CHAPTER 1

INTRODUCTION

1.1 EVOLUTION OF THE WEDM PROCESS

EDM is one of the earliest non traditional manufacturing process, used 50 years ago in a simple die-sinking application. The history of the EDM process dates back to the days of World Wars I and II. Both electrode and work material were found to be removed, and the manual feed mechanism lead to more arcing than sparking. During this time the dither or the vibrator came into the picture and this represented the first attempt towards controlling the spark gap. Vibrating the electrode allowed material removal to be effective. The invention of relaxation circuit, and a simple servo controller by two soviet scientists B.R. Lazarenko and N.I.Lazarenko (1946) helped to maintain the gap width between the tool and the work piece. This reduced arcing and made EDM machining more popular.

The two principal types of EDM processes are the die sinking and the wire EDM process. The die sinking process was refined as early as 1940 with the advent of the pulse generators, planetary and orbital motion techniques, CNC and the adaptive control mechanism. From the vacuum tubes, to the transistors to the present day solid state circuits, not only was it possible to control the Pulse on time, but the pause time or the Pulse off time could also be controlled. This made the EDM circuit better, more accurate, and more dependable and EDM industry began to grow.
During the 1960 the CIRP and ISEM conferences were held for the first time in Czechoslovakia which proved to be a driving force in the progress of the EDM process.

There were a number of problems faced when mathematical modeling of the EDM process was done. The gap pollution, the hydrodynamic and thermodynamic behavior of the working fluid are hard to model. Getting a model in all with practical technological results was difficult. This inability along with the high demand from the market lead to a more application oriented research into the EDM process.

The research going on today aims at a more application oriented field rather than searching for a unified EDM model. Today the WEDM market is growing owing to increasing popularity of WEDM in the manufacturing market and secondly due to the indirect influence of fundamental and applied WEDM R&D, carried out at various labs, industrial ones and at universities.

The evolution of the WEDM in the 70’s was due to powerful generators, new wire tool electrodes, better mechanical concepts, improved machine intelligence, better flushing etc.

1.2 THEORIES OF MATERIAL REMOVAL

The removal of material in EDM is based upon the erosion effect of electric sparks occurring between two electrodes. Several theories have been proposed to explain the complex phenomenon of "erosive spark" (Kurafuji 1964, Motoki and Hashiquchi 1967). The following are the theories;
1. Electro-mechanical theory
2. Thermo-mechanical theory
3. Thermo-electric theory

1.2.1 Electro-mechanical Theory

This theory suggests that abrasion of material particles takes place as a result of the concentrated electric field. The theory proposes that the electric field separates the material particles of the workpiece as it exceeds the forces of cohesion in the lattice of the material. This theory neglects any thermal effects.

1.2.2 Thermo-mechanical Theory

This theory suggests that material removal in EDM operations is attributed to the melting of material caused by "flame jets". These so-called flame jets are formed as a result of various electrical effects of the discharge. However, this theory does not agree with experimental data and fails to give a reasonable explanation of the effect of spark erosion.

1.2.3 Thermo-electric Theory

This theory, best-supported by experimental evidence, suggests that metal removal in EDM operations takes place as a result of the generation of extremely high temperature generated by the high intensity of the discharge current. Although well supported, this theory cannot be considered as definite and complete because of difficulties in interpretation.

1.3 PROCESS MECHANISM

It is not absolutely necessary to understand the operating principles of EDM to be a successful machinist. However, an understanding of what is
taking place between the electrode and the work piece can aid in several important areas. A basic knowledge of EDM theory can help with troubleshooting, in selecting the proper work metal/electrode combinations, and in understanding why what is good for one job is not always good for the next.

While several theories have been advanced over the years on the working of EDM, most of the evidence supports the thermoelectric model.

1.4 TYPICAL EDM USAGES
1.4.1 WEDM

WEDM is an electrical discharge machining process with a continuously moving conductive wire as tool electrode. The mechanism of metal removal in wire electrical discharge machining (WEDM) involves complex erosion effect of electric sparks generated by a pulsating direct current power supply between two closely spaced electrodes in dielectric liquid. The high energy density erodes material from both the wire and work piece by local melting and vaporizing. Because the new wire keeps feeding to the machining area, the material is removed from the work piece with the moving of wire electrode. Eventually, a cutting shape is formed on the work piece by the programmed moving trajectory of wire electrode. The equipment is extensively used in making dies and molds.

The related research projects include:

- Avoidance of wire breakage, development of monitoring and control system, database on different machining parameters, machining of advanced materials, comparison of different wire performance and thermal as well as vibration modeling.
1.4.2 Abrasive Electro Discharge Grinding (AEDG)

AEDG is a hybrid process, which combines EDM and grinding. In AEDG mechanical abrasion of a metal bonded diamond wheel is combined with the electro-erosion of electro discharge machining (EDM). The removal of conductive or partially conductive material is by a combination of rapid, repetitive spark discharges between work piece and rotating tool, separated by a flowing dielectric fluid and also by a mechanical action of irregularly shaped abrasive particles on the periphery of the wheel.

The recent research includes monitoring and control, new power generator, 2-axis NC wheel dressing unit, environmental performance of different dielectric fluids. The current research involves strategy for
optimizing neural network modeling, the study of self dressing characteristics and sequence of operations and using neural networks for controls in AEDG.

1.5 APPLICATIONS

WEDM was primarily developed for the tool & die industry. With the advancements in cutting speed, reliability, unattended operation, and accuracy it has grown into many other industries. It is now used in medical, aerospace, automotive, defense, electronics, and extrusion applications to name a few.

In the case of WEDM, the profile must be cut through the entire work piece. Many of today’s advanced WEDM systems allow the upper wire guide to be programmed independently from the lower wire guide. An example of this would be a work piece that is a square on the top and a circle at the bottom.

Die applications require two surfaces referred to as a land and a taper. Both of these surfaces can be cut using the WEDM. For example, the taper can be cut first by programming the desired angle in the opening. Once the taper is complete, the wire would be kept straight to cut the land.

WEDM produces a sharp, burr-free edge. It is a highly desirable machining choice for work pieces such as medical implants and die openings.

Gears are another excellent application for specialty as well as production runs. This is a great way to produce precision gears without the expense of broaching, hobbing, or form grinding.
Stacking of workpieces is another efficient method of cutting. When cutting multiples of the same thin work pieces, they can be stacked to reduce setup time and increase part output.

The applications for wire EDM continue to grow as more people realize its capabilities. It has offered many solutions to difficult or formerly impossible machining tasks. Typical jobs done in WEDM are shown in Figure 1.2.

![Figure 1.2 Typical jobs done in WEDM](image)

### 1.6 ADVANTAGES

- Because of its various advantages, WEDM continues to grow in many manufacturing industries. The following are only a few of its many benefits.
– Precision – Depending on the quality of the WEDM system, profile accuracy of down to 0.001 mm can be achieved.
– Surface Finish – Many WEDM systems can obtain surface finishes down to 0.2 µm Ra.
– Unattended Operation – Once the machine is set up and running, there is time for the operator to carry out other job functions. Multiple work piece setups can extend that amount of time.

1.7 CONCLUSION

In this chapter, the following points were discussed.

● Back ground of the WEDM process, the origin and development of the process.
● Challenges faced so far regarding the modeling and optimizing the process parameters.
● Earlier theories regarding the material removal.
● Applications of WEDM in modern manufacturing industries.
● Opportunities exploited by using WEDM for conductive and non conductive materials.
● Advantages of WEDM over other conventional machining process.