An analysis study of Wire EDM process

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ABSTRACT

In this paper a Theoretical analysis of very thin strip of brass material has been carried out. For the analysis equations of conduction has been considered for the sake of easiness and quick results. Like other welding processes a Wire EDM is also a material removal processes. A thin brass strip of diameter 0.0499–0.3 mm electrode wire is used in WEDM process.FEA meshing is prepared for the stress and strain analysis and it has been observed that at various interval of temperature variation of stresses has been observed which are discussed in the paper

Keywords: WEDM, variable stress,variable temperature, governing equations, Theoretical analysis.

1.INTRODUCTION

In the welding process several electric spark occurs at the regular interval between the job and the electrode or tool which is used. A wire Electrode machining process is a more complicated process due to the interaction between the particles and dielectric fluid during the process.

The basic principal of the welding process works on the intensity of the electric field which is reduced between the tool and the work piece to stop the current flow and generate the spark this spark will be responsible for the welding and these are very rapid spark and time interval between the spark is very much low. In solid. the heat transfer mode is conduction.

For make it simplest and minimizes its randomness some assumptions are taken into consideration. For thermal modeling of the process assumptions made are as follows:

- Single spark is considered at a time for at least some microseconds.
- Gaussian distribution is assumed
- The material will be thermal conductive and uniform but its physical properties such as density, volume and expansion due to the temperature are not affected.
- Thermal analysis is of momentarily or fleeting type.

For thermal modeling process some mathematical equations are to be written as a governing equation of the process. As a heat transfer mode in the solid is conduction and the thermal analysis is of fleeting type so the equation may be written is as follows:

Eqn.1

$$\frac{\partial}{\partial r}\left(kW\frac{\partial T}{\partial r}\right) \ldots\ldots 1$$

Eqn.2

$$\frac{1}{r^2}\frac{\partial}{\partial \emptyset}\left(kW\frac{\partial T}{\partial \emptyset}\right) \ldots 2$$

where;

r -radius and,

φ -angle coordinates.

Eqn.3

$$\frac{\partial}{\partial z}\left(kW\ \frac{\partial T}{\partial z}\right) \ldots\ldots 3$$

where;

z - axial coordinate

kW- thermal conductivity of the wire

Eqn.4

$$q''' \quad \ldots\ldots\ldots\ldots\ldots\ldots 4$$

where;

q"'- rate of heat transfer

Eqn.5

$$\rho c\frac{\partial T}{\partial t} \ldots\ldots\ldots\ldots\ldots\ldots 5$$

where;

ρ- density of wire material

c- specific heat of wire material

T- temperature of the element in the wire

Combining all four equations find a simplest mathematical equation which governs the solutions :

$$\frac{\partial}{\partial r}\left(kW\frac{\partial T}{\partial r}\right) + \frac{1}{r^2}\frac{\partial}{\partial \emptyset}\left(kW\frac{\partial T}{\partial \emptyset}\right) + \frac{\partial}{\partial z}\left(kW\ \frac{\partial T}{\partial z}\right) + q''' = \rho c\frac{\partial T}{\partial t} \ldots\ldots\ldots 6$$

2.MATERIAL PROPERTIES AND ANALYSIS

1.Brass Zn =40%,Cu=60%

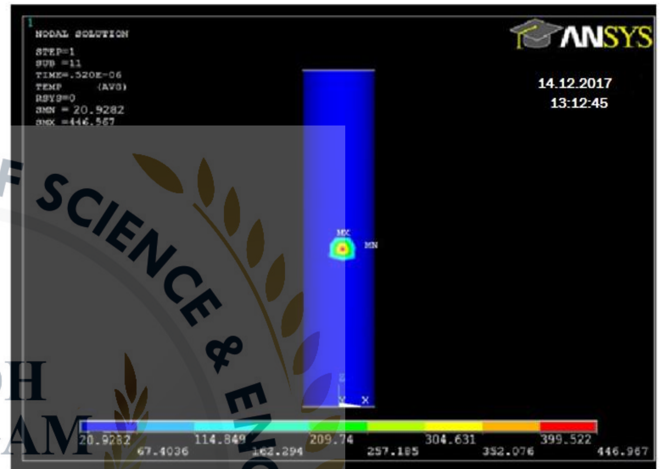
Table 2.1 properties of Brass material

Properties	Value	Unit
Density	8522	Kg/m^3
Thermal conductivity	110.7	W/m-K
Specific heat	385	J / kg-K
Modulus of Elasticity	102-125	G Pa
Bulk Modulus	108	G Pa
Poisson's Ratio	0.331	---
Melting temperature	930	^{0}C
Shear Modulus	40	G Pa
Solidus	785	0C
Stress relief temperature (1 hr)	260 0C	0C

Table 2.2 parameters used for analysis

Parameter	Unit	Value
Peak current of electro-discharge	A	30
Voltage of electro discharge,	V	24.9
Duration of single pulse	µs	0.14, 0.28, 0.42, 0.56, 0.70, 1.1, 1.72
Wire radius	Mm	1
Convective coefficient	$W/m^2\,^0C$	3040
Temperature of the dielectric	^0C	21
Poisson' ratio		.31
Coefficient of linear thermal expansion	K^{-1}	1.9×10^-5
Convective coefficient	$W/m^2\,^0C$	3040
Temperature of the dielectric	^0C	22
Poisson' ratio		0.331
Coefficient of linear thermal expansion	K^{-1}	18-19x10^-6

3.FEA Modelling



3.1Temperature distribution in Brasswire with V=24.9V, I=30 A, P=0.39 and t_{on}=0.52µ

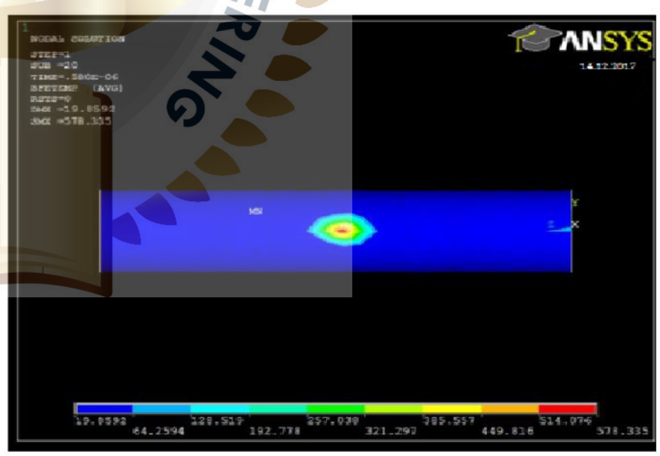


Fig.3.2: Temperature distribution in Brass wire with V=24.9 V, I=30 A, P=0.39 and t_{on}=0.56µs

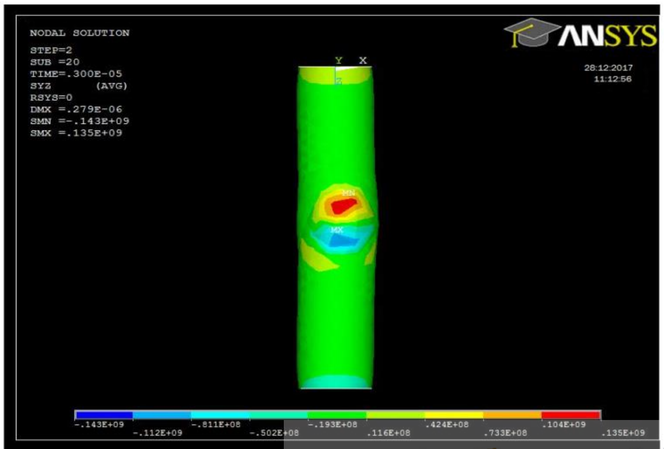


Fig. 3.3: Thermal shear stress in YZ-component at t_{on}=0.56µs

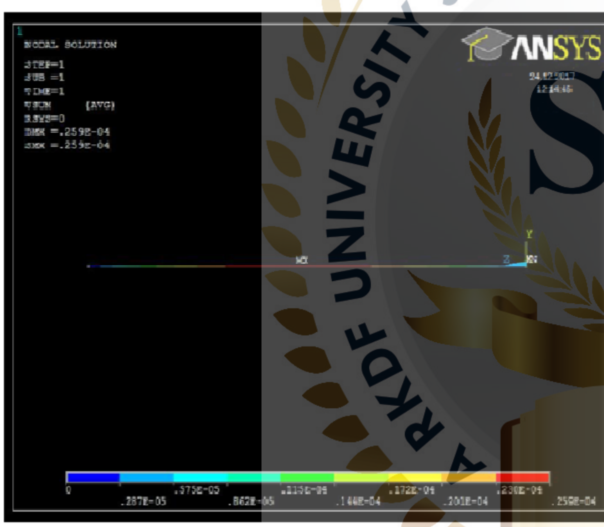


Fig. 3.4: Displacement Graph of Nodal solution

Fig. 3.5: Displacement Graph

4.CONCLUSION

The distribution of temperature for single discharge is observed with the constant parameter

Ip= 30A,

voltage =24.9V

with varying pulse time.

For the Brass strip following results were obtained during various pulse rate:

1.At pulse time = 0.14 µs, corresponding temperature is 92.8.

2.At pulse time = 0.28 µs, corresponding temperature is 258.7^{0}C.

3.At pulse time = 0.42 µs, corresponding temperature is 411.6^{0}C.

4.At pulse time = 0.56 µs, corresponding temperature is 546.9^{0}C.

5.At pulse time = 0.70 µs, corresponding temperature is 582. 5^{0}C. and so on.

6.At pulse time = 1.2 µs, corresponding temperature is 854.8^{0}C.

7.At pulse time = 1.82 µs, corresponding temperature is 1144^{0}C.

Further increase in the rate of the pulse time is not possible because, at temperature 1083^{0}C, the brass wire (strip) gone melt.

The maximum compressive stress is 568MPa for t_{on}=0.14µs in X-component, and maximum residual stress is 778 MPa.

The maximum compressive stress is 288Mpa for t_{on}=0.52µs in Z-component and maximum residual stress is 288 MPa.

The maximum compressive stress is 425Mpa for t_{on}=1.82µs in Z-component and maximum residual stress is 533 MPa.

REFERENCES

[1] Datta,s. and Mahapatra,S.S. (2010) Modeling,simulation and parametric optimization of wire EDM process using response surface methodology coupled with grey-Taguchi technique, International Journal of Engineering, Science and Technology, vol. 2, pp. 162-183.

[2] Kunieda, K. and Furudate, C. (2001) High Precision Finish Cutting by Dry WEDM, Journal of Materials Processing Technology, vol. 149 pp. 77–82

[3] Okada, O., Uno, Y., Nakazawa, M. and Yamauchi, T. (2010) Evaluations of spark distribution and wire vibration in wire EDM by high-speed. Manufacturing Technology, vol.59, pp. 231–234

[4] Cabanesa, I., Portilloa, E., Marcosa, M. and Sa´nchezb, J.A. (2 0 0 8) An industrial application for on-line detection of instability and wire breakage in wire EDM, journal of materials processing technology, vol. 1 9 5, pp. 101–109

[5] Saha, S., Pachon, M., Ghoshal, A.and Schulz d, M.J. (2004) Finite element modeling and optimization to prevent wire breakage in electro-discharge machining Mechanics, Research Communications, vol. 31,pp. 451–463

[6] Hou, P.J., Guo, Y.F., Sun, L.X. and Deng G.Q. (2013) Simulation of temperature and thermal stress filed during reciprocating traveling WEDM of insulating ceramics, Procedia CIRP vol. 6 PP. 410 – 415

[7] Hada, K. and Kunieda, M. (2013) Analysis of wire impedance in wire-EDM considering Electromagnetic fields generated around wire electrode, Procedia CIRP vol.6 245 – 250

[8] Cabanesa, I., Portilloa, E., Marcosa, M. and Sa´nchezb, J.A. (2 0 0 8) On-line prevention of wire breakage in wire electro-discharge machining, Robotics and Computer-Integrated Manufacturing, vol. 24, pp. 287-289.

[9] Cheng, G., Zhijing, H.and Feng (2007) Experimental determination of convective heat transfer coefficient in WEDM, International Journal of Machine Tools & Manufacture, vol. 47,pp. 1744–1751

[10] Yan, M.T. and Lai, Y.P. (2007) Surface quality improvement of wire-EDM using a fine-finish power supply, International Journal of Machine Tools & Manufacture, vol.47, pp. 1686–1694