

AFFINITY DIAGRAM APPLIED AT INCREASING FLEXIBILITY OF ULTRASONIC ELECTRODISCHARGE MACHINING TECHNOLOGY

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Abstract: The paper deals with improving the flexibility performances of ultrasonic aided EDM micromachining (μ EDM+US) through application of affinity diagram. The characteristics of affinity diagram are presented and also practical suggestions to apply it in order to obtain the best results. The lack of flexibility of μ EDM+US measured in time consume of machining preparation when surface to be machined is changed is the problem to be solved. Therefore ideas to solve the problem are generated through Affinity Diagram and also the groups comprising these ideas, which represent the targets to be considered aiming at flexibility improvement.

Keywords: electrodischarge machining, ultrasonics, flexibility, affinity diagram.

1. INTRODUCTION

The Affinity Diagram represents a new instrument able to solve problems from system and operational management [1]. When using this instrument one can see the forest and not only the trees. H. Mitoneau deems that this quality management instrument is a basic one because it is essential to be combined to other instruments [2]. The problem addressed, the lack of flexibility of electrodischarge micromachining aided by ultrasonic longitudinal vibrations of electrode-tool (μ EDM+US) represents the main disadvantages of this combined nonconventional technology among very apparent others as machining rate and surface quality [3].

The difficulty which makes an obstacle to use μ EDM+US in individual and short series fabrication is high time consume during manufacture preparation which is mainly due to set up the ultrasonic chain to resonance condition working. If μ EDM+US flexibility could be improved, a very promising perspective of this technology would be opened to its larger application.

2. METHODOLOGY

The Affinity Diagram known as KJ (from the name of its author Kawakita Jiro)

represents an intuitive and creative approach rather than a strictly logical one [2]. This is usually based on brainstorming applied within the working team in the first stages of the KJ methodology. Some recommendations for KJ application are:

- When the problem to be solved comprises phenomena insufficient known or hardly controlled, as in case of this combined nonconventional technology;
- Breakthrough from traditional concepts is necessary;
- When the problem is not simple and does not require a fast solution – a study of background is essential.

KJ instrument assembles large amounts of issues and organizes them into groups based on their natural relationships. The Affinity process is used to group ideas generated by creativity of participants.

The process of developing an Affinity Diagram seems to work most excellent when there are no more than five or six participants [4] or six to eight persons [2]. This number is also compatible with Brainstorming method.

Some features of the Affinity process presented below are important to its success:

- ✓ *Working silently.* The most effective way to work is to have every member of the team move the displayed ideas without talking. It has two positive results: it

encourages creative thinking and discourages disputes about the meaning.

- ✓ *Spontaneity.* Encourage team members to react fast to what they observe; this is based on intuition.
- ✓ *Manage divergences simply.* The process provides a simple way to handle disputes on the placement of ideas. If a team member does not consent where an idea is grouped, simply moves it to another group. If an agreement cannot be reached with members of the group having a different viewpoint, a duplicate of the idea is made and placed one copy in each group.

The Affinity Diagram methodology is presented step-by-step as it follows [2], [5]:

Step 1 – Establishing the problem to be solved. As a starting point, choosing the appropriate problem is essential, which can open a thinking horizon to participants, i.e. the problem must not be too simple, solved through yes or no. The problem must have a low degree of generality. The moderator has to be ensured that the respective problem is correctly understood by all participants.

Step 2 - Generate ideas. At the beginning, the brainstorming is used to generate a list of ideas within the group of participants that could solve the approached problem. In our case, because it is about a technical specific problem the group is formed mainly by experts. Participation of some persons from other fields could be a benefit through bringing some unexpected and genuine ideas in discussion. The rest of the steps in the Affinity process will be easier if these ideas are written on post-its. It is also useful to have a warming-up discussion of five minutes which facilitates a first change of ideas, as in case of brainstorming.

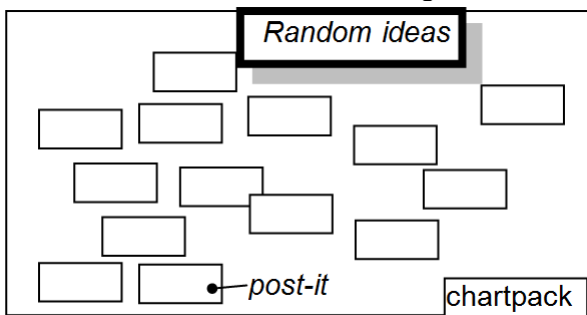


Fig.1. The process of generating ideas by each member of the team

Step 3 - Display the ideas. Each participant posts the ideas on a chartpack, a

wall, or a table in a *random* manner (fig.1). This can be done silently and more post-its are displayed, more ideas are provided by the group a brainstorming effect being generated. In some cases a reasonable limit of 20 post-its is imposed.

Step 4 – Explain each idea within the group. Before the process of affinitizing begins, the moderator of the group is ensured that each participant understands exactly in the same way the meaning of each post-it / idea. Thus each idea is taken from the left and brought to the centre of the table where is discussed and after clarification is moved to the right (fig.2).

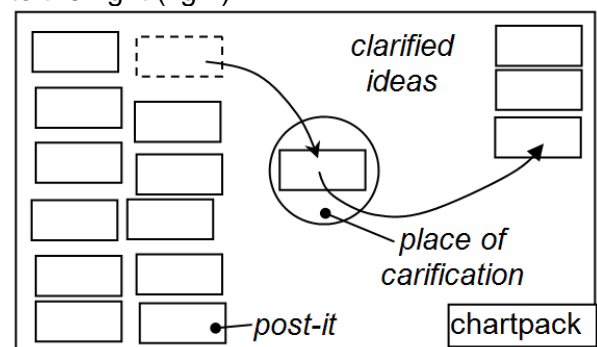


Fig.2. The process of clarification of each idea.

When each idea is placed to the right it is considered that it belongs to the group and not to its author.

Step 5 - Sort the ideas into related groups. The team members sort the post-its into groups, without talking, using the following suggestions:

- Start by looking for two ideas that seem related in some way. Place them together to one side of the chart;
- Look for the other post-its / ideas that are related to those that have already been grouped and placed aside;
- Look for other post-its / ideas that are related to each other and establish new groups.

This process is continued until the members of the team have placed all the post-its / ideas into groups.

It is ideal if all of the post-its can be sorted into related groups. If there are some that can not be integrated in any of the groups already created, it is not necessary to force them into groups where they don't really belong. In this stage, they may stand alone.

Step 6. Create subgroups if necessary. Some times large groups of ideas need to be broken down more precisely [6].

Step 7. Duplicate ideas. If some ideas fit in more groupes, create a duplicate post-it and put it into the appropriate group [7].

Step 8. Check the omissions. Through discussion occasioned by regrouping, new ideas are emitted by the group. During the previous stages it is important not to use some known patterns to find ideas. If the team uses only formal or predefined relations between ideas, the solution to really solve the problem is hard to be found. It is essential that the team brings into play its creativity.

Step 9 - Create header post-its for the groups. A header is a title that catches the deep link between the ideas contained in a group of ideas. This title is written on a post-it and could represent: only a fragment of phrase or sentence that clearly expresses the meaning, even to people who are not from the team. In order to find these headers, the following indications can be used:

- Find already existing ideas within the groups that could serve as headers and place them at the top of the group of related ideas;
- Otherwise, discuss and agree on the sense of ideas created distinctively to be headers;
- Discover a relationship among two or more groups and arrange them in neighboring columns under a *superheader* (fig. 3). Further, the same rules apply for superheaders as for regular header post-its. For that, only titles are considered. Use also a "sub-header" post-it where is necessary [7].

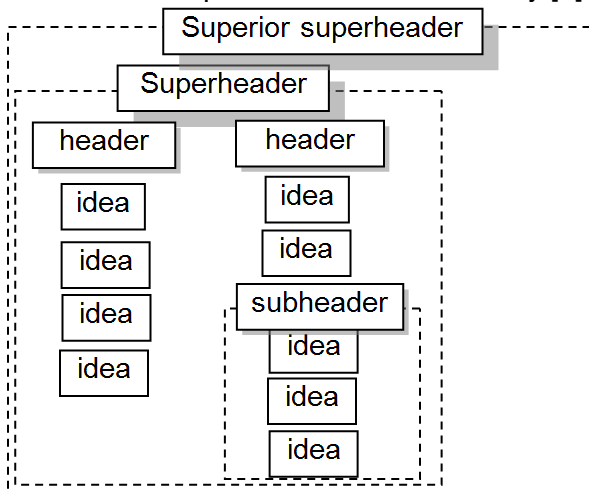


Fig.3. Grouping the ideas under headers, superheaders and subheaders.

If the header is not appropriate to its group, it is possible that some ideas from the group are not taken into account, the header is too general or too formal.

Step 10 - Draw the finished Affinity Diagram. This is the moment to display the result of the team work, the obtained structure comprising the ideas for solving the approached problem grouped under headers, superheaders and subheaders. Nevertheless it is important to establish a priority among the ideas, to evaluate their importance, useful in order to set a plan of action. For this reason, the members of the team have to vote using the symbols from fig. 4. They place a symbol next to the issue. The vote addresses only the ideas and the headers.

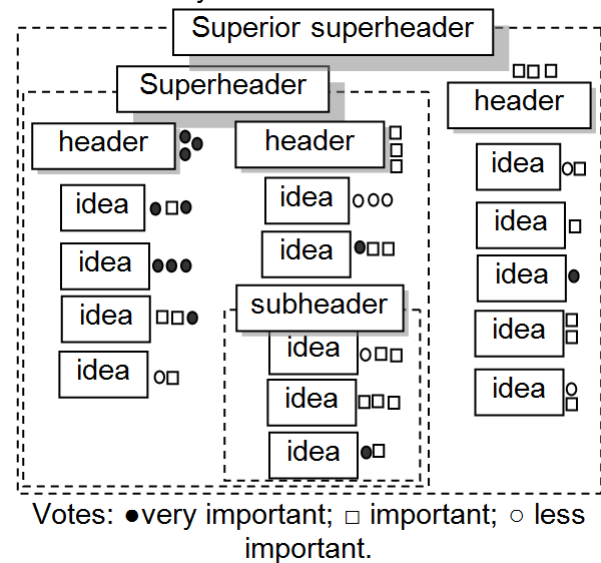


Fig.4. Display the diagram and the votes to establish the ideas importance.

3. APPLICATION OF AFFINITY DIAGRAM

The application of affinity diagram step-by-step is presented above:

Step 1 – Establishing the problem to be solved: Improvement of μ EDM+US flexibility.

Step 2, 3 - Generate and display ideas. The ideas obtained by brainstorming within the working group are presented in fig. 5:

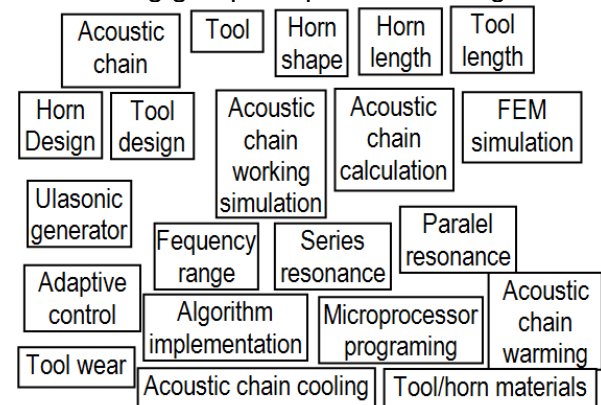


Fig.5. Random ideas.

Step 4, 5 – Explain and sort ideas. The ideas are explained and grouped (fig. 6):

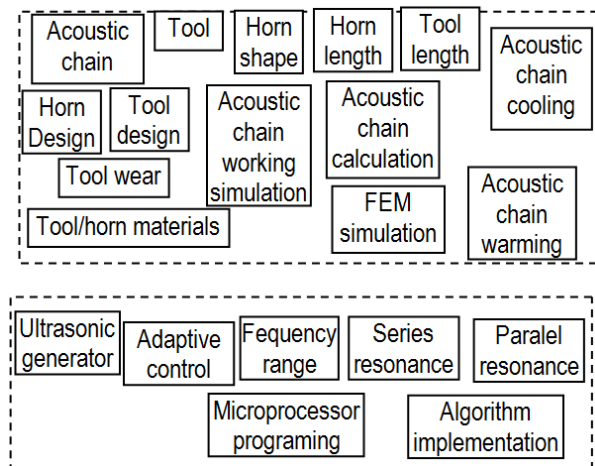


Fig.6. Ideas grouped under different categories.

Step 6, 7. Create subgroups or duplicate ideas. To obtain a more exact relation between the ideas, a more detailed sorting is needed (fig. 7). Acoustic chain calculation was duplicated belonging to two subgroups.

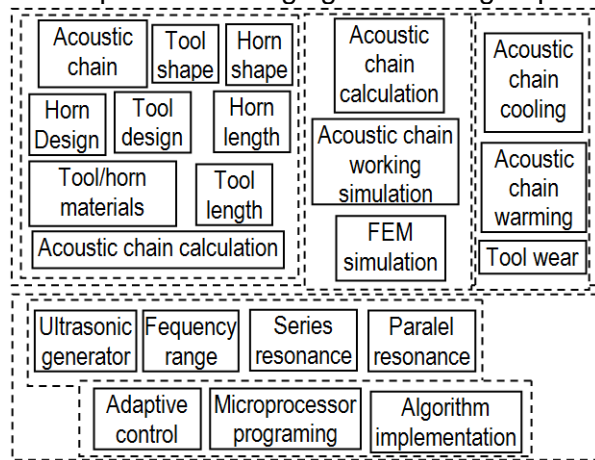


Fig.7. Ideas subgroups and duplicate ideas.

Step 8, 9, 10. Check the omissions, create headers and display the diagram. Some omissions related to acoustic chain were found and completed the diagram. A header, superheader or subheader is assigned to each group or subgroup (fig. 8).

The work team voted in order to establish the most important issues to act on. As it can be noticed from fig. 8, where the symbols represent the label assigned by the team, the most important groups for flexibility improvement are: acoustic chain work, simulation and execution as well as ultrasonic generator flexibility through adaptive control.

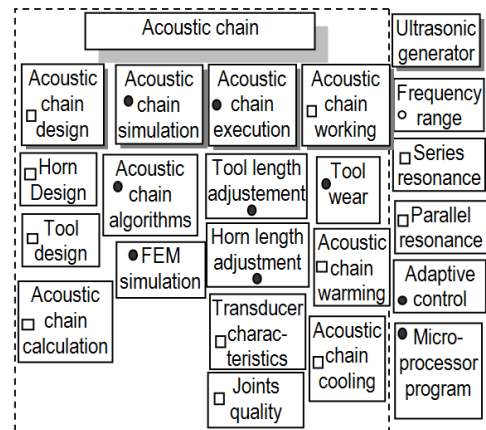


Fig.8. The Affinity Diagram and most important issues to be approached.

4. CONCLUSIONS

The Affinity Diagram, conducted to solve the problem of μ EDM+US flexibility improvement, identified the most important headers as follows: the acoustic chain with some belonging issues as FEM simulation and corresponding calculation algorithms that aim at decrease of manufacture preparation time; ultrasonic generator flexibility itself emphasized by adaptive control to ultrasonic chain own frequency variation through microprocessor programming and algorithm implementation in order to avoid critical nonconformities.

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