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Comparative Study on the Effects of Twr and Mrr for Inconel 718 and Inconel 925 - For Non-Powder Mixed Dielectric, Jet Flow Dielectric and Alumina Powder-Mixed Dielectric Conditions

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ABSTRACT: This study aims at evaluating the MRR and TWR keeping in mind and in apparatus, all the various parameters that might affect the above mentioned. Like Alumina powder, powder mixing in dielectric fluid, the electrode material, workpiece material, degree of current used, and keeping other factors constant.

In this experiment, we have taken into consideration a substantial number of varying parameters and conditions which were presumed to affect MRR and TWR. The materials used in our job-piece are Inconel 718 and Inconel 925. Tool material is the alloy named Brass that has been centre aligned to fit our requirements.

The conditions that we have considered in the experimentation are:

- Non powder mixed dielectric condition
- Dielectric with Jet flow
- Powder mixed dielectric condition (Alumina Powder)

KEYWORDS: Electro-Discharge Machining, Dielectric Fluid, Inconel 718, Inconel 925, Material Removal Rate (MRR), Tool Wear Rate (TWR).

I. INTRODUCTION

EDM or Electro Discharge Machining is a non-conventional method of machining that is used to produce finished parts for the aerospace and automotive industry and surgical components. As the 1940s drew to a close Electro Discharge Machining took over the periods from the post-world war era to today. Machining is done with repeated electrical discharges created between the workpiece and the tool in the presence of a dielectric fluid. In our case, we are going to use both powder-mixed, non-powder mixed dielectric fluids and Jet Flow conditions. The electrode (also called the tool) is slowly brought down upon the workpiece until the gap is reduced to a mere 0.5Ꮇm. This is done so the voltage generated is large enough to Ionize the dielectric fluid successfully. These electrical discharges are done in short bursts. EDM acts on the principle of corrosion. In this case, the tool is Anode and job-piece is Cathode. Inconel 925 is one of the numerous metal alloys used in the industry for various purposes. It can be used in form of bars, ingots, ribbons, wires, shots, sheets, and even foils. Ultra-high purity and high purity variants also include metal powder, submicron powder, and nanoscale powder that targets thin film deposition. It is also used in the form of pellets for chemical vapor deposition (CVD) and physical vapour deposition (PVD) applications. Practical use cases also involve bearing assembly, ballast, casting, step soldering, and radiation shielding. Inconel 718 is also used in all the forms in which Inconel 925 is available. Used for both CVD and PVD applications, Inconel 718 is just another variant with similar characteristics as its successor Inconel 925. The standard grades of Inconel 718 is also used for Mil-Spec (military grade), and are also used in agriculture, food, and pharmaceutical industries. In this paper, we will be analyzing the effects on TWR and MRR for Inconel 925 and Inconel 718 in the conditions of Powder-mixed dielectric, Non-Powder mixed dielectric and Jet Flow dielectric condition. We also keep varying the tools' material to get a holistic understanding of

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these essential industrial-grade metals. In this experiment, we will be taking various materials as an electrode and using it to erode and machine the two different grades of Inconel that we will be using. The Inconel bars are sliced into small disc-like shapes with smooth surfaces using a power saw. The slices are 300mm diameter and weigh about 50 gms a piece. The electrode is made of brass throughout the experiment. The tools are made with a 6mm diameter and centre-aligned using a lathe in the workshop. We have also come up with an innovative solution to bring down the cost of the experiment, i.e., we will be using a small bowl-like apparatus that is made of steel and is attached with a flat mild steel base plate. The bowl-like apparatus, from here on called an "Isolation Container" is also affixed with an inverted DC motor which is run on a 9V battery. The copper wires are properly insulated using an additional layer of electrical tape so that it does not come in contact with the dielectric fluid which might cause it to short circuit or catch fire. Propellers are attached to the motor shaft in order to create a dynamic flow between the electrode and the workpiece. The base-plate of the Isolation Container also holds a workpiece holder that keeps the job piece in place during the proceedings of the much-awaited experiment. The question arises, what problems does this isolation container solve?

- It reduces the amount of Alumina Powder that we have to mix in a specific proportion in the dielectric fluid, thus bringing down the cost dramatically.
- It helps create the dynamic flow which is one of the key observational parameters that we will be dealing with in this experiment.

The Isolation container is placed in perpendicular alignment with the electrode and is raised to the desired height by a metallic cylinder that we have sourced. All of the team members will be using medical-grade latex gloves and industrial-grade safety goggles to prevent any mishaps in the laboratory.

II. EXPERIMENTATION PROCEDURE

The experimentation starts with us cutting the Inconel bars into the required dimensions of 300mm diameter and a thickness of 50mm. Also, we have centre aligned a thin rod of brass in our lathe, so that, we can observe atleast 6 readings on one surface of Inconel piece. Using a steel bowl and a mild steel base plate, we have created an isolation container with an inverted DC motor attached to the circumference of the bowl.

The first process is to perform the experiment normally without the isolation container using Jet flow dielectric from the EDM dielectric pipes to create a dynamic setting, where, the fumes are removed. Removal of the fumes guarantees the continuous sparking of the tool interrupted at regular intervals as per the settings of the Electro Discharge Machine. The tool is Anode, i.e. negatively charged, and the job piece is Cathode, i.e. positively charged. Then we place the Inconel 718 slice over a solid iron cylinder of a specific height whose sole purpose is to adjust the height of the job piece accordingly. Next, attaching the tool to the holder of the EDM machine, we auto position the tool with the job piece, so that the required gap of $0.5\mathcal{M}$m is achieved accurately. The pump is started and the dielectric is filled into the EDM basin, and when it comes up to the accurate level, we adjust the valve so that a steady flow is maintained over the basin.

Please note that we are not using any sort of powder mixing in this stage of the experimentation. The Jet flow pipes are adjusted over the job piece to create the necessary environment of the experiment. Each observation is made with 10 minutes of sparking individually with the following current values: 2A, 4A, 6A, 8A, 10A, and 12A. The spark is turned on and the observations are made one by one. The process is repeated with Inconel 925.

III. CONSTRUCTION AND WORKING OF ISOLATION CONTAINER

A steel bowl of necessary dimension is sourced and a mild steel base plate is attached to the bottom of the bowl. The circumference is fitted with a thin parabolic sheet of tin with a slot in between. This leaf-like structure is used to attach the DC motor upside down. Since the job piece will be placed in the isolation container and will be cut off from Jet flow, it is important to look for alternate methods of creating dynamic flow. Thus this DC motor is used to continuously stir the dielectric contained within the bowl in order to remove any sort of fumes/ debris that might get in between the tool and the job piece.

IV. REASONS FOR USING ISOLATION CONTAINER

Both Alumina powder and the Dielectric fluid are quite expensive and should be used carefully. If we had used the powder in the dielectric directly without the container, the proportion of Alumina used will be humongous. With the container, the dielectric volume comes down to 600ml volume and simultaneously the powder used decreased certainly.

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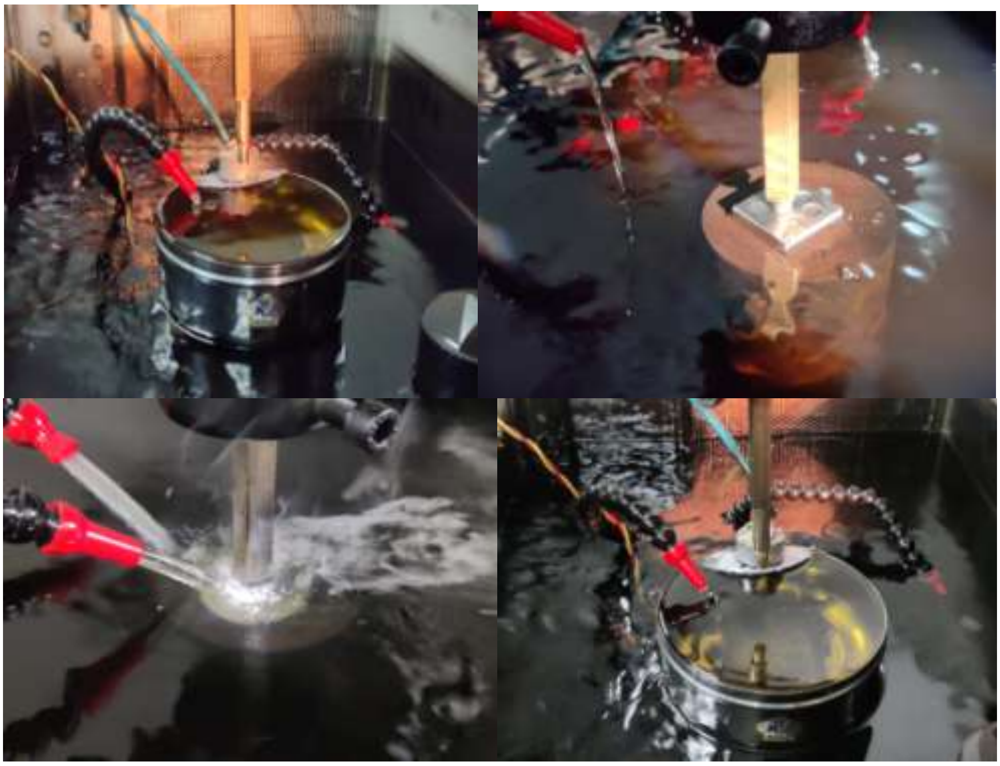
Next we place the 718 slice on the base plate of the isolation container and fill the container with 600 ml of dielectric fluid taken from the EDM basin directly. The volume of the dielectric is measured using a measuring cylinder. The tool is brought down upon the job piece and is auto-positioned. The spark is turned on and the observations are made at currents: 2A, 4A, 6A, 8A, 10A, and 12A. The exact same process is repeated with Inconel 925 slice.

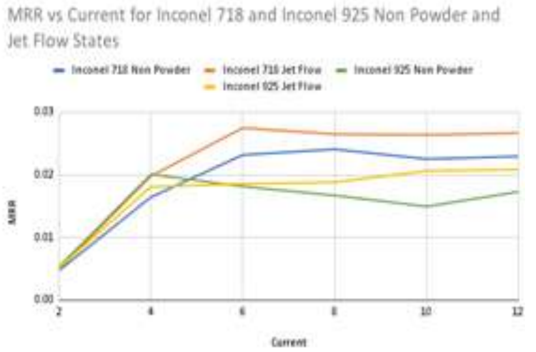
In the next phase of the experiment, the Inconel 718 slice is placed on the isolation container's base plate, and the container is filled with 600 ml of dielectric fluid directly from the EDM basin. We also mixed exactly 3g of Alumina powder in the 600ml dielectric fluid and stirred it well, so that sedimentation can be reduced. A measuring cylinder is used to determine the volume of the dielectric. The tool is dropped onto the job piece and auto-positioned. The DC motor is turned on using a 9V battery. The spark is activated, and measurements are taken at currents of 2A, 4A, 6A, 8A, 10A, and 12A. The same procedure is followed with the Inconel 925 slice.

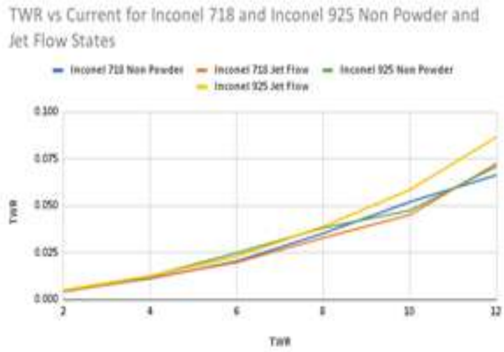


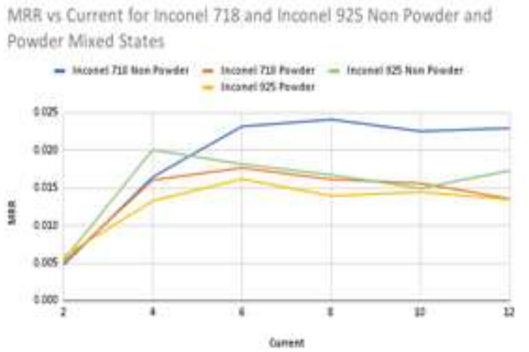
Images of the Experimental Setup

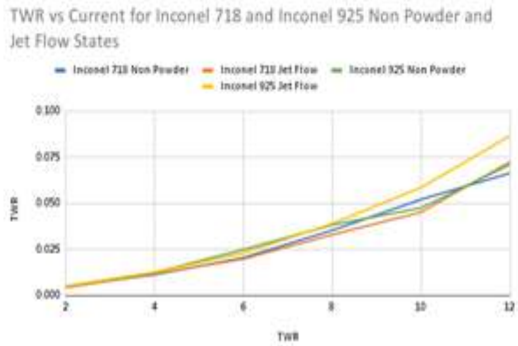
V. OBSERVATION

We have observed that in the EDM process, various parameters play an important role in the overall outcome of the experiment.









The graph of Material Removal Rate (MRR) vs Current plotted for Inconel 718 & 925 under Non Powder Condition, Powder Mixed Condition and Jet Flow Condition reveal that the peak MRR for Inconel 718 Jet Flow and Inconel 718 Non Powder Condition is at 6A. The rest of the plots for Inconel 925 Jet Flow, Inconel 925 Powder-mixed condition and Inconel 925 Non Powder shows a peak at 4A.
The Tool Wear Rate (TWR) is increasing with gradual increase in current.

VI. CONCLUSION

After the experimental procedure, we have come to the conclusion that the powder mixing and use of jet flow in the process varies the rate of MRR for both Inconel 718 and Inconel 925.
The Material Removal Rate seems to peak at 6A for Inconel 718 and at 4A for Inconel 925 for both powder-mixed, and Jet flow condition.
The Tool Wear Rate (TWR) keeps increasing gradually with the increase in current remaining indifferent to other conditions such as powder-mixing, or jetflow condition.

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