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USING TRIZ METHOD FOR CREATIVITY IN CONCEPTUAL DESIGN

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Abstract: *This paper's structure is introduction, conceptual design phase in systematic and axiomatic approaches, TRIZ use to support the creativity and conclusions. The creativity techniques are useful to manage the creativity process during conceptual design phase. This paper's aim is to find for a jigsaw's main functionality new possible solution's directions that can be applied further in order to accomplish this main functionality in other ways. The paper presents the use of an existing meta-algorithm based on TRIZ creativity technique as a way to stimulate the creativity. Following the meta algorithm's diagnostics stage it were identified four solution's strategic directions that can be explored further and serve as a support for new possibilities to accomplish the main functionality -to cut materials.*

Key words: *design phase, conceptual design, creativity, TRIZ*

1. INTRODUCTION

When we have to make an improvement or to find new ways to solve new problems regarding a product, process or even an organization, no matter in which domain we are developing our activities, we use a conceptual design process. How we develop, a conceptual process depends upon the received design tasks and the domain specific requirements.

The conceptual design phase is present in all design models and its important role is emphasized because it is determinant in establishing the basic product's structure and features. The result for conceptual design phase is a principle solution. If this principle solution is not a good one then in constructive and detailed design phases, the minor improvements brought by small technical details improvements are not satisfactory, they cannot remove the faults generated by a solution principle that is not so good.

In the last 15 years, numerous approaches that use artificial intelligence in conceptual design phase are presented in literature, aiming to automate the conceptual design phase or a part of the product design process. In (Sören, 2005), a generally applicable conceptual design model is presented, which has been established by theoretical reasoning applied to a number of products, using the incremental constraint networks for quantitative analysis of incomplete, evolving concepts in original design tasks allowing different principle solutions, and for various products of mechanical design. In (Jin et al. 2006), are conducted studies that use artificial intelligence during conceptual design phase aiming to obtain solutions to functions through the development of a conceptual design method based on a hierarchical co-evolutionary approach.

In (Kurtoglu et al., 2010), is presented a research that aims to automate the Pahl and Beitz systematic design process. A critical point in product's design process is the creation process. To respect the imposed short terms and the quality requirements, the product's development process requires innovative, creative thinking and design approaches. Creativity is not a controllable process and it is difficult to force creativity and breakthroughs. A way to managing this creativity process is the use of TRIZ, the Theory of Inventive Problem Solving (abbreviated as TRIZ, the original Russian acronym).

In this paper, the researchers want to find out new possible directions for solutions that can help to solve the main functionality of a jigsaw, namely to be able to cut materials. In this way, it was used, as a way to stimulate the creativity, a part from a meta-algorithm of inventing based on TRIZ technique in order find new possible solution's directions, directions that can be explored further, they being a starting point for next researches.

2. CONCEPTUAL DESIGN PHASE IN SYSTEMATIC AND AXIOMATIC APPROACHES

In (Pahl & Beitz, 2007), the product's development process comprises four phases. These are: planning and clarifying the task (specification of information in a requirements list), conceptual design phase (specification of principle) that has as objective to determine the principle solution, the embodiment design phase (specification of layout) where a working principle is elaborated in the form of preliminary layouts that are then evaluated and rejected and/or combined to produce a definitive layout and the last phase is detail design (specification of production) and it is the phase where all production documents are produced.

The conceptual design phase has as result the principle solution and comprises the following steps: abstracting to identify the essential problems, broadening the problem formulation, identify the essential problem from requirements list, and establish the function structure, developing working structures and developing concepts. Regarding this conceptual design phase, in systematic design one has to formulate the product's overall function. Next, this function will be decomposed into lower level sub-functions, sub-functions seen as transformations between material energy and information (Pahl & Beitz, 2007) and all the steps reminded above have to be followed.

In axiomatic design, the decomposition does not follow a conventional way - it is done through zigzagging - and the design itself is guided by the two design axioms, independence axiom and information axiom (Suh, 2001). First, the functional requirements are established and next the design parameters that accomplish these functional requirements have to be found. This understanding of FRs (functional requirements) in terms of physical domain, DPs (design parameters), is a mapping process, passing from *what* we want to achieve to *how* and implies a creative conceptual work. After the general design concept is generated, the DPs has to be identified and next continued the decomposing process for FRs. During these process designers has to think to all the possible ways to accomplish each FR by identifying the most plausible DP, avoiding the functional coupling between functional requirements. In selecting the appropriate design parameters and in generating the DPs are useful databases, morphological techniques, analogy, reverse engineering. The eventual coupling has to be resolved and this implies a creativity process.

The conceptual design phase, in both approaches, is related to creativity techniques that prove to be useful, the conceptual design phase implying a creativity conceptual work conducted by the question of how we can respond to design requirements.

3. TRIZ USE TO SUPPORT THE CREATIVITY

The creativity domain is hard to control because it is depending on how the designers think and the many different possible ways that designers can follow to reach the desired finality. In this sense, it is useful to use tools that support creativity, helps the idea emergence and help to avoid the mental blocking.

One of these methods is TRIZ that is a "human-oriented knowledge-based systematic methodology of inventive problem solving" (Savransky, 2000) and can be used to help the emergence of new ideas. It provides a systematic way of solution finding and the results are in the form of more innovative product.

TRIZ is a methodology that formalizes the process of solving the physical and technical contradictions in order to solve technical problems and is a powerful methodology in finding new ideas. To support the emergence of new ideas regarding the finding of new inventive solutions, it can be used a meta-algorithm of inventing (Orloff, 2006) that uses TRIZ technique.

Is stated in (Orloff, 2006) that TRIZ is a qualitative model that can provide recommendations, rules, instructions, suggestions, and examples. These types of qualitative models are all instruments for thinking – the achievement of practical results based on systematic and generalized experiences – and they correspond closely to the concepts of constructive mathematics. An algorithm is the entire set of rules that determine the development of the objects to be constructed. A generalized scheme of a meta-algorithm for invention is presented in (Orloff, 2006) and it comprises four stages:

- Diagnosis (statement of the problem)
- Reduction (reference to known models)
- Transformation (identification of ideas based on controllable rules of transformation)
- Verification (check of the potential attainability of goals)

The diagnosis and reduction stages are in essence procedures for the analysis of the problem, while the transformations and verification stages synthesize the solution. This meta-algorithm for invention is the primary navigation system for solutions to any problem in inventing. The procedures from this scheme are supported by database shown clearly in the form of drawings whose basis is the A-navigators (Orloff, 2006). Taking into account these, we searched a set of solutions for redesigning a jigsaw's main functionality - to be able to cut materials.

We followed the diagnostics stage from the meta-algorithm of inventing, the next steps:

- Defining goals and problems
- Defining the operative zone and its elements,
- Constructing the initial model of contradiction,
- Identifying a strategic selection for solution's directions

We tried to solve technical contradictions and find solutions using Su-Field analysis. It was employed the TRIZ inventive principles to establish the possible technical solutions for the jigsaw. Using the A-Matrix for the Selection of specialized A-navigators (Orloff, 2006) and considering that the positive factors are the cutting productivity and the curvilinear contours cutting us found: 01 productivity, 30 force, 36 power, 02 universality and adaptability.

In addition, using the same A-Matrix and considering that the negative factors are stressed tool's wear, increased vibration and efficiency we found: 04 reliability, 27 loss of material, 14 internal damaging factors, 39 loss of energy.

The strategic directions for solutions that we found using the contradiction matrix (***) are:

1) Employing the mechanical oscillation – a possible solution with buried permanent magnet; the transformation chain being decreased - permanent oscillatory machine with surface permanent magnets. The principle solution can be found in (Tutelea, 2008)
2) Replacement of mechanical matter - the use of air under pressure, cutting with liquid jet
3) Inverse action - solutions that uses laser beam cutting, electrical cutting
4) Dynamization, segmentation - according to this solution direction applied to jigsaw, the tool constructive design should be changed so that continuous rotating movement can be used at high speed.

4. CONCLUSION

The use of the algorithm and TRIZ technique leads us to find possible new ways to conduct further researches regarding the accomplishment of the main functionality. An interesting direction is that of using the mechanical oscillation the other three directions found being already used as solutions that has as aim the cutting of materials.

The linear permanent magnet oscillatory machines have gained momentum in the last decade and could play an important role in the direct driving of piston pumps, compressors, etc. A flat surface mover allows for permanent magnet flux concentration, and the machine core is easy to manufacture from laminations. Further, it is interesting to study more this direction –the use of mechanical oscillation and try to solve the problems that appear here: the frequency of the mover has to be equal with the resonance frequency of the mechanical spring, the cutting speed has to be constant, and the length of the maximum stroke that is 30-40 mm.

5. REFERENCES

Jin, Y., Li, W. and Lu, S. (2005). A Hierarchical Co-Evolutionary Approach to Conceptual Design, *Annals of the CIRP*, 54/1, pp. 155-158

Kurtoglu, T., Swantner, A. and al. (2010). Automating the conceptual design process: From black box to component selection. *Artificial Intelligence for Engineering Design*, Analysis and Manufacturing, 24, pp. 49–62.

Orloff, M.A. (2006). *Inventive Thinking through TRIZ*, Springer-Verlag Berlin Heidelberg

Pahl, G., Beitz, W., Feldhusen, J. and Grote, K.-H. (2007). *Engineering Design. A Systematic Approach*, Third Edition, Springer-Verlag London Limited

Savransky, Semyon D. (2000). *Engineering of creativity: introduction to TRIZ methodology of inventive problem solving*, ISBN 0-8493-2255-3, pp. 22, CRC Press LLC

Sören W. (2005). Function and constraint-based conceptual design support using easily exchangeable, reusable principle solution elements in *Artificial Intelligence for Engineering Design, Analysis and Manufacturing* Volume 19, Issue 3, June 2005, pp. 201-219, ISSN:0890-0604

Suh, N.P. (2001). Axiomatic design advances and applications, Oxford University Press.

Tutelea, L.N., Kim, M.C., Topor, M., Lee, J. and Boldea, I., (2008) Linear permanent magnet oscillatory machine, comprehensive modeling for transients with validation by experiments, *IEEE Transactions on Industrial Electronics*, vol. 55, no. 2 February, 2008, pp. 492-500.

*** TRIZ 40, Interactive TRIZ Matrix & 40 Principles available at http://www.triz40.com/, *Accessed on: 2010-06-10*