SURFACE CHARACTERIZATION OF M42 HSS TREATED WITH CRYOGENIC AND NON-CRYOGENATED BRASS WIRE IN WEDM PROCESS

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Abstract: M42 super high speed steel is a finest cobalt high speed steel with a chemical composition intended for high hardness and better hot hardness. These properties make the steel an outstanding option for machining high-strength and pre-hardened steels. Its applications are twist drills, milling cutters, taps, reamers, broaches, saws, knives, and thread rolling dies. The present research work is mostly focused on the inspection of integrity of the work surface after machining with WEDM. Experimental results demonstrated that pulse on time and pulse off time considerably affected the surface integrity with the growth of deep-wide overlapping craters, debris and micro cracks. Much work has been devoted to the study of surface integrity in WEDM of regular steel alloys, particularly tool and die-steels. However, little research has been found on the effects of WEDM on the surface characteristics of M42 HSS. Specifically, no significant literature has been found relating to surface integrity of M42 HSS. In the present research work the comparison of cryogenated and noncryogenated treated M42 HSS has been investigated by studying surface characterstics using SEM analysis. It has been found that with the cryogenic treatment the surface become more uniform with less craters and micro cracks as compare to the non cryogenic M42 HSS.

Keywords: WEDM, HSS, SEM, RSM

Introduction: The current research work is mainly focused on the examination of integrity of the work surface after machining with WEDM. In this paper the surface properties of M42 HSS explored with cryogenic and non-cryogenic treated brass wire in WEDM process. Wire electrical discharge machining was first presented to the manufacturing industry in late 1960s (Jameson, 2001)[1]. By 1975, its popularity was quickly increasing, as the processes and its capabilities were better seen by the industry (Benedict, 1987)[2]. WEDM employs continuously moving electrode in the shape of a wire. The wire electrode is formed of different materials (Cu, brass, zinc coated, diffusion annealed etc.) of diameter ranging from 0.05-0.35mm. The opening between the wire and the work piece is flooded with de-ionised water, which behaves as a dielectric. The wire is held under stress by a tensioning device to overcome the inaccuracies in the machined parts and is steered by two support members just opposing with the workpiece. The material is detached from the succession of electrical discharges (Mcgeough, 1988)[3].

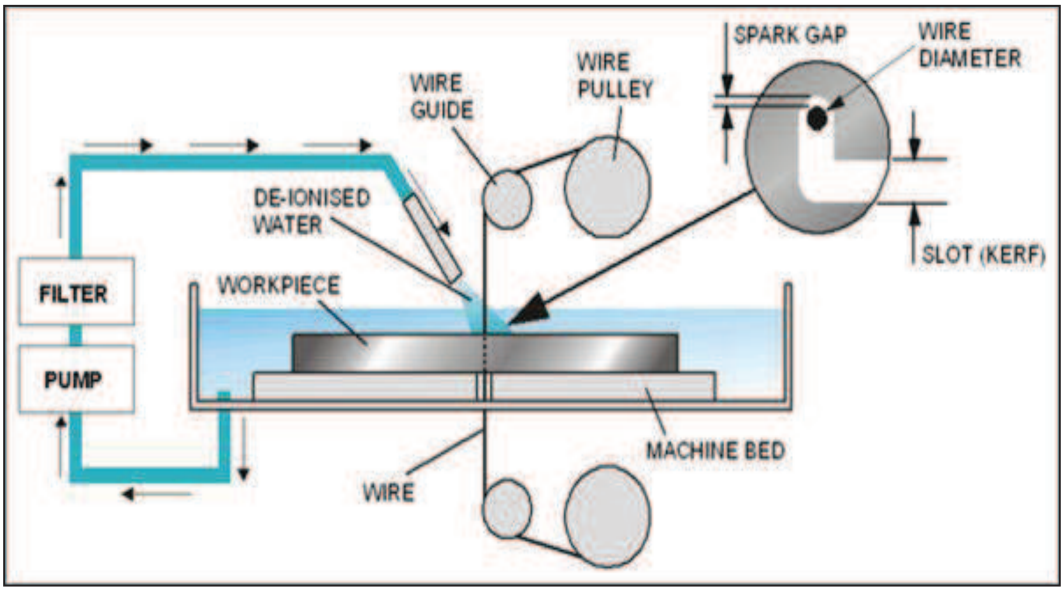


Fig 1. Schematic diagram of WEDM system (Guitrau, 1997)[4]

Cryogenic processing is the method of cooling a material to temperatures far below room temperature. Cryogenic treatment is done in a chamber, where the materials to be treated are steadily lowered in temperature from room temperature. Deep cryogenic treatment is carried out at -180ºC to -196ºC for 18-24 hours, where as shallow cryogenic treatment is performed at around -110ºC for 4-8 hours.

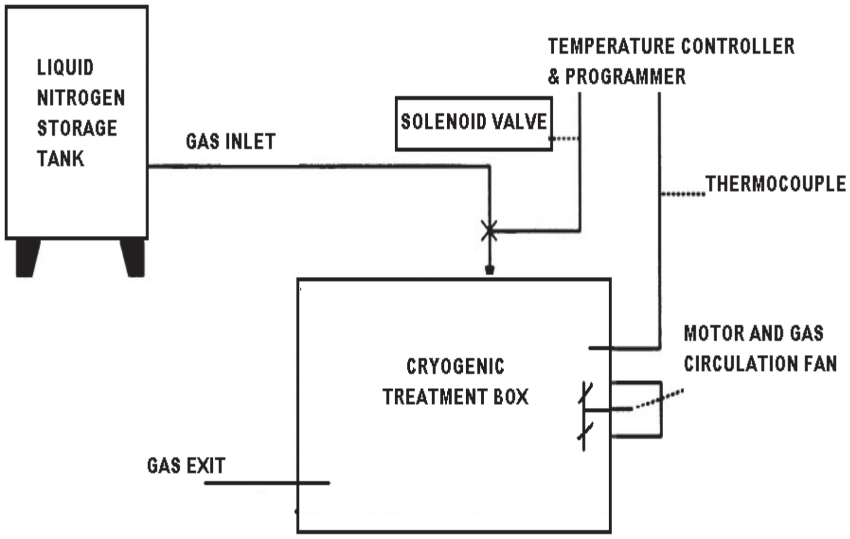


Fig 2: View of Cryogenic Processor

Literature Review: The literature view mainly focuses on the surface integrity and characterization in WEDM process. Anish et al.(2014)[5] investigated microstructure analysis and material transformation of pure titanium and tool wear surface after wire electric discharge machining process. Experimental results showed that pulse-on time, pulse-off time and peak current significantly affected the surface integrity with the formation of deep-wide overlapping craters, pock marks, debris, micro-cracks and recast layer. D.K. Aspinwall et al. (2008)[6] investigated work piece surface roughness and integrity after performing WEDM of Ti–6Al–4V and Inconel 718 using smallest amount damage generator technology. Results include productivity, 3D topographic maps of work piece surface, micro structural and micro hardness depth profile data. Vikas et al. (2014)[7] presents an idea about the effect of the different input process parameters like the Pulse ON time, Pulse OFF time, Voltage and Discharge Current over the Surface Roughness for an EN41 material. It was found out that the discharge current had a bigger impact over the Surface Roughness value, followed by the Voltage.

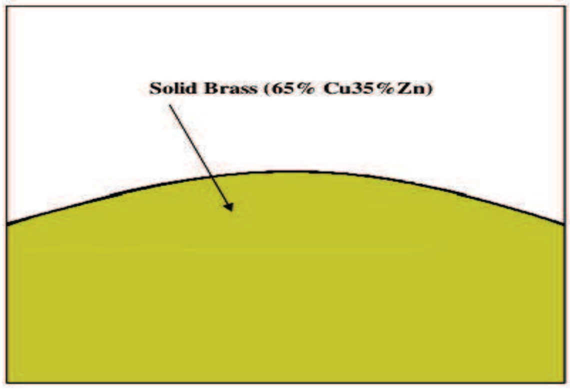
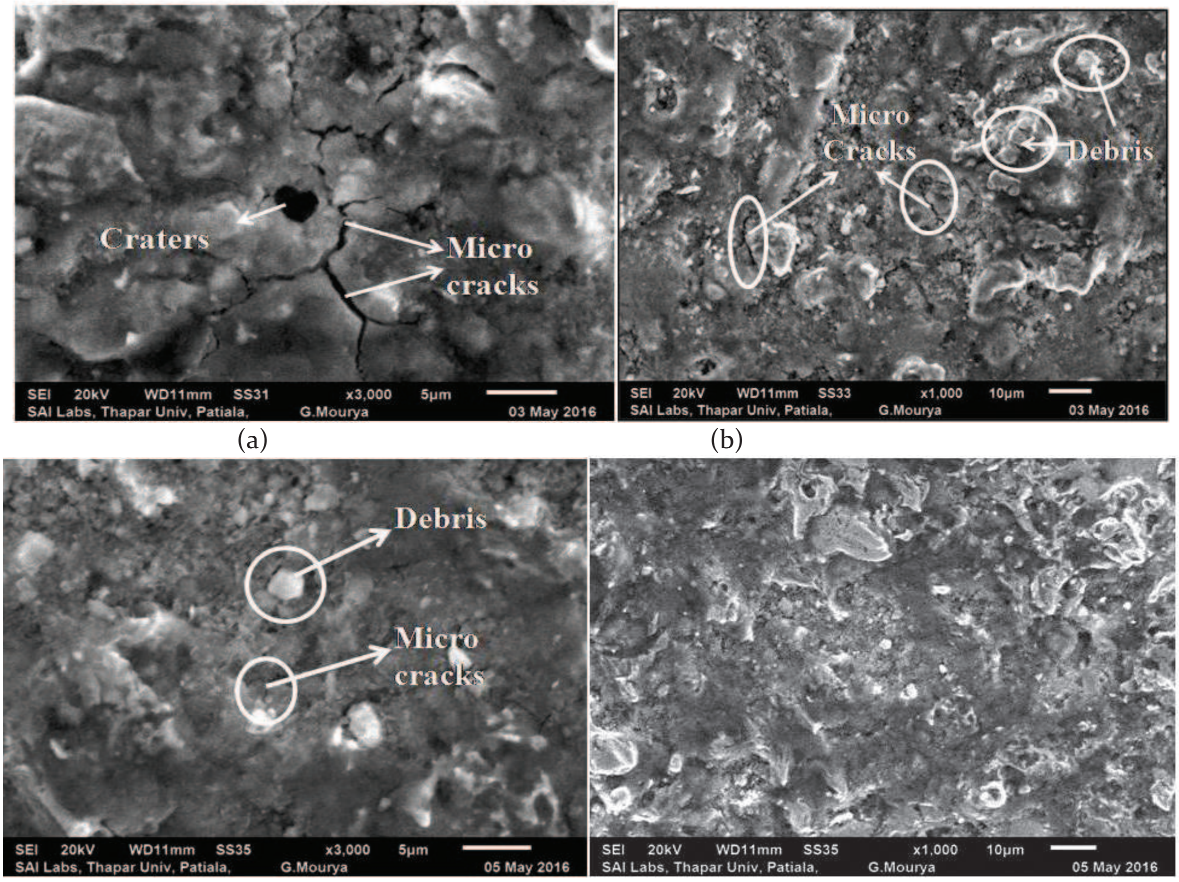


Fig 3: Plain Brass Wire Electrode

Sarkar et al., (2008)[8] investigated modeling and optimization of wire electrical discharge machining(WEDM) of γ-TiAl in the trim cutting operation. A second-order mathematical model, in requisites of machining parameters, was advanced for cutting speed, surface roughness and dimensional deviation using response surface methodology (RSM). Brass wires (Figure 3) are the amalgamation of copper and zinc, alloyed in the assortment of 63-65% copper and 35-37% zinc (Schacht, 2004a)[9].

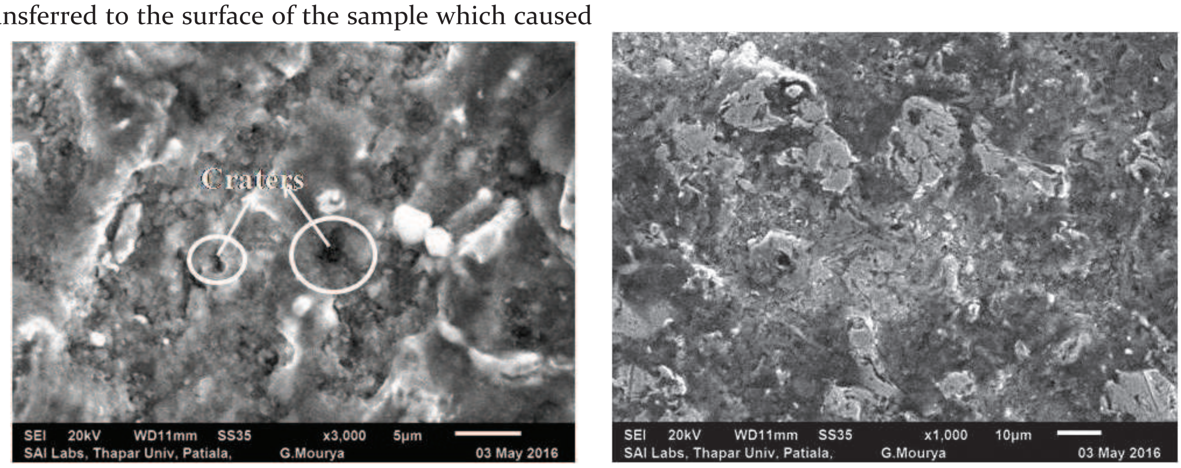
Results and discussion on machined surface topography and micro-cracks creation: The quality of a machined surface is generally characterized by surface topography which includes micro-cracks, heat affected zone, recast layer and phase transformations on the surface and subsurface regions. The surface properties might be altered due to effect of process parameters such as pulse on time, pulse off time, spark gap voltage and wire feed.



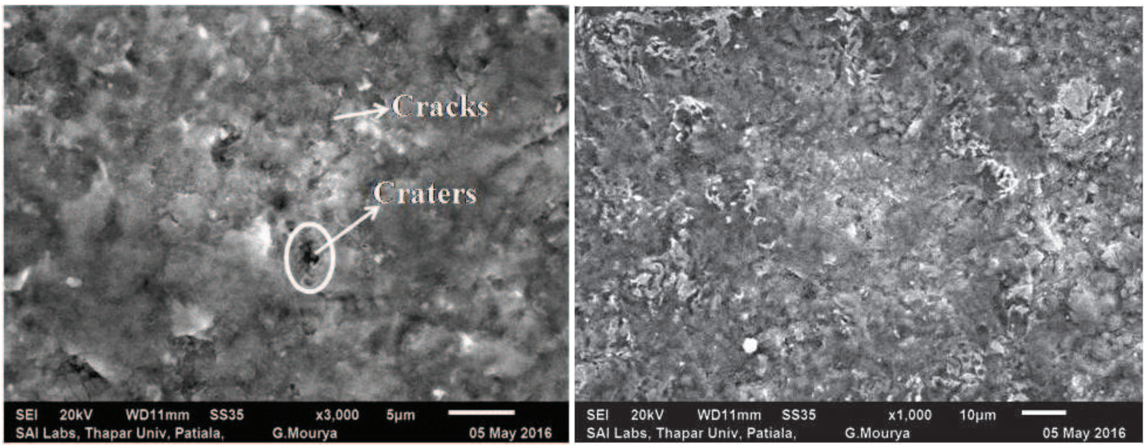
(c) (d)

Figure 4 SEM micrographs of untreated sample(a,b) and cryogenated treated samples(c,d) observed with Cracks, Craters and Debris at higher pulse on time = 120 mu, pulse off time = 45 mu, Spark gap voltage= 50 V and and Ra= 2.36 µm. (Source: Sai Labs, Thapar University, Patiala)

It was observed from SEM micrographs, that machined surface contained globules of debris, spherical particles, craters, pockmarks and micro-cracks. The increase in pulse on time resulted in the formation of deep craters on the machined surface. These deep and overlapping craters were formed due to consecutive electrical discharge, intense heat transferred to the surface of the sample which caused confined melting or evaporization of work material. Some of the molten material produced by the discharge was carried away by the deionized water. The main possible reason for deep and big craters is the oxidation reaction, the impulsive force of dielectric pressure concentrated on localized spark gap area.



(a) (b)



(c) (d)

Figure 5 SEM micrographs of untreated sample(a,b) and cryogenated treated samples(c,d) observed with Cracks, Craters and Debris at higher pulse on time = 120 mu, pulse off time = 50 mu, Spark gap voltage= 60 V and Wire feed= 5 m/min

Due to low peak current and pulse on time, the work surface is impinged with less intensive discharge. High peak current and low pulse off time increased the debris in the spark gap, which lead to abnormal arcing. The abnormal arcing decreases the discharge rate and material removal rate (Sarkar et al.; 2010)[10]. Here the SEM images of the M42 HSS samples which are machined with untreated and cryogenated treated EDM brass wire is shown below. The surface topography, debris formation and micro-cracks formation is compared between untreated and cryogenated treated samples. The SEM images are obtained at different setting of process parameters to check the effect on surface roughness in both cases.

Conclusion: The SEM micrographs of workpiece surfaces processed by shallow cryogenic treated wire electrode in WEDM suggest that surfaces are more uniform and smooth than produced with untreated wire electrode in WEDM. There are more cracks, craters and debris formation when M42 HSS is treated with non cryogenated brass wire with respect to the M42 HSS when treated with cryogenated treated brass wire. In the case of cryogenation the properties of brass wire improved due to the shallow cryogenic treatment, due to which when the cutting operation is performed in WEDM process, the surface roughness decreases. Due to decrease in surface roughness, there are less microcracks, debris and cracks formation appears in the SEM micrographs when treated with cryogenated brass wire.

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