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Estimation of Residual Stress Induced in the Surface Post Machining

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***Abstract* - The present assessment is undertaken so as to elucidate the estimation of the developed residual stress in the surface post machining. In order to develop the relation, the diffraction method was employed that includes measuring of angles of ultimate diffracted intensities occurring while the crystalline solid is put through the X-rays. For this X-Ray Diffraction (XRD) technique is employed for assessing the lattice spacing of stress-free surface and machined surfaces. The strain developed is latter used to estimate the residual stress in the machined surface.**

***Keywords* – Residual Stress, XRD, Lattice Spacing;**

1. Introduction

The stress induced in a job when no external load is applied is known as residual stress. The major reason for formation of residual stress is inhomogeneous distortion of grains. The techniques entailing excessive temperature frequently led to formation of residual stress due to inhomogeneous distortion of grains caused by varying cooling rates. The extent of stress development counts on the EDM variables and the heat treatment that the surface of composite is prone to.

While machining on EDM, when molten metal solidifies, it starts to shrink but as it is in junction with base metal which is at lower temperature, the contraction is hindered to some degree. Due to this hindering of surrounding region, residual stress development initiates in the machined surface.

The residual stresses are the result of abrupt cooling and change of phase in the machined specimen. Researchers have undergone studies to analyse the nature of residual stress. Moreover, the researchers have found that residual stress is majorly developed by the thermal aspect.

A tensile nature internal stress is developed due to abrupt cooling and change in phase while machining [2,3,5,6,7]. It is also reported that these stresses leads to the formation of surface cracks [1,2,3,4,5,6,7].

2. Methodology

The internal residual stress is deduced by employing X-Ray diffraction technique. The average stress in a material is described by the irradiation area of X-rays and its penetration depth. The depth of penetration of X–ray in a material is governed by its linear absorption coefficient.

By this method, it generally estimates the angle of maximum diffracted intensity when the job is put through to X-ray. By the angles obtained, the inter-planar spacing of diffracted planes is found by applying Bragg's law as given by Eq. 1:

$$2dsin\theta = n\lambda \ldots\ldots Eq. 1$$

Where wavelength of radiation is denoted by λ and the lattice plane spacing of a family of diffraction peak is represented by d. Malvern Panalytical XRD Machine was used to determine the diffraction.

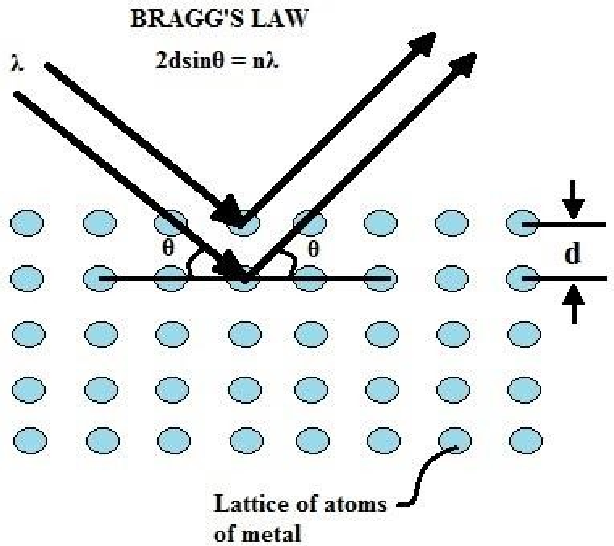


Figure 1. Workpiece subjected to X-Ray

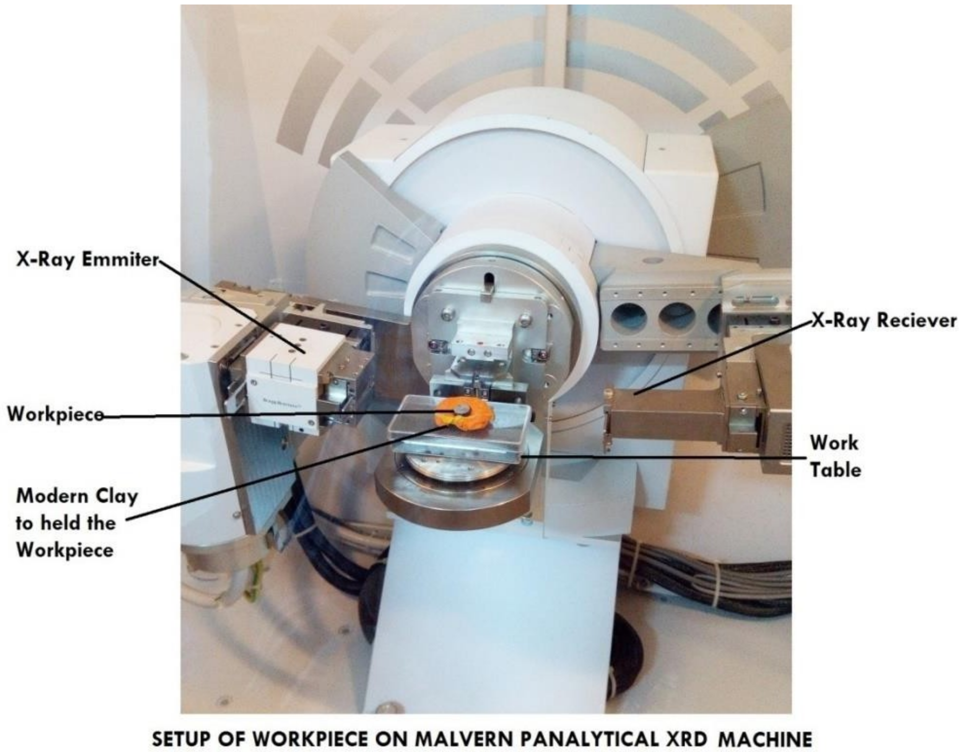


Figure 2. XRD Machine Setup

3. Calculations

When the residual stress exists inside the job, the value of d-spacing must differ from the un- stress condition. The variation of d-spacing is proportional to the immensity of developed stress. For the present investigation, the d-spacing of each stressed sample (EDMed) is analyzed by X-ray diffraction and is compared with the un-stressed sample.

The developed strain (ε) is demonstrated in terms of crystal lattice spacing change given by Eq. 2:

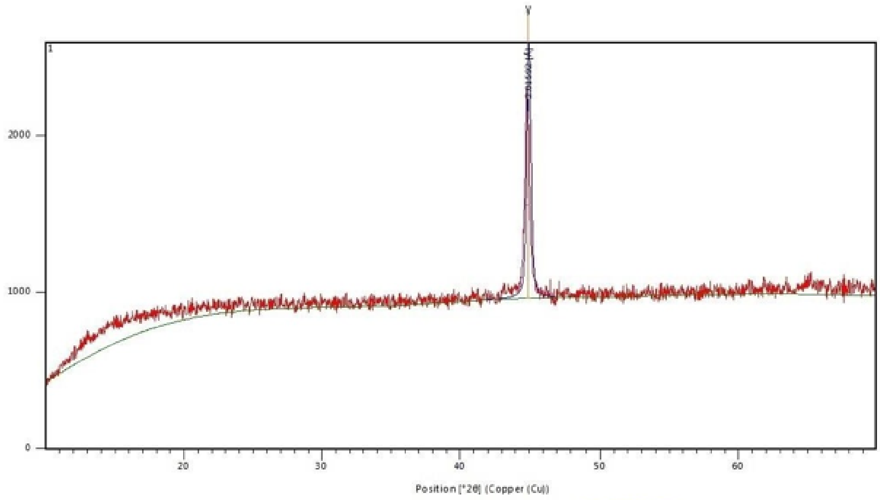
$$\boldsymbol{Strain\ (\varepsilon) = \frac{d_{\Psi\phi} - d_o}{d_0}} \dots\dots \boldsymbol{Eq. 2}$$

Where d_o is the stress-free lattice spacing.

The residual stress is calculated by following formulae in Eq. 3:

$$\boldsymbol{Residual\ Stress\ (\sigma) = \frac{\varepsilon \times E}{\gamma}} \dots\dots \boldsymbol{Eq. 3}$$

and E is young's modulus whose value is 196 GPa for selected specimen. γ is the poisons ratio which is equal to 0.3 for the specimen.



Pos. [°2θ]	Height [cts]	FWHM Left [°2θ]	d-spacing [Å]	Rel. Int. [%]
44.9285	1199.97	0.3120	2.01592	100.00

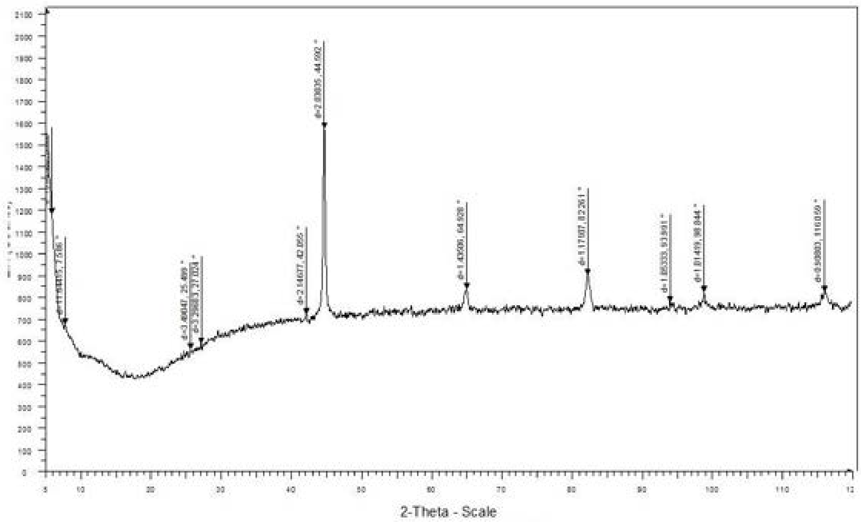
(a)

Figure 3. Diffraction for machined specimen

The figure 3 and 4 shows the XRD graphs for machined and unmachined samples. From the figure 3 and 4, we consider the d-spacing values to calculate the strain developed during machining. The calculations are as follows:

$$Strain\ in\ machined\ sample\ (\varepsilon) = \frac{2.01592 - 2.03035}{2.03035}$$

$$Strain\ in\ machined\ sample\ (\varepsilon) = -0.00710715$$



Pos. [°2θ]	Height [cts]	d-spacing [Å]	Rel. Int. [%]
44.592	1578	2.03035	100.00

(b)

Figure 4. Diffraction for un- machined specimen

Now the residual stress developed due to strain for machined sample is calculated by following formulae:

$$Residual\ stress\ in\ machined\ sample\ (\sigma) = \frac{-0.00710715 \times 196}{0.3}$$

$$Residual\ stress\ in\ machined\ sample\ (\sigma) = -4.643\ GPa$$

So, from the above equation it is clear that a residual stress of 4.643 GPa (compressive) is developed in the machined sample of AISI 4340.

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