Experimental research regarding structural and quality changes entailed by contact break electrical erosion (CBEE)

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Abstract: - The present paper sets forth the results obtained from some experimental research performed at the „Lucian Blaga" University of Sibiu, Romania – in the framework of a project for educational scientific research – on processed metallographic samples from semi-products delivered by contact break electrical erosion, with transfer object – metal tape. The paper presents the metallographic analysis for the selected semi-products, while for the metallographic processed the authors have mentioned their conclusions regarding their micro structural analysis. These experimental research were an integral part of certain practical courses, laboratory activities, postgraduate and doctoral courses at the School of Engineering.

Key – Words: - Quality, Factorial experiment, Statistical methods, Parameters, Experimental research, metalographic analysis, Modelling and Optimisation.

1 Theoretical considerations

Nowadays, statistical processing of experimental or observed data is a method common to all fields of study and research: from social, medical or economic ones, to engineering, physics, chemistry, biology or agricultural science. [1]
A consistent statistical approach to theoretical and experimental problems has led to valuable results in the most varied fields of science resorting to experimental data processing. In all economic and technical fields, knowledge of phenomena and processes of any type relies heavily on the processing and optimization of some information resulted from certain experiments.
Romania`s integration to the European Union entails an improvement of services and product quality, as well as to diversifying and perfecting of material production. The challenging tasks that our industry is confronted with nowadays can be completely and qualitatively solved only by means of a scientific approach and optimal management of technological processes. Science as a productive force enables man to focus on decision-making and mental activities rather than manual labour, which has been gradually replaced by automated machines and tools. For such mental and decision-making activities in process management, science makes available the necessary means, i.e. mathematical and physical patterns able to respond to any change of working conditions.
The experimental research set forth in the present paper is part of a study delivered to postgraduate students at the "Lucian Blaga" University of Sibiu, "Hermann Oberth" School of Engineering.
The students and their advisor identified the initial experimental data as well as output data in view of process modelling and further optimization. [2]
A sine-qua-non condition for the accomplishment of a proper processing of a line of experimental data is that the specialist – i.e. The postgraduate student – in charge of data processing should have thorough knowledge of the experiment leading to the respective data as well as all details regarding the manner and circumstances of measurements, the purpose of the experiment, the physical nature of the measured of neglected parameters, the objective of the data, etc. All these requirements are met provided that data processing and interpretation is performed by a person

who was actively involved in performing the experiment and measurement.

Proper experimental design and, further, experimental data processing represent are highly significant for the approach of any experimental research, completed by the modellation and/or optimization of objective function.

The factorial strategy of experimental design ensures the researcher that the designed experimental plans are optimal from the point of view of the ratio number of measurements/estimation accuracy regarding the value of objective function, accomplished by means of the explained factorial pattern.

Such aspects are directly connected to the way of delivering information to students in class and further applied in laboratory.

The delivery process by means of contact break electrical erosion with transfer object – metal tape takes place in a working environment characterized by very high and low temperatures of the semi-products undergoing delivery. The Joule-Lenz effect leads to an overheating of the working areas until they reach melting temperature, while the cooling area can determine the emergence of some structural changes in the adjoining areas to the working environment.

The macrostructure as well as the microstructure of the delivered samples have been studied and the results evinced the heating, melting and removal of cuttings, specific to CBEE. [4]

2 Analysis of the delivered semi-products macrostructure

Five samples have been considered for the macro structural analysis, according to fig. 1, 2, 3, 4, 5, made of materials: 34MoCoNi15 and RUL – 1. They were delivered by CBEE with O-T metal tape, with different status.

The cut-off surface is marked by specific phenomena and processes of CBEE discharge:

- different measures and structures of T.I.A. entailed by uneven cooling process with cooling agent during surface cutting-off process;
- the are of melted and resolidified material (specific to the Joule-Lenz effect) especially on the outside of the metal tape (fig. 1 and 3);
- the quality of the cutting is not even on the whole cut-off surface;
- if pressure values exceed 400N (towards high values), then the number of O.T.-O.P. contacts increases, the metal tape will „sweep" thus changing its perpendicularity and it entails a emphasis of „erroneous" springs between this and O.P. as well as a diminishing of the quality of the cut-off surface (fig. 3);
- the „range" of the metal tape engenders discharge amplification in non-stationary spring between this and O.P., resulting in a deterioration of the respective surfaces (fig. 4 and 5).

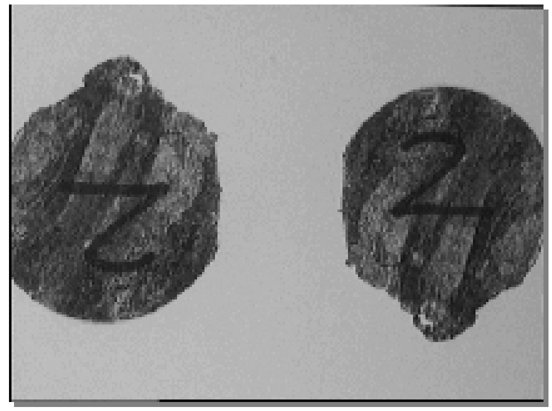

Fig. 1 Sample 2 – 34MoCrNi15

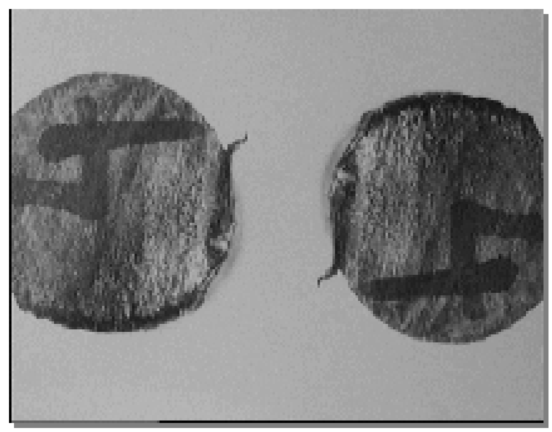

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Fig. 2 Sample 4 – 34MoCrNi15

Fig. 3 Sample 6 – 34MoCrNi15

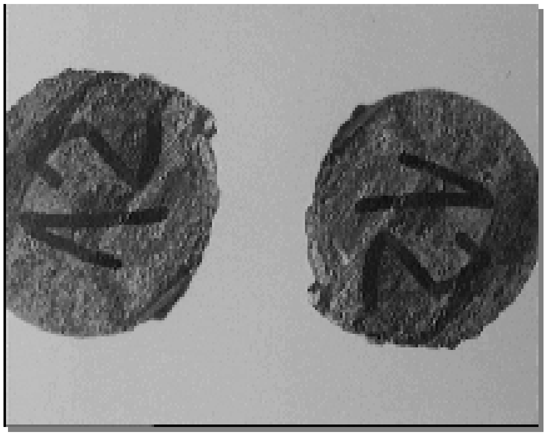

Fig. 4 Sample 12 – 34MoCrNi15

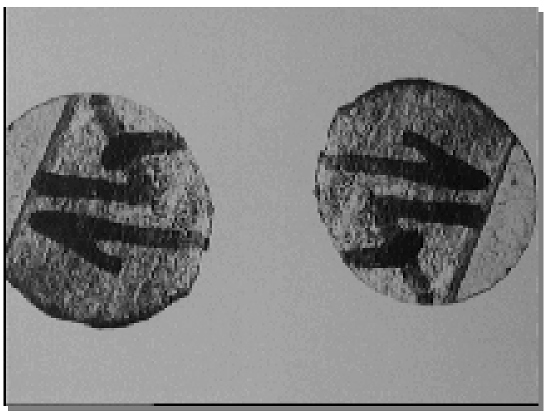

Fig. 5 Sample 14 – RUL - 1

3 Micro structural analysis of the metallographic samples

Table 1 presents the 2 categories of materials (34 MoCrNi15 and RUL-1), as well as the corresponding 16 metallographic samples and collected from the discharged samples. [4]

Micro structural analysis performed by means of the electronic microscope NEOPHOT-2 allows the researchers to highlight the following characteristics – for samples 6 and 7 – one can notice on surface 1 a 1 mm-wide decarburated area, determined by employing a medium working environment.

Table 1

Material	Fig.	Significance
34MoCrNi15	6	1 mm-wide decarburated area
34MoCrNi15	7	M.B. area
34MoCrNi15	8	2 sub-areas T.I.A.
34MoCrNi15	9	Large crystals in T.I.A.
34MoCrNi15	10	T.I.A.
34MoCrNi15	11	Edge + T.I.A.
34MoCrNi15	12	M.B. structure
34MoCrNi15	13	Non-decarburated edge
34MoCrNi15	14	Decarburated edge
RUL - 1	15	Decarburated edge + T.I.A.
RUL – 1	16	T.I.A. + M.B.
RUL - 1	17	M.B. structure

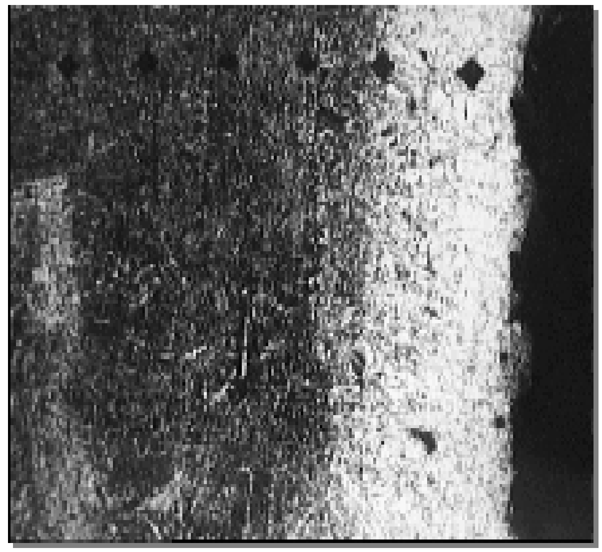

Fig. 6 Sample A – S1; 1
(x 100). (decarburated area)

For samples 8,9,10 one can notice a thermal influenced area (T.I.A.) with 2 sub-areas thus indicating the existence of high values of hardness determined by the abundance of the cooling agent for samples 11, 12 and 14.

One can notice structure that highlight a very well marked T.I.A. and the existence of a tough working environment.

Deep cooling during discharge did not facilitate the emergence of decarburated areas.

Samples 15, 16, 17 (collected from material RUL-1) evince different structures than the ones previously mentioned (from 34MoCoNi15) rows 1-9 of table 1

Discharge for these samples was performed in a medium working environment while the edges evince a transition structure from T.I.A. to M.B. (for samples 16 and 17).

The results prove variety, determined by the employed technological parameters and their potential control during discharge processes by CBEE with OT – metal tape.

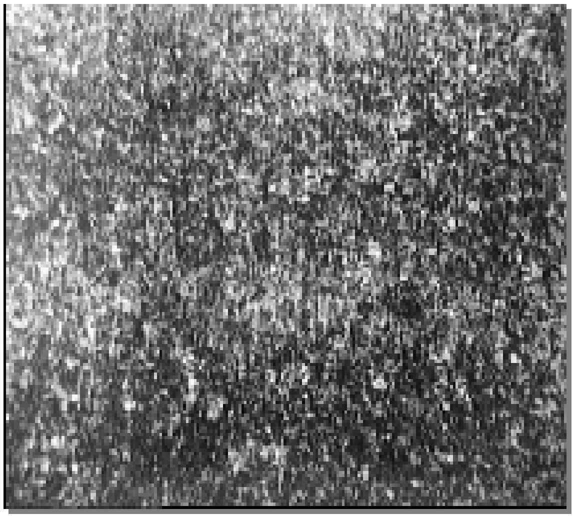

Fig. 7 Sample A – S1; MB
(x 200). (M.B. structure)

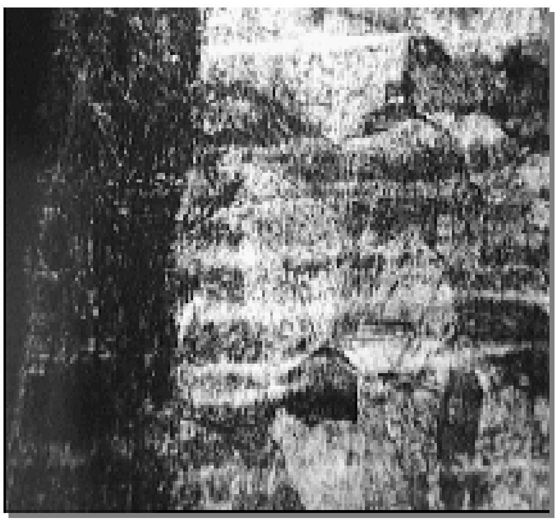

Fig. 8 Sample B – S1; T.I.A..
(x 50). (T.I.A. with 2 sub-areas)

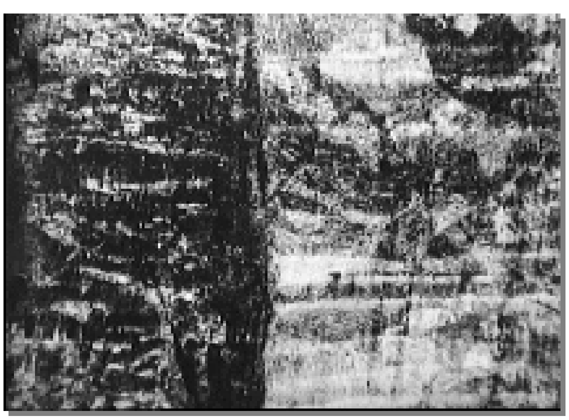

Fig. 9 Sample B – s1; T.I.A. (c)
(x 50). (large crystals in T.I.A.

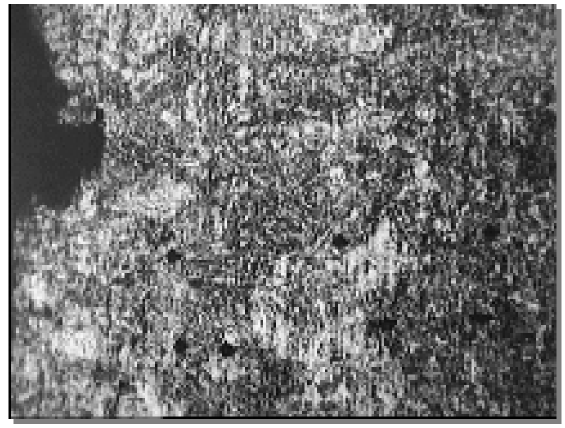

Fig. 10 Sample B – s2; T.I.A.
(x 200). (T.I.A.)

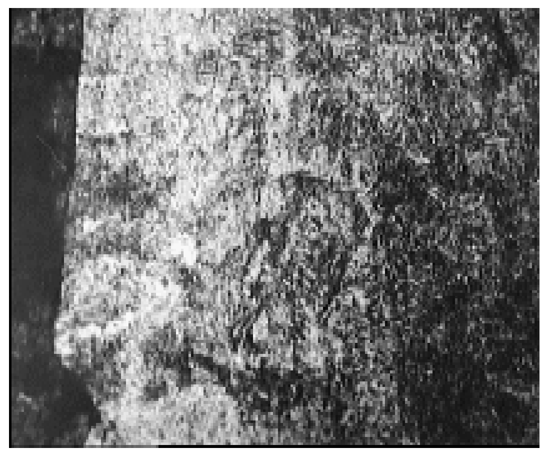

Fig. 11 Sample C – S1;M+ T.I.A.
(x 100). (edge + T.I.A.)

Special attention should be given to the cooling agent which plays a significant part in the structural change of cut-off surfaces. [4]

The manifold aims pursued during this research generate a diversity of experimental programmes, and the theory of mathematical experiment makes available a series of concepts vital for the accomplishment of research purposes.

Experimental data processing by means of statistical methods requires the knowledge and command of some essential information. Therefore, management is an information process, relying on a methodology that includes: gathering and preparing information about the status of the object undergoing the management process; processing the resulted information in order to obtain the necessary decisions; issuing the command of performing management decisions. [3]

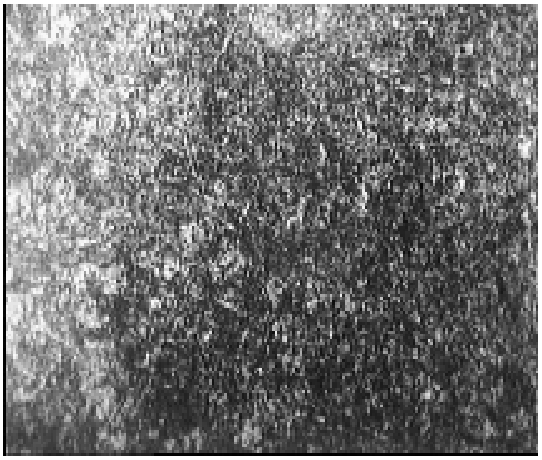

Fig. 12 Sample C – S1; MB
(x 100). (M.B. structure)

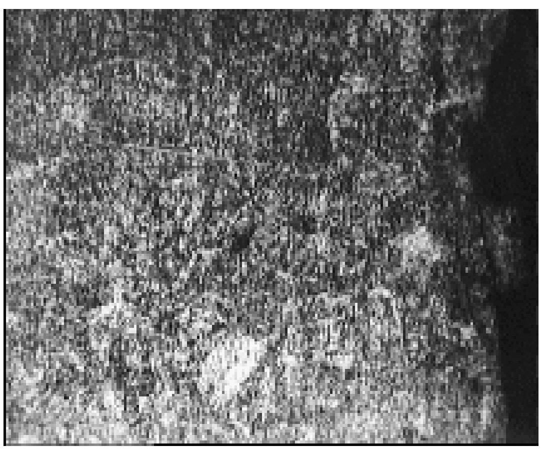

Fig. 13 Sample C – S2; M-D
(x 100). (decarburated edge)

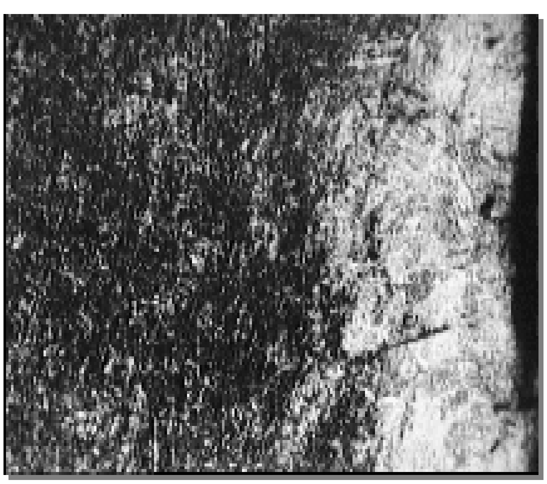

Fig. 14 Sample C – S2; M+D
(x 100). (decarburated edge)

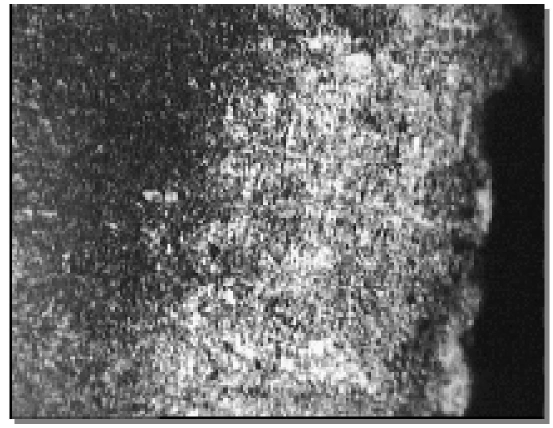

Fig. 15 Sample D–S1; M+D+ T.I.A. (x 200)
(decarburated area edge + T.I.A.)

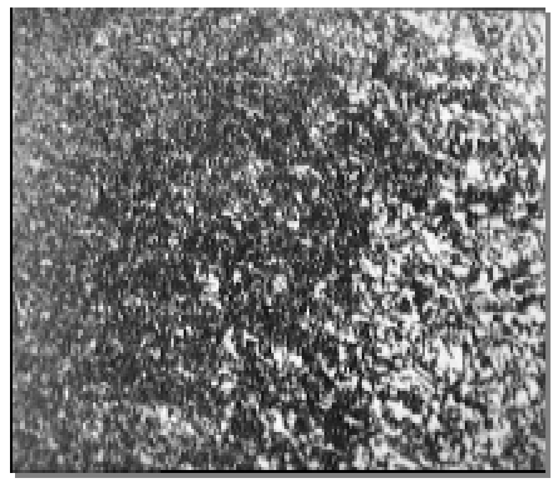

Fig. 16 Sample D – S1; T
(x 200). (T.I.A. + M.B.)

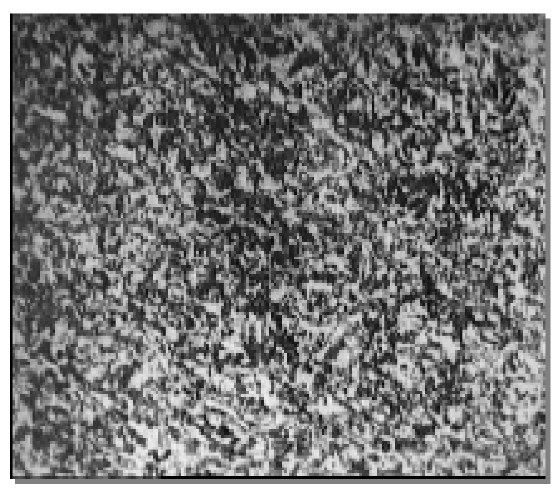

Fig. 17 Sample D – S1; MB
(x 200). (M.B. structure)

4 Conclusions

In their turn, the systems can be studied by means of various methods. The „modellation concept" is the common denominator for all theories, irrespective of the employed method.

Modellation is a method employed for the study of technological processes (technological objects) where the experiment is performed on a random object (model/pattern) and not on the „original"; in order to achieve this, one uses the experiment. [3]

Specialized literature reinforces the idea (testified by the application of factorial experimental method during practical classes of "experimental research and data processing" at postgraduate courses) that factorial experiment is so significant that, even if inefficiently employed, it leads to better results than most other methods of experimental data processing. We can definitely state that a brief analysis of the world economic picture of the present day allows us to highlight some indisputable defining features: diversifying and rapid renewal of product offer, under the impact of the fast scientific and technical development, market globalization, facilitated by the progresses recorded in the field of telecommunications, increasing customer as well as society requirements. Under these circumstances, the quality of products and services singled itself out as a the vital element of company competitivity. On the other hand, there is an increasing interest in matters of quality assurance and management, at a national, regional and international. There is also heated debate about the „phenomenon" of ISO 9000 standards, with a strong impact on international commerce. Starting from the premise of necessary changes in the approach to quality assurance and management, we can notice in our country a growing and deeper interest in this field, both on the part on economic units as well as some governmental and non-governmental organization, associations, consultancy companies, higher education institutions, etc. Many companies evince a strong interest towards quality assurance patters set forth by the international standards pertaining to ISO 9000, that are in various stages of implementation of such a pattern. Hundreds of organizations hold certified quality system relying on these standards. They believe that quality system certification will have a positive impact on business performance, and they also admit that such a system requires constant improvement as well as further implementation of the principles total quality management as prerequisites for successfully competitive companies. [3]

This process will be facilitated by progress recorded in defining the legal and institutional framework regarding conformity assessment and certification of inspection and certification organizations, as well as laboratories, according to European and international certification rules.

On the other hand, in the current economic context, marked by phenomenon globalization, an ever-wider recognition of the interdependence between environment and development, we can notice the increase of society`s requirements regarding environmental protection, testified by more and more exacting regulations. [2]

From the premises of such regulations and considering the increasing importance of ecological criteria in distinguishing existing products on the market, in the context of a very dynamic and diverse offer, more and more organizations, even in Romania, are concerned with the implementation of an environmental management system, to meet the demands of certain patterns, that have already been internationally recognized. Of such patterns, we should single out in terms of significance, the one set forth in the European Union, due to its community system for audit and environment management, more precisely the pattern promoted by ISO 14000 international standards. [2]

Interest in conformity certification according to the aforementioned patterns can be added to the previous preoccupations regarding quality systems relying on ISO 9000 standards, whose 2000-2001 issue sets forth new requirements concerning the increase of process efficiency in accomplishing goals. Furthermore, there is an increased compatibility with ISO 14000 standards, which facilitates all organizational approaches to the implementation of an integrated quality-environment management system. [3]

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