ISSN (e): **2250 – 3005** || *Volume, 07 || Issue, 12|| December – 2017 ||*
International Journal of Computational Engineering Research (IJCER)

The impact of residual stresses on awire-cut EDM cutting process

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ABSTRACT:
Wire cut EDM is an exceptionally complex method that is used in precision manufacturing. Due to the minute residual streses that exist inside a grain, generally as an outcome of the presence of disengagements and other glasslike surrenders, lingering stresses delivered duringcutting tasks should be thought about. The essential objective of this examination is to give an outline of flow improvements in the field of leftover pressure age and theirimpact on various factors like surface unpleasantness, dielectric material used, and heartbeat on schedule during wire cut EDM. Analyze the strategies for estimating lingering pressure momentarily also.

Keywords: Wire-CutEDM, ResidualStresses,PerformanceParameter,AdvanceManufacturingProcess.

I. INTRODUCTION

For precise component production, the WEDM is well known cutting technique. Wire electrical discharge is used in the nuclearreactorandautomobileindustriestomanufacturecomplex,high-precisioncomponents.TheWEDMmethodusesapulsatingcurrentto erode material at the work piece and tool. At the conclusion of the discharge cycle, part of the molten metal solidifies again andisdepositedonthe cuttingsurface.

The tensions that remain in a material or body after manufacturing and processingarereferred to asresidual stresses. Techniquesfor measuring residual stress measure strains rather than stresses. The residuals are then calculated using material characteristicslikeYoung'smodulus, Poisson'sratio, andYoung'sratio.

II. LITERATURE SURVEY

J. Crookall et al. [1] at the University of California, San Diego discovered that electro- discharge machining induces extremelyhigh residual tensile stresses. Residual stresses in various materials are proportional to their thermal and other characteristics andare usually unaffected by the tool electrode and dielectric material. They were found using the bending- deflection method, whichisaverysensitiveapproach for constantlymonitoring deflectionscausedbyelectrochemical cellstresses.

J. Liu et al. [2] simulate residual stress generation in die-sinking EDM of the ASP 23 tool steel, a novel modelling techniqueaccounting for large random discharges has been devised. The highest value of average residual stress is determined in the subsurfacerather than at the top surface, which is consistent with experimental results. The low residual stress on the surface is a result of theroughnessof the surface.

B. Ekmekci et al. [3] investigates in their study that high tensile residual stresses are seen to increase quickly with depth, reachinga maximum value around the yield strength, and then rapidly decaying to compressive residual stresses in the material's core. Thispatternisdependentonthethermalcharacteristicsoftheworkpiecematerialandthedielectricliquid.Additionally,thereisastrongrelationship betweenthenhardnessdepthand the afflictedlayers.

R.Panetal.[4]observedintheirresearchthatresidualstressesareoftengeneratedduring thequenchingofaluminiumalloysandpose a danger of cracking or distorting duringfollowing production operations. It is critical to investigate ways for minimising theRS in quenched components. Cold rolling (CR) was used in this study to remove the RS from quenched AA7050 blocks. AlthoughCRconvertsnear-surfaceresidualstressesfromhighcompressiontohightensionintherollingdirection,itachievesexceptional RSalleviation inthe core.

B. Ekmekci et al. [5] in their research work concludes that the dielectric liquid and electrode

typehavebeeninvestigatedwiththeimpactofretentionofausteniteandresidualstrainsusing X-ray diffraction methods on the structure of the white layer inelectric discharge machining surfaces. The current study indicates that when machining with kerosene dialectic liquid, the surfaceis saturated with carbon regardless of the tool electrode material. However,residual Austenite forms on the surface as a result ofcarbon absorptionfromthegraphite toolelectrodewhen usingde-ionizedwaterdielectrics.

H.-T. Lee et al. [6] perform the study to determine the effect of the EDM parameters on different elements of the surface integrityof AISI 1045 carbon Steel, this research carried outsmall area electro-discharging (EDM), using a low wear-rate cupper/tungstenelectrodeinthediameterof1.5mm.Thefindingsshowthatvisiblefracturesin largerwhitelayersarealwaysapparent.Itisobservedthatthe MRR,SRand surface fracturedensity diminishduring aprolongedperiodofthe pulse.

S.Bhattacharyaetal.[7]introducetheFEmethodthathasbeenappliedtosimulateresidualstressesgeneratedtheduring WEDMcuttingontheHAZ ofP91steel.Residualstresses areof Tensile in nature and can affect the service life of the components subjectedto fatigueloading.Thispaperalsodescribesthe sizeof cratersandheataffectedzone.

W.P.Rehbachetal.[8]performthestudyanddevelopanEDMdrillingprocessformeasuringresidualstressinhigh-performancematerials whose stress state is difficult to obtain using a commonly used technology called high-speed (HS) hole-drilling (ASTMStandard E837). SKD11 (JIS) tool steels were prepared at various pre-stress levelsto simulateany residualstressthat mayexistintheworkpieces.Theexperimentalresults indicate that the stress measurement curves for both EDM conditions are parallelto the ideal curve. This demonstrates the feasibility of measuring residual stress on materials with a high degree of hardness andwearresistance.

K. Bonny et al. [9] discovered that wire-EDM produces more friction and wear than grindingand polishing. This trend wasconfirmed by X-ray diffraction measurements, which revealed residual tensile surface stresses in WC following wire- EDM, incontrast to compressive surface stresses following ground and polished equivalents. Additionally, the researchers discovered thatreduced surface quality had a significant effect on (running-in) wear behaviour, including binder depletion, residual surface stress,thermalgraincracking, andincreasedsurfaceroughness.

BulentEkmekcia et al. [10] on the surfaces of electric discharge machined components, significant residual tensions occur. Theyriseinvalueastheyapproachthesurfaceandeventuallyachievetheirmaximumworth.Thishighestvalueisclosetoth ematerial'sultimate tensile strength. The layer removal approach is utilised in this work to determine the residual stress profile generated bydie sinking type EDM as a function of depth under the surface. On samples machined with extended pulse durations, cracking anditseffectsare alsoinvestigated.

Philips Analytical et al.[11] the author describes the process of creating and configuring anelectronic database for elastic constants.For materials having cubic, hexagonal, or tetragonal crystal symmetry, calculation models such as Voigt, Reuss, and Hillareprovided.Dataentries arechecked toavoidtheintroductionof new typing mistakes.

Hwa-Teng Lee et al. [12] the measurement of residual stress in AISI D2 cold work tool steelis investigated using the electrodischarge machining (EDM) hole-drilling technique. The microstructure and hardness of the white layer that had re-solidified onthe EDMed surface were studied using scanning electron microscopy, transmission electron microscope, and Nano indentationmethods.

ShuvraDasetal.[13]inthispaper,afiniteelement-basedmodeloftheelectricdischargemachining(EDM)processisintroduced.The transitory temperature distribution, liquid-to- solid-state material transition, residual stress, and ultimate crater shape are allpredictedbythemodel.Inthenearfuture,themodel willbeextendedto mimicthe impactsof numerouspulses.

Y.H. Guua et al. [14] AISI D2 tool steel was used for the investigation ofelectrical discharge machining (EDM). A study wasconductedtodeterminethesurfacecharacteristicsandmachiningdamageproducedbyEDMintermsofmachiningpa rameters.Theresultsshowthatthethicknessoftherecastlayerandtheroughnessofthesurfacearerelatedtothe amountofpowerused.Increasedpeakcurrentsresultinan increaseinthemeltingofthematerial,resultinginsignificantdamagetothesurfaceandsubsurfaceareasofthestructure.

F.Ghanemetal.[15]Thisresearchlooksathowmachiningaffectsthefatiguelifeofan EN

X155CrMoV12toolsteel(SAEJ438b)Thecuttingprocessesofelectro-dischargemachining (EDM), which has a high energy density, and milling, which is moretraditional, were compared. When comparing the EDM samples to the milled samples, it was discovered that the fatigue limit wasreduced by about 35%. This was ascribed to the presence of a tensile residual stress state after EDM, which was coupled withsubstantial phase change and hydrogen embrittlement to produce the observed results. Compressive residual stresses were found inthemilledsurfaces,despite the factthat therewasnomicrostructuralchange orsurfacecracking.

J.F. Liu et al [16] the current EDM modelling approaches are only capable of simulating onedischarge. In die-sinking EDM of theASP 23 tool steel, a novel model has been created to predict residual stress generation. The highest value of average residual stressis found in the subsurface rather than the top surface, which is consistent with experimental results. To produce reduced tensileresidualstress, lowerdischargeenergyisdesiredinEDM.
A. Umapathi et al.[17] Using synchrotron radiation X-rays from BL-11 at INDUS-2, RRCAT, Indore, India, the residual stressdistribution due to laser peening without coating (LPwC) was studied. The findings demonstrate that depending on the titaniumalloy, LPwC causes greater and deeper residual stress. Although compressive residual stress (CRS) was found in the majority ofinstances,tensileresidualstress(TRS)wasonlyfoundinahandfulofthem.

N.S. Rossini et al. [18] many constructed structures and components have residual stresses. For different types of components,several methods for measuring residual stress have been devised. The purpose of this study is to identify the various residual stressmeasuring methods and to give an overview of some of the most recent advancements in this field. The breadth, physical limitations,advantages, and drawbacksofeachapproachare outlined.Finally, itsuggestssome possible futuredevelopmentdirections.

X. Yanga et al. [19] the generation mechanism of residual stress and its distribution were simulated using molecular dynamicstechniques in this research. Residual stress is one of the key features of the surface machined by electrical discharge machining(EDM).Itwasdiscoveredthatduringdischarge,agreaterpressuregradientwasformedinthemeltingarea.This indicatesthatcrackscan easilyforminthere-solidifiedlayer.

YukioUedaetal.[20]inanewarticle,anewmethodformeasuringthree-dimensionalresidualstressesisprovided.Theapproachis used to calculate residual stresses in a quenchedshaft, and it is shown to be reliable and practical. It is based on Sachs' finiteelementapproach, whichhedevelopedin1975.

Philip Allen et al. [21] in many materials, micro electro-discharge machining (micro-EDM)is an excellent method for achievingburr-free machined micron-size holes. A thermo- numerical model that replicates a single spark discharge process is used toinvestigatematerialremoval.TheimpactsofcriticalEDMparameterslikepulselengthonthecrater dimensionandtoolwear%areinvestigated using the numerical model. The model predicts that when the pulse rate increases, the percentage of tool wear falls,with molybdenumhavingaconsiderablygreaterpercentageof toolwear thansteel undermachining circumstances.

III. CONCLUSION

Thefollowing arethefindingsbasedonvariousliteraturereviews.

- Residualstressesindifferentmaterialsarerelatedtotheirthermalandotherproperties,andtheyaregenerallyunaffected bythetoolelectrodeanddielectric material.
- Betweenthehardnessdepth andthenumberofaffectedlayers,thereis asignificantconnection.
- Thesubsurface,ratherthanthetopsurface,hasthegreatestaverageresidualstressvalue.InEDM,decreaseddischargeenergyissoughttominimisetensile residual stress.
- Itwasfoundthatalargerpressuregradientwasgeneratedinthemeltingregionduringdischarge.Thisimpliesthatfractures in there-solidifiedlayerarelikelytodevelop.
- Increasedpulserateresultsina decreaseinthepercentageoftoolwear.
- Thematerialremovalrate,surfaceroughness,andsurfacefracturedensityalldecreasewith thedurationof thepulse.

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