GLOBAL ANALYSIS OF CUTTING SYSTEM BY ELECTRICAL EROSION WITH WIRE ELECTRODE

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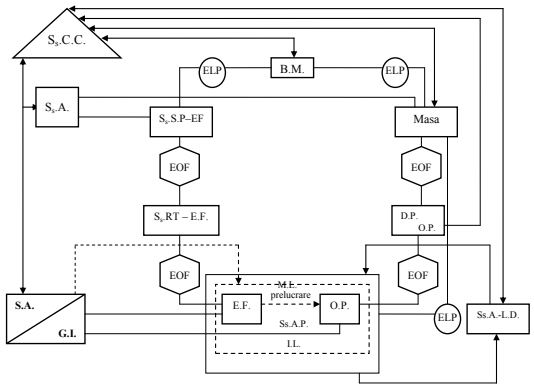
ABSTRACT: The cutting of the metal materials based on the electrical erosion with wire electrode is already established and appropriated by many companies. This paper is the result of one of global analysis of the whole system with technical and human peculiarities assumed of this application. It took into account the evolution of the situation from the first industrial machines that used this principle to the present, these equipped with modern computer numerical control (CNC) that has revolutionized the machining processes.
KEY WORDS: electrical erosion_1, wire electrode_2, cutting system_3, global analisis_4, behavior_5.

1. INTRODUCTION

Nonconventional technologies are characterized by the fact that they use as tools to remove excess material from the processed "energetically tools" such as electricity, heat, or electron beam, ultrasonic waves, etc. The nonconventional technology most used is electrical erosion. The electrical erosion is primarily applied by converting electricity into heat between two electrodes. In applying the potential difference U generates a strong electric field and an ion channel forming unloading. Through the channel, which can be regarded as consisting of a plasma environment, the transporting power, the effect of removing a quantity of material from the electrode (piece surface) and discharge it. [1]

The evolution of this technology was upward since the first use from 1969 to the present. The model of the technological structure specific electrical erosion processing with wire electrode is shown in Fig.1, where are highlighted the major subsystems of the composition of these technological systems.[2]



The model of the technological system of the processing by Wire Electric Discharge Machining. (WEDM)

The *Wire Electric Discharge Machining* (WEDM) is a thermo-electrical process which material is eroded by a series of sparks between the work piece and the wire electrode (tool). The part and wire are immersed in a dielectric (electrically no conducting) fluid which also acts as a coolant and flushes away debris. The movement of wire is controlled numerically to achieve the desired three dimensional shapes and high accuracy of the work piece. Wire EDM, is not the new kid of machining. It was introduced in the late 1960s', and has revolutionized the tool and die, mold, and metalworking industries. It is probably the most exciting and diversified machine tool developed for this industry in the last fifty years, and has numerous advantages to offer. In this process, there is no contact between work piece and electrode, thus materials of any hardness can be cut as long as they can conduct electricity. Whereas the wire does not touch the work-piece, so there is no physical pressure imparted on the work-piece and amount of clamping pressure required to hold the work-piece is minimal. Although electrical conductivity is an important factor in this type of machining, some techniques can be use to increase the efficiency in machining of low electrical conductive materials. [2]

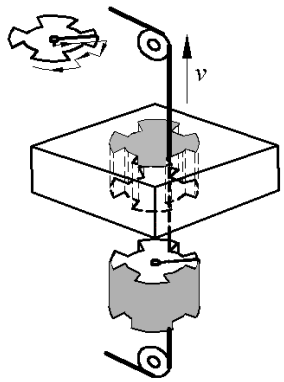


Figure 1. The schematic drawing of the electrical erosion wire electrode

The Spark Theory on a wire EDM is basically the same as that of the vertical EDM process. Many sparks can be observed at one time. This is because actual discharges can occur more than one hundred thousand times per second. The heat of each electrical spark, estimated at around 15,000° to 21,000° Fahrenheit. [3], [4]

This process has been widely used in aerospace, nuclear and automotive industries, to machine precise, complex and irregular shapes in various difficult-to-machine electrically conductive materials.

Recently, WEDM process is also being used to machine a wide variety of miniature and micro-parts in metals, alloys, sintered materials, cemented carbides, ceramics and silicon. These characteristics makes WEDM a process which has remained as a competitive and economical machining option fulfilling the demanding machining requirements imposed by the short product development cycles and the growing cost pressures. [5], [6]

So, the WEDM processing is characterized by the use of a wire electrode-tool in the form of a strand of material with high electrical conductivity, which is shifted axially guided and tensioned between two arms of the support. The work-piece is attached in the console between the two support arms of the wire electrode so that the lower arm can access under work-piece (Fig.2).

2. THEORETICAL ASPECTS

Global Analysis is a specialized technique used in many fields of science to fit multi-dimensional experimental data to one of a number of specified models. [7], [8]

Also, Global Analysis may be applied if it is desired a characterization of a company environment. This analysis is part of a company's analysis-system, which also comprises various other analyses, like the industry analysis, the market analysis and the analyses of companies, clients and competitors. This system can be divided into a macro and micro level. Except for the global environmental analysis, all other analyses can be found on the micro level. Though, the global environmental analysis describes the macro environment of a company. Obviously, a company is influenced by its environment. Many environmental factors, especially economical or social factors, play a big role in a company's decisions, because the analysis and the monitoring of those factors reveal chances and risks for the company's business. This environmental framework also gives information about location issues. A company is thereby able to determine its location sites. Furthermore, many other strategic decisions are based on this analysis. In addition, the factors are analyzed to evaluate external business developments.http://en.wikipedia.org/wiki/Global_environmental_analysis - cite_note-4 It is finally the task of the management to adapt the firm to its environment or to influence the environment in an adequate way. The latter is mostly the more difficult option. There are different instruments to analyze the company's environment which are going to be explained afterwards. [8], [9].

3. APPLICATION OF GLOBAL ANALYSIS ON THE *WEDM* CUTTING SYSTEM

For the study by the entire system has been considered WEDM cutting, like workspace, consisting of:

- The machine itself
- Appropriate processing software
- Operator
- Elements of the connection to the complex environment of the company.

These components have evolved spectacularly.

In the last 50 years the entire technical system of cutting system by electrical erosion, there are a number of changes, of the terms determinants for process quality and of the efficiency technology application. Thus, from 1970 to the present its have increased:

- The thickness of the metal piece cut: from 20 mm to 500 mm;

- The intensity of the discharge current of 60 A to 800 A;

- Wire electrode diameter of 0.2 mm to 0.8 mm. [10]

The starting point of the global analysis for the WEDM cutting workspace can be done with the help of a checklist that evaluates every criteria of a segment. In this manner, the status of the global environment shall be defined. In general, every

segment needs to be worked on systematically to recognize changes. Then, the factors and its impacts can be interpreted right. After the segmentation of the determinants factors assembly for optimum using of the system with maximum efficiency of the cutting by electrical erosion with wire electrode, the analysis consists of four further steps on WEDM technical system:

1. *Scanning*
2. *Monitoring*
3. *Forecasting*
4. *Assessment*

Through WEDM technical system *scanning*, every factor analyzed to find trend indicators. Thus, after having examined the influence factor, indicators for its development are defined. The scanning reveals actual or imminent change because it explicitly focuses on areas that the organization may have previously neglected. Scanning is also used to detect weak signals in the workplace, before these have conflated into a recognizable pattern, which might affect the organization's competitive technical system [8], [11]. Were scanned the manufacture conditions of two machines with related equipment, according to two different generations of specialized machines:

5. *Elerofil*- manufactured by Electrotimis in 1985;
6. *Sodick*AQ300L – made in 2008.

It was noted a lot of optimizations achieved, the last being with more performance systems providing that can to increase the productivity performance and the surface quality of the cutting sections. [12]

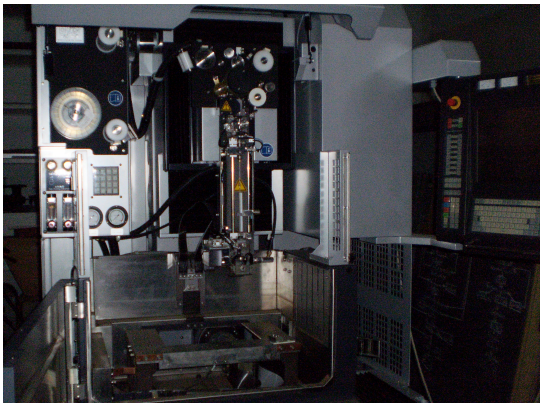


Figure 2. Planer Electric WEDM Sodick AQ300L

WEDM technical system monitoring is the process of repetitive observing for defined purposes, of one or more elements or indicators of the technical system according to pre-arranged schedules in space and time, and using comparable methodologies for environmental sensing and data collection. Through WEDM technical system monitoring, data about environmental developments are recorded, followed and interpreted. Out of this, historical development changes that are important for the company can be recognized and evaluated. Additionally, the relevance and the reliability of the data sources are tested. Furthermore it is checked, where prognoses are required. The monitoring was performed for various metallic materials and complex shapes of contours. Also, were followed the conditions required of the operator training level.

Figure 3. LN1WCNCmachineused to control electrical erosionAQ300L

The direction, intensity and speed of environmental trends are explored through WEDM technical system *forecasting*. Especially the search for possible threats is of importance. A prognosis of trends is necessary to get a picture of the future. This is done by adequate methods, like strategic foresight or scenario analysis. Several other methods of forecasting are the following: guessing, rule of thumb, expert judgment, extrapolation, leading indicators, surveys, time-series models and econometric systems. In general forecasts after the analysis of the first rudimentary equipment came true at the new one. [2], 12]

In the last step of the global analysis, the results of the previous three steps (Scanning, Monitoring, and Forecasting) are assessed. The discovered environmental trends are reviewed to estimate the probability of their occurrence. Furthermore, they need to be analyzed to evaluate whether they represent a chance or a risk for the company. The dimension of the chances or risks is also of importance. Moreover, a reaction strategy to the occurring risks or chances needs to be defined. This is done with the help of the Issue-Impact-Matrix, an adequate instrument to evaluate and prioritize trends. The forecasted of the assembly of the factors are here classified with respect to their probability of occurrence and their impact on the company. According to their classification, they demonstrate a high, medium or low priority for the company for

using the WEDM cutting system. The factors with a high occurrence probability and a high, significant impact on the company have the highest priority. The higher the priority, the faster need to be reacted to avoid risks and to benefit from chances. The technical system assessment represents the last step of the global analysis. This stage highlighted a variety of issues that need to be sorted by specific criteria of the study interests. [8], [13].

If it consider the economic efficiency of the beneficiary of this services offered by the WEDM cutting system can be applied Taguchi loss function.

Taguchi Method use the definition of the nebulous and elusive term „Quality" as the characteristic that avoids loss to the society form the time the product is shipped. Loss is measured in terms of monetary units and is related to quantifiable product characteristics. Taguchi defines quality loss via "loss function" and unites financial loss with the functional characteristics specifying through a quadratic relationship that comes from a Taylor series expansion. The quadratic takes the form of a parabola. Taguchi defines the loss function as a quantity proportional to the square of deviation from the nominal quality characteristics. The representation of the Taguchi loss function is graphically shown in fig. 5. [7]

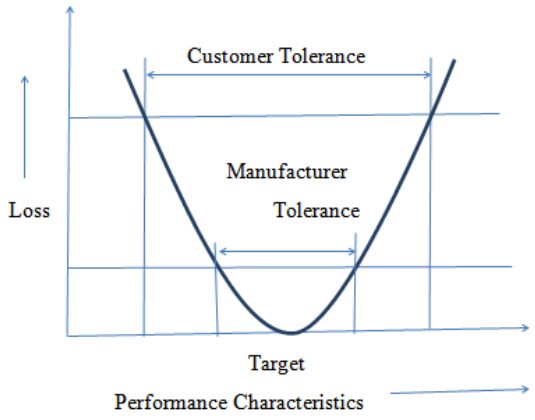


Figure 4. Graphically form of the Taguchi loss function.

The factors affecting quality characteristics of machined parts are given below: Machining parameters – Gap Voltage, Discharge Current, Pulse duration, Gap control and pulse control. Machining tool parameters – Tool material, Tool geometry Work piece related parameters – hot worked, cold worked materials, hardness. Taguchi's experimental design method is used to obtain optimum parameter combination for maximization of MRR, SF as well as minimization of cutting width (kerf). [7], 13].

For to complete the evaluation of the WEDM technical system also it count other more measures for that optimization. For example:

- The modelling of the WEDM process by means of different approach like mathematical techniques has also been applied to effectively relate the large number of process variables to the different performance of the process.
- The using of expert system implementing and testing the general characteristics of the processing by erosion. Expert systems are used to reach a conclusion, a solution or a recommendation. EXSYS CORVID uses for these conclusions/recommendations term GOALS (alternative-purposes). The execution rules for obtaining conclusions/recommendations are necessary responses to be taken from users through specialized interfaces or interfaces with other external programs. This knowledge of the system are stored and subsequently evaluated by the rules. If permission from the IF of a rule is true knowledge will enable spare part for THEN, otherwise knowledge will enable parts of the ELSE. If the ELSE part will stick to cold the next rule in the decision tree. EXSYS CORVID uses two types of facts (pieces of knowledge) Questions and Variables. [2], [11], [12].

For a more complex analysis of the WEDM cutting system, most important for organizational development, it applies the strategic analysis of the system looked at socio-technical systems. In this case it is an approach to complex organizational work design that recognizes the interaction between people and technology in workplaces. The term also refers to the interaction between society's complex infrastructures and human behavior. In this sense, society itself, and most of its substructures, are complex socio-technical systems. Socio-technical theory, as distinct from socio-technical systems, proposes a number of different ways of achieving joint optimization. They are usually based on designing different kinds of organization, ones in which the relationships between socio and technical elements lead to the emergence of productivity and wellbeing. [13], [14], [15].

4. CONCLUSIONS

The global analysis of WEDM technical cutting system it gives the possibility to determine the use of this technology for industrial application in the technical, ergonomic and economic optimum conditions. As global analysis is deeper, with the penetration of the 4 stages in detail, the results may be in conclusive for the most appropriate decisions in order to establish the necessary investments for the production of the products with a low price.

The modern WEDM cutting system, equipped with CNC and other facilities, that was studied here, can be used for precision performance and quality they offer. Global analysis of the use of this technology can conclude its futility where processing costs are too high, requiring complex and expensive software, superior operator training. For accompany it is important to use the right equipment for the right need. It is recommended some modular construction of WEDM technical systems which can provide solutions compatible with existing human and material resources.

5. ACKNOWLEDGMENT

We thank to **Professor Aurel NANU**- pioneer on Romanian Nonconventional Technologies. [16], for him contribution to the development of the Romanian school in unconventional technologies, for him support with the basis in the WEDM field and for to realize of this research.

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Notations

EDM – Electrical Discharge Machining

WEDM – Wire cut Electrical discharge Machining

SF - surface finish

MRR - metal removal rate.