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IMPROVEMERNT OF TOOLS

FOR FLOW ANALYSIS

Author's thesis for the TRIZ Master degree

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Outline

– General description of research

The goal of the research consists in refinement of Trend for increasing efficiency of utilization of substance, energy and information flows and in improvement of methodology for flow analysis.

The author has conducted an analysis of flows in a system and formulated recommendations for increasing practical value of flow analysis results due to changes in formulations and conclusions of the current version of the “Trend for increasing efficiency of utilization of substance, energy and information flows” in wording of S.Litvin and A.Lyubomirskiy. Improved methodologies are proposed by the author based on the above-indicated.

Besides, the author also carried out classification of flows in terms of main classification criteria and proposed recommendations regarding use of this classification.

– Actuality of research subject matter

On the whole, combined application of function analysis (FA) and flow analysis (FLA) stably gives good results. However, the accumulated experience of combined use of these tools in actual practice enabled to formulate several problems and disadvantages:

At the level of interaction between FA and FLA

- Absence of unambiguous correlation between function model elements and flow model elements, which makes it more difficult to formulate key disadvantages
- Absence of correlation between function model elements parameters and flow model elements parameters, which makes it more difficult to formulate requirements to parameters of elements.

At the level of FLA proper

- Absence of specific recommendations enabling to choose one of the available sub-trends
- Difficulty of accurate distinguishing between harmful flows and parasitic ones in a system
- Inconsistent application of notion “flow conductivity”
- Absence of algorithm for parametrization of flows

In addition, the procedure for flow model building is almost completely separated from the procedure for the analysis of this model in basic manuals.

– Goals and tasks of the research

The goal of research consists in enhancing the capabilities of flow analysis and integration of flow analysis with other TRIZ tools.

The tasks of research were formulated to attain the above-named goal:

- Refinement of formulations used when conducting flow analysis and in the Trend of enhancing the efficiency of utilization of substance, energy and information flows
- Development of upgraded methodology for the performance of flow analysis for ES
- Development of recommendations for elimination of problems identified as a result of flow analysis
- Development of methodology for integrating flow analysis with function analysis.

– Scientific novelty of research

- Integration of function analysis with flow analysis was carried out on the basis of Trend of increasing completeness of system components and function approach
- Main static ES components related to the passage of flows in ES were identified and described
- The flows were classified and recommendations on enhancement of flows and engineering systems on the basis of obtained classification
- Recommendations represented in the Trend of enhancing the efficiency of utilization of substance, energy and information flows were supplemented and structured
- Enhanced methods for building flow model and conducting flow analysis were proposed
- A method for switching over from flow analysis to function analysis was suggested.

– Practical significance of research.

Research results are intended for practical use in consulting projects and teaching TRIZ to engineers. The experience of application of proposed methodology and approach to flow analysis showed their efficiency. An important advantage of this methodology consists in possibility of its application within the frames of traditional industry analysis – i.e. without conducting full-scale TRIZ analysis.

– Main results of research to be presented at thesis defense

The function approach in parametric form (used as the basis for GEN3:ID methodology) was chosen as a methodological foundations for flow model building. Consequently, function modeling and flow modeling used in GEN3:ID methodology were chosen as prototype.

A system of trends of Engineering System Evolution (also used in GEN3:ID methodology) was chosen as theoretical foundations for the analysis of obtained models.

The following changes were introduced in the above-indicated system pertaining to flow modeling and analysis:

1. Correlation of flows with other components of systems

- A definition of flow as dynamic component of a system was introduced (this definition missing before).
- According to that, it is proposed to consider flow analysis as a specific particular case of function analysis. An appropriate refinement of model for functionally complete system was suggested.
- Four types of static components of function model were singled out on the basis of model for functionally complete system. These statistic components always accompany any flow passing in a system:
  - Source,
  - Channel,
  - Receiver,
  - Control system.

Similarly to function model, each of these components (with the exception of channel) can be missing in explicit form or can be located in the supersystem.

- Two types of sources were identified and their main specific features were analyzed:
  - Source of potential; and
  - Source of current.

  It was shown that taking these specific features into account should lead to more adequate choosing of strategy of evolution (improvement) for system that includes flow.

- Also, two main types of control system were identified:
  - “Pump” type, and
  - “Check valve” type.

It was shown that taking the type of control system into account also enables to choose strategy of enhancement of flow (and system on the whole) more consciously.

- As a rule, flow receiver represents an operating element, i.e. key element of functionally complete ES. Often analysis of flow receiver does not refer to flow enhancement tasks, being an analysis of higher system level. Therefore it was not considered in the present research.
- It was shown that flow channel is a flow element that is selected most often for the enhancement (together with the flow proper).
- Principles for flow enhancement proposed in the systems of trends were systemized and refined based on above-indicated singling out of static components related to flows.

- In particular, it was shown that reduction in channel conductivity of harmful flow (recommended by the Trends) represents infrequent particular case. There is a much more efficient way (which is observed more frequently) – the so-called “channelization of harmful flow”, which means that a new channel intended for the removal of such flow from a system is created. And conductivity of such new channel should be high.

2. Classification of flows

- Being a particular case of function model component, flows can be classified in terms of a number of specific features. Such classification enables to describe specific features of different flows more accurately. Hence, an opportunity appears to propose additional recommendations specific for flows of different types.
- Classification in terms of following specific features was proposed:
    - Classification of flows in terms of functionality (useful, harmful and parasitic)
    - Classification of flows in terms of source (primary or secondary)
    - Classification of flows in terms of feature “horse-rider” (functional or carrier)
    - Classification of flows into closed flows and open ones
    - Classification of flows into discrete, continuous and complex.
- In particular, a more accurate definition was suggested, which allows distinguishing harmful flows from parasitic ones and, hence, propose different recommendations for them:
    - Harmful flows – are the flows performing harmful function (and not having main useful function), which are predetermined by the action principle of a system. For instance, carbon dioxide produced as a result of fuel combustion in internal combustion engines.
    - Parasitic flows – are also flows performing harmful function (and not having main useful function), but which are NOT predetermined by the action principle of a system. For instance, nitrogen oxides and carbon monoxide produced in the case of inadequate operation of engine.
- Typical specific features were described for different types and kinds of flows in accordance with classification. Additional techniques for flow improvement were suggested on the basis of such specific features.

3. Methodology for flow model building

- There are two main approaches to compiling methodologies for analysis and work in TRIZ. By convention they could be called “step-by-step strategy” and “step-by-step algorithm”.
- Step-by-step strategy describes main directions, while leaving the solver enough freedom for fantasy and creativity. Step-by-step algorithm implies strict (or almost strict) performance of detailed instructions.
- Two methodologies have been developed and tested on the basis of proposed integration of function analysis with the flow analysis. These methodologies correspond to strategy and algorithm and combine advantages of both prototypes.
- For cases when flow analysis shows that it makes sense to concentrate efforts on one or another static component, a methodology for switching over from flow analysis to function one was developed and tested.

– Personal contribution of degree seeker

The personal contribution of degree seeker consists in statement of research problem, review of approaches to flow analysis, classification of types of flows and development of methodologies for flow analysis.

– Practical testing of research results

Methodology and recommendations of the present thesis were tested by the author and his colleagues in the course of analysis and solving of a number of practical problems at GEN3/Algorithm, Samsung SDI and Kontekh Ltd. Besides, they have been also tested during training seminars, in the course of which students successfully solved practical problems.

– Published sources

- Yu.V.Levedev. Structuring the Trend of Increasing Efficiency in Utilizing Flows of Substance, Energy and Information. 2011. http://www.metodolog.ru/node/850
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- Yu.V.Levedev, S.A.Logvinov. Rube Goldberg's Machine as a Subject for Analysis. 2015. http://www.metodolog.ru/node/1910

– Structure of thesis

The thesis includes introduction and eight chapters. Chapters are integrated into three large sections (intentionally not explicitly indicated):

1. Correlation between flows and other components of system.
2. Classification of flows.
3. Methodology for flow model building.

The content of these sections corresponds to that described in the chapter "results of research to be presented at the defense" of the author's abstract.