Manufacturing industries demands for materials with attractive properties, led to the development of advanced materials such as super alloys, composites and ceramics. They are high potential materials for aviation, automotive, defense and aero-engine components.

Wire Electrical Discharge Machining (WEDM) process is widely utilized to shape complex geometries on materials having high strength and hardness. WEDM process provides the solutions for machining of slit-profile widely applicable in the manufacturing of micro slits, diffraction gratings and micro-electro mechanical systems (MEMS) components. Past work depicts that, the traditional tool-electrode materials are not capable to produce better machining performances viz. material removal rate, surface finish and dimensional accuracy. This may be due to stiffness of wire-electrode and problem of wire-electrode breakage during taper cutting. To overcome these problems during WEDM process, cryogenic treatment of wire-electrode’s is implemented in the present investigation to improve machining performances by providing more wear resistant property with better fatigue strength, thermal and electrical conductivity.

Preliminary experiments have been performed to find out the effective and non-effective parameters. Wire-electrode (normal and cryogenic), current, pulse on time, pulse off time, wire feed and wire tension are selected as machining parameters and effect of these machining parameters on the performance characteristics i.e. material removal rate and surface roughness has been analyzed. Zinc coated wire and diffused wire are selected as tool electrode materials and cryogenic treatment is done on these tool electrodes that enhance the physical and mechanical properties of wire-electrode materials. Inconel 625 super alloy, is selected as work piece material, widely used for aerospace and automotive components.

Rectangular slits and V slits are fabricated/shaped by employing WEDM process and final experiments has been performed in four phase, where Taguchi’s L18 mixed orthogonal array ($2^4*3^5$) has been used to perform the experiment runs. An optimum value of parameters has been identified by Signal-to-Noise ratio (S/N) methodology and Analysis of Variance (ANOVA) has been used to identify the significant and non-significant parameters during the fabrication of rectangular and V slit’s. Interaction plots are also developed to
examine the interaction between first and second parameters viz. tool electrode and peak current. The investigation concluded that enhanced material removal rate and better surface roughness were obtained by using cryogenically treated wire-electrodes. In addition a comparative study has been accomplished between the phases I vs. II and phase III vs. IV respectively upon which phase I and phase III provide the better results in terms of MRR and surface roughness. Scanning Electron Microscopy (SEM) is used to analyze the surface characterization of the machined work-piece material (Inconel 625) by normal and cryogenic treated wire-electrodes. Machining performances results observed that work piece materials machined by cryogenically treated tool electrode yields betters surface characteristics as compared to normal tool electrode. This reported investigation can be employed as guidelines for design and manufacturing of precision slits on super alloys, with improved machining characteristics.