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Thermal modelling of spark in wire cut EDM

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ABSTRACT

Wire EDM is a noncontact machining process of contouring different intricate shapes from a bulk material. The phenomenon behind material removal is high temperature due to spark in the wire the material melts and vapours. This process enables the manufacturer to fabricate new high temperature resistive material. The wire is made of brass on which the analysis has been carried out. The existing work deals with Thermal modelling of spark using ABAQUS CAE software. Material of wire considered is brass. Heat transfer is transient in nature due very small time available to single spark. The variation of heat flux and temperature were analyzed by results obtained from modelling.

Keywords**—** *Wire EDM, ABAQUS CAE, Meshing, Finite element method*

1. INTRODUCTION

Wire EDM is advance setup of conventional EDM in which wire in motion acts as tool. Motion is provided to the wire to enable it cut contours of desired shape and size. The wire also moves in axial direction so that the wire rupture do not take place. Once the applied voltage exceeds the breakdown voltage of dielectric, the medium gets ionized. The electrons move towards the anode and protons towards anode; thus, a plasma channel is formed in the narrow inter electrode gap. A high intensity spark is generated during pulse on time. During off time the medium becomes non conducting and dielectric fluid flowing takes away the debris from the inter electrode gap. The temperature of spark is very high in order of 8000-10,000 ̊C.

This causes melting of work piece material. Wire EDM application ranges from machining punches dies to highly specific in aerospace industry such as manufacturing of compressor wheel and turbine rotor disc. The movement of the wire ensures the shape of component which has to be cut out of the material. Only conductive materials are machined using this process. Kasinath Das Mohapatra, Susanta Kumar Sahoo, and Munmun Bhaumik analyse the temperature, total heat flux and equivalent stress of the work-piece material using finite element analysis in ANSYS workbench software.[1]

The temperature at contact between the wire and the work-piece is found to be 886.5℃ and the heat flux of 64w/mm^2. J.F. Liu, Y.B. Guo analysed the multiple discharge in EDM. Anshuman Kumara, Dillip Kumar Bagal the temperature obtains by thermal modeling of Wire Electrical Discharge Machining of Super alloy Inconel 718 obtained the maximum temperature of 7005 ̊C. [2] Meinam Annebushan Singh, Koushik Das analyzed the stress distribution 2-D axis-symmetric geometry using Finite element and Finite volume method.[3]

2. MODELLING ON ABAQUS CAE

The geometrical model is developed on Abaqus CAE student version 2018. The part that is wire has diameter of 0.3 mm and length of 10mm. After creating the geometry, the material properties are assigned to the section. Now in the assembly section the part is divided into finite element by meshing. In this particular software the meshing is restricted to 1000 nodes.

After the meshing steps are created for different physical phenomenon in this case a heat transfer step is created heat flux loads and boundary conditions of temperature is specified. The next step is providing the environmental condition using interaction define the ambient temperature and heat transfer due to convection of dielectric fluid. The final step is to create the job, run the job check for then submits the job to get the results.

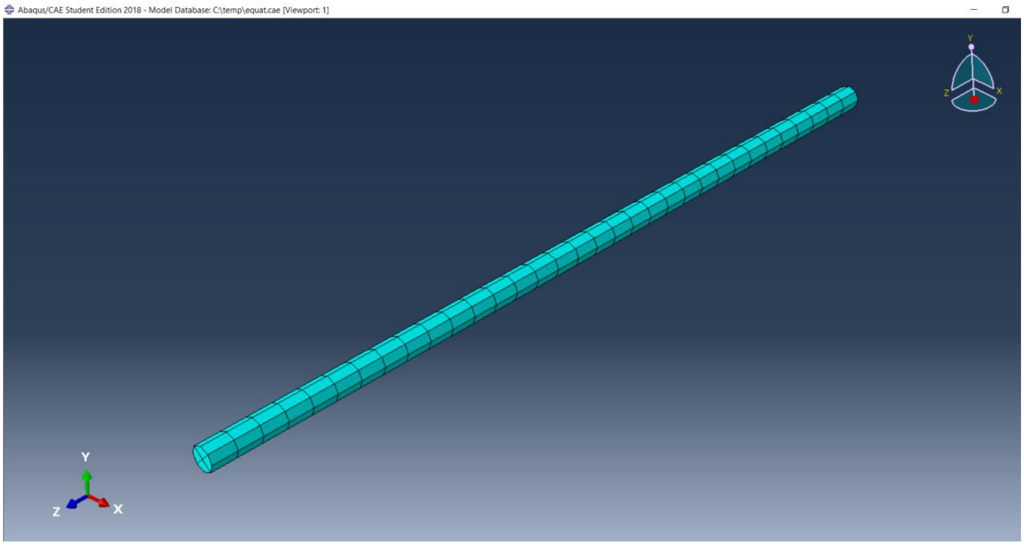

Fig. 1: Meshed model of brass wire electrode

2.1 Assumptions of Model

In wire EDM the spark is instantaneous and for very short duration of time. The joule heating of wire due to current, convective heat transfer due to moving dielectric and of course conduction in workpiece and wire make it very complex process difficult to analyze. Besides this the wire is subjected to axial motion, deflection due to bubble formation, electrostatic force and tension along its axis. The on time is few microseconds during this time period a high temperature of 10,000 ^{0}C is reached. So many factors cannot be taken account altogether, hence there are some assumptions of the model. Properties are defined in axial direction of wire. As spark is of short duration thermal analysis is transient type. Internal heat generation followed is Gaussian distribution of heat flux. Vibration in lateral direction and joule heat effects are neglected. The thermal properties are temperature dependent. The model is developed for single discharge. Wire material is homogenous and isotropic. The geometry chosen is in axial direction type. The effect of wire tension is neglected.[4]

2.2 Heat Flux variation in wire

The heat flux variation in the wire is given by Gaussian heat input model due to spark generated given by q heat flux, P is constant energy distribution and equal to 0.4, r is the radial distance from the axis of the spark, V is the voltage between anode and cathode, I is the peak current and R is the spark radius [5]

$$\mathbf{q = \frac{4.45PVI}{\pi R^2} e^{\frac{-4.5r^2}{R^2}}} \quad (1)$$

Further spark radius is the function of input current and pulse on time.

$$\mathbf{R = 2.04e^{-3}\, I^{0.43} T_{on}^{0.44}} \quad (2)$$

2.3 Boundary conditions

During discharge Near the Wire the heat transfer is by conduction

$$\mathbf{k\frac{dT}{dZ} = q(r)} \quad (3)$$

Region away from wire are cooled by dielectric by convection

$$\mathbf{k\frac{dT}{dz} = h(\Delta T)} \quad (4)$$

2.4 Simulation conditions

The spark radius, heat flux of the brass wires the machining process parameter are predefined the discharge voltage is fixed at voltage of 30 V, peak current is 2A and pulse on time is30µs. By equation of spark radius equation number three we get R =0.6mm.

The Heat flux variation as for spark radius 0.6 mm in brass wire

$$\mathbf{q(r) = 94.4e^{-9r^2}} \quad (6)$$

2.5 Material Properties

The thermal and mechanical properties of brass wire electrode are

Table 1: Properties of Brass wire

Properties	Values	Units
Density	8500	Kg/m^3
Thermal Conductivity	120	W/m-K
Specific Heat	380	J / kg-K
Young's Modulus	100	GPa
Melting Point	1084	^{0}C
Poisons Ratio	0.31	-

2.6 Dielectric Properties

The dielectric fluid used is kerosene

Table 2: Properties of Kerosene

Properties	Values	Units
Thermal Conductivity	0.15	W/m K
Density	780	Kg/m^3
Specific Heat	2090	J/Kg^0C
Viscosity	2.4×10^{-6}	$N\text{-}s/m^2$
Coefficient of Heat Convection	1.2×10^{4}	W/m^2K

3. RESULTS

The results are obtained after simulation on Abaqus CAE The following figures depict the variation of heat flux and tempature in wire electrode of wire EDM for a very short duration of time 60µs

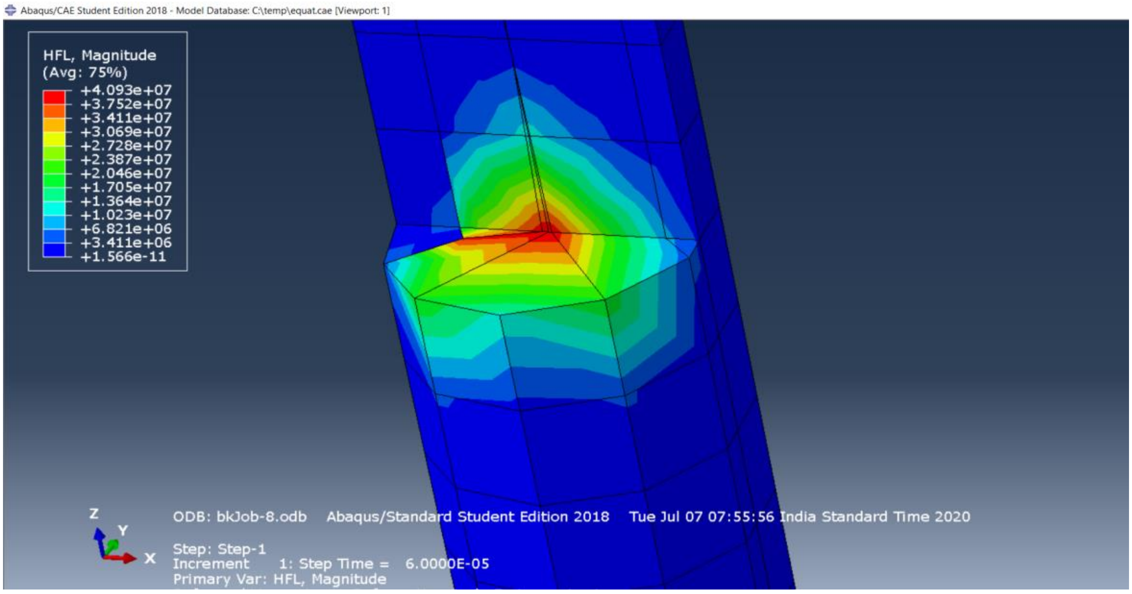

Fig. 2: Heat flux variation in wire electrode

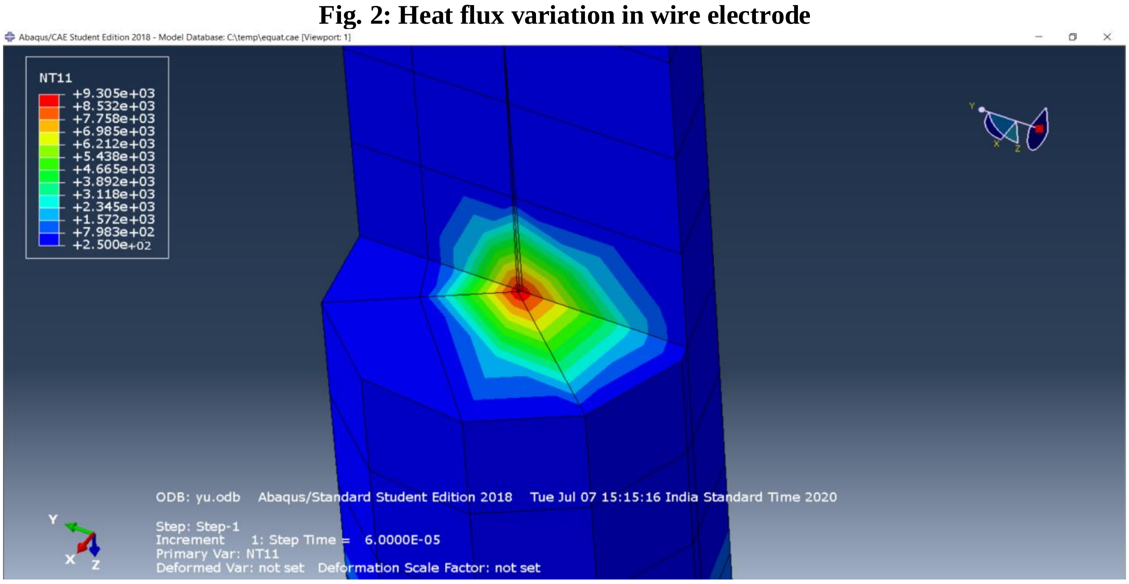

Fig. 3: Temperature variation in wire electrode

4. CONCLUSION

At the centre of the the wire the temperature is very high as the spark initiates where the interelectrode gap is minimum the temperature decreases as the distance from the centre of wire increases. The temperature is highest at the centre of wire 9305℃ Nearly same variation is observed for Heat flux 41 W/mm^2. The excess Heat is carried away by the dielectric fluid which reduces the heat flux and temperature.

5. REFERENCES

[1] Kasinath Das Mohapatra, Susanta Kumar Sahoo and Munmun Bhaumik Thermal Modeling and Structural Analysis in wire EDM Process for a 3D Model Applied Mechanics and Materials Submitted:2016-01-03 ISSN: 1662-7482, Vol. 852, pp 279-289

[2] J.F. Liu, Y.B. Guo Thermal Modeling of EDM with Progression of Massive Random Electrical Discharges JDept. of Mechanical Engineering, The University of Alabama 44th Proceedings of the North American Manufacturing Research Institution

[3] Meinam Annebushan Singh, Koushik Das and Deba Kumar Sarma Thermal simulation of machining of alumina with wire electrical discharge machining process using assisting electrode Journal of Mechanical Science and Technology 32 (1) (2018) 333~343
[4] H. K. Kansal, S. Singh and P. Kumar, Numerical simulation of Powder mixed electric discharge machining (PMEDM) using finite element method, Math. Comput. Modell., 47 (11) (2008) 1217-1237.
[5] T. Ikai and K. Hashigushi, Heat input for crater formation in EDM, International Symposium on Electro Machining, 11 (1995) 163-170
