duration produces a very high temperature in a fraction of second which melts the metal at such a high temperature in the order of 8000°C to 12,000°C which evaporates the metal and in this way machining is done in Electric Discharge machining. During the pulse off duration no current is flowing in the circuit. In this time dielectric fluid comes into action and in addition to providing cooling action, also performed the function as a flushing agent, remove the debris present in the dielectric fluid and clean the area by washing out micro-chips.

1.5 EXPERIMENTAL WORK

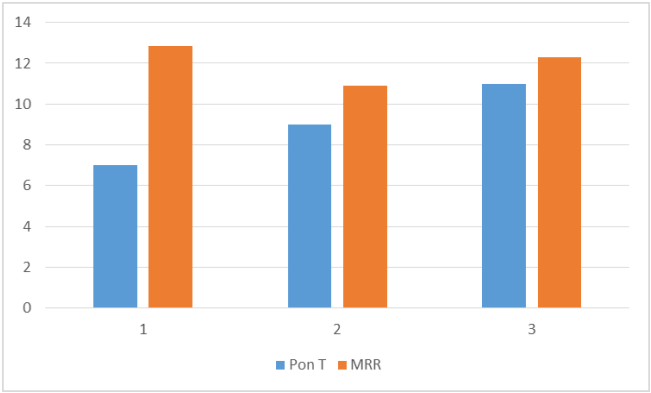
Semi-automatic machine (SAM) Electric Discharge Machine (Die Sinking), namely EMS 5030 made by Massive Engineering Pvt. Ltd., Pune. Copper tool electrode was given positive polarity and workpiece HCHCr was given negative polarity for the conduct of experiments. EDM oil (specific gravity= 0.765, flash point= 94˚C) was used as dielectric medium in this experiment for external flushing, with a fixed value of flushing pressure as 0.4 kgf/cm2. Here three different values of spark producing current (Ip), two different values of copper flat thickness (t) and three different values of pulse on duration (Ton) were chosen as discussed later in detail. As per Figure various parts of Die-Sinking Semiautomatics machine are it contains dielectric rotational system with filter, pump and container for dielectric fluid. Servo control system and Unit for power development. Electro- magnetic job fixing device with tank for completely submerged workpiece with dielectric fluid while external flushing.



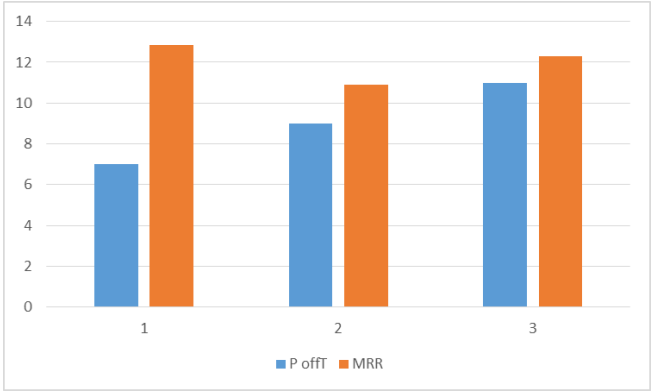
1.5 Experimental Result

Experiments	Inputs Factors			Output Responses
Trial No.	Pulse on time (µs)	Pulse off time (µs)	Current (A)	Material Removal Rate (mm3 /min)
1	**28**	**7**	**2**	12.8290
2	**32**	**9**	**4**	10.9051
3	**36**	**11**	**6**	12.2769

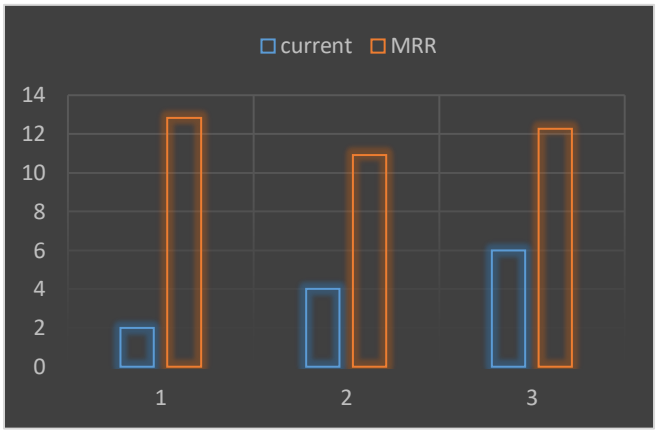
Pulse on time Vs MRR



Pulse off time Vs MRR



Pulse current time Vs MRR



2.1 CONCLUSION

The current study relates to machining of HCHCr (D2) by Die Sinking EDM and investigates to find the optimal values of output process parameters with respect to changing input response variables and finding various data related as per parameter variation techniques. The effect of machining responses is then analyzed for MRR, TWR,final conclusions related to MRR, TWR and SR are drawn. Below are the conclusions: Conclusion related to MRR: optimal value of MRR is found to be 10.9051 mm3/min. which is found at Run-18 when the optimum combination of input parameters is copper tool electrode thickness is (t) = 8 mm, and pulse on duration Ton = 32 µs and Discharge Current Ip = 4A. Further it is also concluded that value of discharge current (Ip) is most dominating parameter and after that pulse on duration (Ton) is most contributing factor and the thickness of electrode is least influencing parameter

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