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FINITE ELEMENT ANALYSIS OF THE COMPLEX SHAPE PUNCH MANUFACTURED THROUGH WEDM FOR HCHCR

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Abstract: - To manufacture the complex shaped die and punch having different shape on top and bottom face. Wire cut electric discharge machining (WEDM) process was used from die steel material HCHCR (D2 grade). Initially programming was done to develop wire electrode tool path, to cut different profile on top and bottom face of the punch. The manufactured specimens were tested at laboratories for measuring hardness values for five no. of samples and the results are validated through finite element analysis by determining the strength of the punches theoretically

Keywords: WEDM, FEM Analysis, HCHCR Material, Die punch.

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INTRODUCTION

In the recent years, manufacturing scenario is changing rapidly due to innovations in the engineering design and also ever increasing demands on the material performance have resulted in the development and discovery of a spectrum of advanced engineering materials. As their alloys widely being used in the aerospace, nuclear and automotive industries for various purposes and applications, the wire cut EDM or wire-electro discharge machining (WEDM) has become an important non-traditional machining process in the present days. Wire cut EDM process provides an effective solution for machining hard and difficult to machine materials such as super alloys, composites and ceramics etc. with intricate shapes, which are not possible by the conventional machining methods such as turning, drilling and grinding, milling.

2.0 WORKING PRINCIPLE OF WIRE CUT EDM

WEDM uses a thin continuously travelling wire electrode fed through the work piece controlled by microprocessor, which enables to machine the complex shape parts with exceptional high degree of accuracy. WEDM eliminates the need of pre shaped cutting electrode which is prime requirement of EDM machining. A temperature range of 8000°C–12,000°C exist between cathode and anode in the form of thermal energy after applying voltage pulses between the work–piece and the wire electrode during WEDM process. When the pulsating DC power supply occurring between 20,000 and 30,000 Hz is turned off, the plasma channels breaks down. As a result of breaking of plasma channel a sudden reduction in the temperature allowing the circulating dielectric fluid to implore the plasma channel and flush the molten particles from the machining zone in the form of microscopic debris. Figure 1.1 below describes the basic working principle of wire cut EDM.

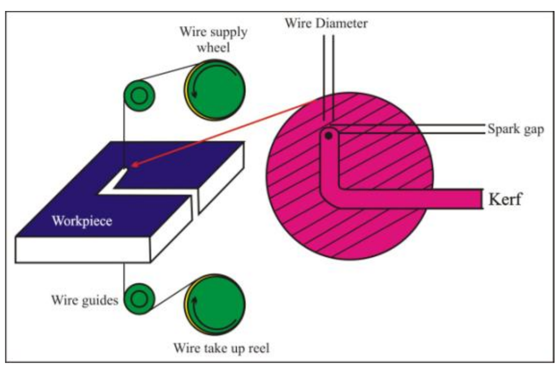

Figure2.1 Working Principle of wire cut EDM

3.0 EXPERIMENTAL SET-UP DESIGN

The experiments were carried out on a wire-cut EDM machine (ELEKTRA SPRINTCUT 734) of Electronic Machine Tools Ltd. installed at Shree Tirupati Balaji Press tools and Moulds PVT.LTD. Hingna M.I.D.C. Nagpur. The WEDM machine tool (Figure 2.1)

Figure 3.1 Pictorial View of WEDM Machine Tool

4.0 WORK PIECE MATERIAL

The High Carbon High Chromium Die steel (HCHCR) D2 grade steel grade were used as a Work piece materials. Plates of size 200mm x 200mm x32mm was used for the present experimentation. The chemical composition for HCHCR the materials is as per table given below

Table 4.1 Chemical Composition of the HCHCR Material

Constituent	C %	Si %	Mn %	P %	S %	Cr %	Ni %	Mo %	Al %	Cu %	V %	Nb %	Ti %
% Composition	2.012	0.184	0.290	0.021	0.021	11.337	0.097	0.048	<0.001	0.036	0.051	0.004	0.001

5.0 EXPERIMENTAL DESIGN

Response surface methodology (RSM) was use for designing the experiments and carrying out detailed investigations on WEDM (wire Cut EDM) for manufacturing complex shape punches of HCHCR and the process parameter were selected to cut the desired profile by using operation manual for WEDM. The following figure shows the view of manufactured punches of HCHCR.

Figure 5.1 Specimen View HCHCR Punches

6.0 FINITE ELEMENT ANALYSIS

With the help of ANSYS Workbench software we have checked the strength of the complex shape Punch manufactured on WEDM for HCHCR materials. This is required because for manufacturing each of the specimens, the set of input parameters used was different as per the design of experiments. Results obtained are tabulated for further inference. CAD Software PROE WILDFIRE was used for CAD modelling as it is a parametric, feature based, solid modelling System.

Table 6.1 Punch Part Information

Bounding Box	
Length X	20. Mm
Length Y	20. Mm
Length Z	23.29 Mm
Properties	
Volume	5910. Mm^3
Mass	4.5288e-002 Kg
Centroid X	-3.6621e-016 Mm
Centroid Y	-2.2487e-017 Mm
Centroid Z	10.768 Mm
Moment Of Inertia Ip1	2.9422 $Kg·Mm^2$
Moment Of Inertia Ip2	2.9422 $Kg·Mm^2$
Moment Of Inertia Ip3	1.8562 $Kg·Mm^2$

Table 6.2 Finite Element Mesh Details

Statistics	
Nodes	48864
Elements	11258

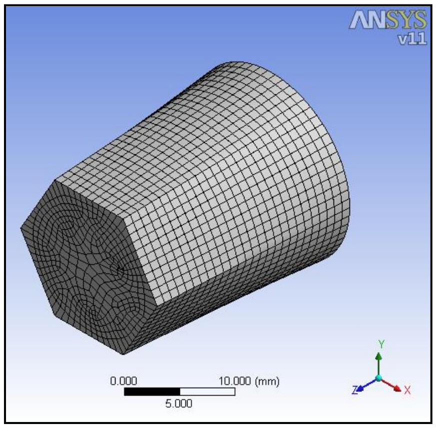

Figure 6.1 Finite Element Meshed Model

Table 6.3 Force Analysis Initial Setting

Reference Temp	37. °C	
Object Name	Support	Force
Define By	Face	Vector
Magnitude	NA	4.9609e+006 N (Ramped)

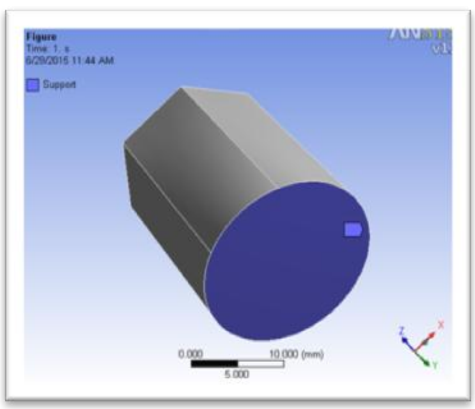

Figure 6.2 Applied Support Condition

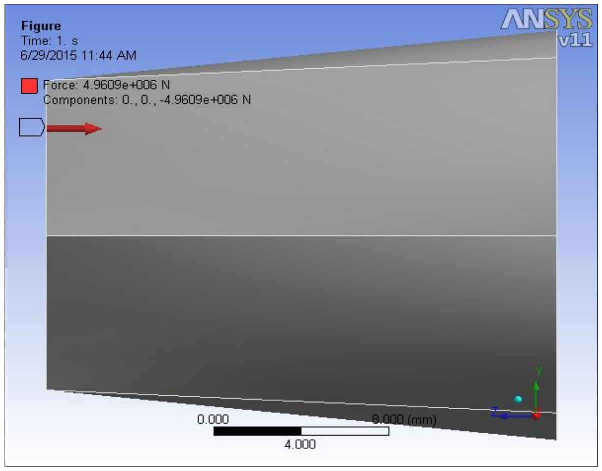

Figure 6.3 Applied Ramped Force on Other End

Table 6.4 Material Data HCHCR Material

Structural	
Young's Modulus	1.9e+005 Mpa
Poisson's Ratio	0.27
Density	7.663e-006 Kg/Mm³
Thermal Expansion	1.2e-005 1/°C
Tensile Yield Strength	354. Mpa
Compressive Yield Strength	354. Mpa
Tensile Ultimate Strength	546. Mpa
Compressive Ultimate Strength	546. Mpa
Thermal	
Thermal Conductivity	5.478e-002 W/Mm·°C
Specific Heat	546. J/Kg·°C

6.1 Force Analysis results for one of the specimen of HCHCR

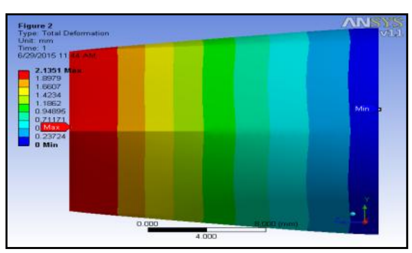

Figure 6.4 Total deformation results

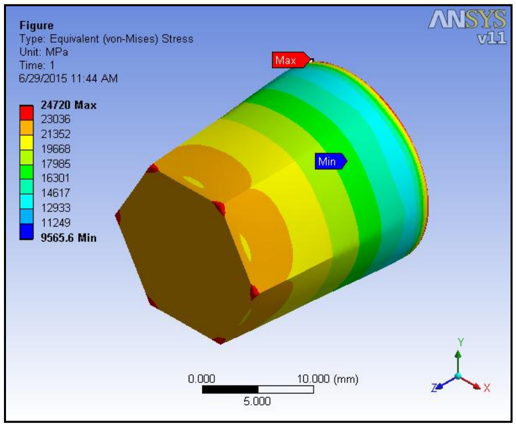

Figure 6.5 Equivalent stress results

6.2 Experimental Results

Table 6.5 Model 1 (Sample no.5) HCHCR

HCHCR	
Youngs Modulus	190000 MPA
Poisson's Ratio	0.27
Density	7.663 x 106 Kg/mm3
Hardness Value	230 BHN
MRR Value	0.027
Input parameter set values	TON 120
	TOFF 58
	IP 180
	SV 7
Weight in gm	45.28
Strength (N) from ANSYS	**4284134**
4284134	

7.0 CONCLUSION:-

We have tested in all ten samples for HCHCR and OHNS, five for each material with ANSYS software and with the help of Rockwell cum Brinell hardness tester at S. N. Metallurgical Services, M.I.D.C. area Waluj, Aurangabad to check the strength of manufactured complex shape punches. The results obtained from both confirm that irrespective of the combinations of the set of input parameters to machine, the final strength of the punches remains nearly the same.

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