Chapter 7
Electric Discharge Machining: A Promising Choice for Surface Modification of Metallic Implants

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ABSTRACT

In the last decade, there has been an increase in interest in electrical discharge machining (EDM)'s innovative applications, with a focus on this technology's potential for surface modification. Along with the erosion of the work material during machining, the inherent nature of the operation also causes some tool material to be lost. The surface composition after machining and, subsequently, its characteristics are influenced by the formation of plasma channel, which is composed of material vapours from the eroding work material and tool electrode, and pyrolysis of dielectric. Under appropriate machining circumstances, deliberate material transfer can be accomplished by distributing metallic powders in the dielectric or utilizing composite electrodes, or by combining the two. This study provides an overview of the phenomena of surface modification by electric discharge machining as well as potential future directions for its use.

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INTRODUCTION

Electrical discharge machining (EDM) has its roots in the 1770 discovery of the erosive properties of electrical discharges by English scientist Joseph Priestly. In the 1930s, attempts were made to a gadget that uses electrical discharges for the first time to work with metals and diamonds. Intermittent arc discharges in the air between the tool electrode and workpiece linked to a DC power source were what caused erosion. Because to the overheating of the cutting region, these procedures were not particularly accurate and may be classified as “arc machining” as opposed to “spark machining” (Ho and Newman, 2003).

With the advent of the internet, the world has become a much smaller place, and the world has become a much smaller place as well (Lazarenko, 1943). A controlled procedure for machining materials was created by channelling the destructive power of an electrical discharge.

In the 1950s, the RC (resistance-capacitance) relaxation circuit was created. It offered the first reliable, constant control of pulse timings as well as a straightforward servo control circuit to automatically identify and maintain a certain gap between the electrode (tool) and the workpiece. In the 1950s, the RC circuit was widely employed and eventually served as a template for further advancements in EDM technology.

When three American employees came up with the idea of employing electrical discharges to remove damaged taps and drills from hydraulic valves, similar claims were made at around the same time. This study served as the foundation for the vacuum tube EDM machine and an electronic circuit servo system that supplied the ideal electrode-to-workpiece separation (spark gap) for sparking without the electrode actually touching the workpiece (Jameson, 2001). Nevertheless, the introduction of Computer Numerical Control (CNC) in EDM in the 1980s was what really made a difference in terms of raising the efficiency of the machining process. Modern EDM machines are now so reliable as a result of ongoing process development that they may be used 24/7 while being monitored by an adaptive control system. Any material that is electrically conductive may be machined with this method, regardless of its hardness, shape, or strength (Abu Zeid, 1997).

1.1 Working Principle of EDM Process

Despite the fact that the method of material erosion used in EDM is still debatable (Schumacher, 2004), the generally acknowledged idea is a sequence of discrete electrical discharges between an electrode and a workpiece submerged in a dielectric fluid that transform electrical energy into heat energy (Tsai and Wang, 2001). In order to prevent electrolysis of the electrodes during the EDM process, the dielectric’s insulating function is crucial. A spark is started at the location of the lowest interelectrode gap by a strong voltage, which overcomes the narrow gap’s low dielectric breakdown strength (Figure 1). There, the metal from both electrodes erodes. The capacitor is refilled from a DC source through a resistor after each discharge, and the spark that results is then transmitted to the following smallest gap (Figure 2). The result of several sparks being scattered out throughout the full surface of the workpiece is its erosion or machining to a form that is roughly complimentary to the tool.

The dielectric works to focus the discharge energy into a very narrow cross-sectional area channel. Moreover, it cools the two electrodes and clears the space of the machining waste. The discharge energy and the period of spark initiation are influenced by the dielectric’s electrical resistance (Kuneida et al., 2005).

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