Use of functional and cost design for the snowmobile and motorcycle all-terrain equipment

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Abstract. The article reveals the essence of functional-cost analysis describes the stages of functional-cost design for snowmobile and all-terrain vehicles, reviews the publications of other authors on this topic and a review of methods similar to functional-cost design.

1. Introduction
The development of the Arctic is an urgent task for the leadership of such Russian and other countries. For example, many types of natural resources can be found here. The Arctic deserts and ice cover account for up to 20% of oil and more than half of domestic gas reserves, deposits of rare metals, gold, coal and other minerals.

One of the most important issues for the development of the Arctic is transport. What is the way to move around in the harsh Arctic conditions? The snowmobiles and all-terrain vehicles are able to cope with this task in the absence of roads with soil cover. Snowmobiles and motorcycles are already available.

But it is necessary to develop the models for particularly severe operating conditions, temperatures down to \(-60^\circ C\). At the same time, the equipment should be inexpensive, respecting the balance of price and quality. This is served by the functionally-cost design.

Functionally Cost Design (FCD) is a type of design technology that has a target functional and cost-oriented orientation and is focused on obtaining the optimal ratio between the quality of execution of functions and the cost of implementation in the sphere of production and operation [1]. In the course of FCD, the task of increasing the level of functionality of products as a prerequisite for improving quality is simultaneously solved. In the course of functional-value engineering the functional-value analysis is used.

Function-cost analysis (FCA) is a purposefully composed set of methods, the essence of which is to search and offer the best or even a fundamentally new solution to the functions of the analyzed object in order to increase the efficiency of its use [1].

FCA is characterized by the following features:
- the object, the increase of efficiency of which is the purpose of application of this analysis, is considered as a complex of functions;
- the functions, which reflect the behavior of the object, are evaluated in terms of value, costs and degree of their implementation. The functions that are too expensive, badly (not enough) performed or, on the contrary, performed above the required level are revealed by comparing such features. Thus, the directions and areas of further growth of the efficiency of using the object of analysis are determined. The decision of a problem — as differently, it is better, more effectively to reach
performance of demanded function, is carried out further by means of the whole complex of methods of activation of creative thinking:

- the criterion of the effectiveness of the solution is the ratio between the level of satisfaction of public needs, expressed by the degree of performance of the function, and the costs of its provision. The purpose of each specific case of application of functional and cost analysis is to achieve the optimum benefit at minimum cost;
- when carrying out a functional cost analysis, a sequence of stages, steps and operations is introduced and reflected in the work plan;
- complexity of problem solving by means of functional and cost analysis requires organization of work of a group of specialists.

FCA can be implemented where it is possible to provide a function for people to do what they want and where the results of their work can be achieved in more than one way.

The object of FCA in the broad sense of the word is the activity that satisfies a public need. It can be an activity that meets the basic innovation premise, i.e. it can be carried out in at least two real ways. Depending on the degree of development of public knowledge, goals and selected scope of solutions, the analyzed activity as an object of functional and cost analysis can most often take the form:

- the technical system or part of it without regard to the degree of materialization. To such systems concern first of all products, the combined systems, subsystems as real objects or as objects at different stages of their design development. Further, this includes working tools and their parts, labour items such as materials, raw materials, semi-finished products, etc;
- process system of material and non-material character or its part. It, for example, such real processes, as technology, industrial process, operation, reception, movement, decision-making, the control etc.” or processes of creation of the design documentation;
- combinations of both (technical and process) systems. They include material and energy or organizational and management systems, for example, organizational structures and processes occurring in them, etc.

FCA is applicable to various fields of activity.

Many authors in their publications [1]–[11] consider its practical application in this or that branch, for example, in construction, educational and many others. In the next chapter, we will look at several publications on the implementation, application and development of the FCD in different fields of activity.

2. Review of publications on the subject of functional-cost design.
How applicable is FCD to the task at hand and what is the practice of using FCD and FCA?

FCD and FCA were first developed in the 1940s, the beginning of the method was the work of the Soviet engineer Y.M. Sobolev and the American L.D. Miles. We are interested in how the FCD will be applied now.

| Product, industry   | Area of application                                                                 | Sources                                                                 |
|---------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Construction room   | Cost-cutting plans                                                                  | Kulikova, Atanova, 2012 — [2]                                         |
| Technological       | Analysis of compliance with the significance of cost functions for their implementation | Balashov, Cherepanov, 2014 — [3]                                      |
| educational process | Improvement of the manufacturing process of parts                                   | Knutarev, 2014 — [4]                                                  |
| Educational process | Assessment of the quality of educational service in the field of "Commerce"         | Larchenko, 2013 — [5]                                                 |
According to the results of the authors’ research review (Table 1), it was revealed that the FCD is used in different industries: construction, education, etc. However, according to the data [2] only 15% of the surveyed builders really understand the meaning of FCD. Nevertheless, most of the researchers agree that the FCD confirms its effectiveness.

3. Similar methods to functional-cost analysis (FCA)

Target Costing — is a method of managing the cost of production (production costs) of products. The essence is to reduce the cost of production throughout its entire production cycle, through the use of production, engineering, research and development.

Modern target costing (Japanese name — “genka kikaku”) was born in Japan in the system of target costing management based on a very simple idea. First, the market price of this type of product is determined, then the desired profit margin is set, and then the maximum allowable cost of production is calculated.

Thus, the allowable size of the cost of production by the target costing method is determined as follows:

\[
\text{Price} - \text{Profit} = \text{Cost price}
\]

The market price in this method is called target price, the desired difference between the cost and sales price is called target profit, and the cost at which the product should be manufactured is called target cost.

The principles of the target costing system are as follows:
- primary and constant focus on the requirements of the market and customers;
- calculation of target costs for new products, as well as their components, to achieve the desired, pre-determined profit under existing market conditions;
- accounting for the impact on the cost of production of the wishes of consumers on the quality and timing of production;
- using the product life cycle concept.

For release of new production the enterprise carries out marketing research, positions a product in the market, then establishes the potential selling price for the given production. At the same time it is necessary to allocate such functional characteristics and properties of a product to which consumers give the greatest preference: so the component concept of the future manufacture is put and quality criteria are defined.
The so-called allowable costs are determined on the basis of the revenue forecast by the marketing department. Allowable costs are calculated as a deduction from the projected revenue, net of indirect taxes, of the planned profit attributable to the product. Target costs are calculated for all components and functions of the designed product. At the same time, it is necessary to determine the production costs taking into account the existing technologies and equipment of the enterprise. Such expenses in target costing name current expenses.

Monetization of innovations
The book (Madhavan Ramanujam, Georg Tuck, 2018) describes nine rules for monetizing innovation based on the experience of Simon-Kucher & Partners. For example, Monetizing Innovation argues that all failed products and services can be divided into four categories: overfunctioning, underpricing, hidden treasures and living dead — all of which are easily avoided. Real life examples show how some of the most innovative companies in the world (Uber, Porsche, LinkedIn, Dräger, Optimizely and Swarovski) apply the principles outlined in this book.

The authors of the book have a list of monetization errors, which are divided into four categories.
1) «Unnecessary functions»: trying to "stuff" a product with the maximum number of functions unnecessary — creates a product that does not meet the needs of customers and is often unreasonably expensive.
2) «Underpricing»: Even if the product is selected correctly and the market is looking forward to it, the price is too low to get all the potential income.
3) «Hidden treasure»: A potential bestseller that is not correctly brought to market because it goes beyond the scope of the core business.
4) «Living Dead»: Innovations that are not needed by customers but have been brought to market anyway, either because they are the wrong answer to the right question or because they are the answer to a question that no one has asked.

If we compare the target costing method and the monetization of innovations with functional cost design, we can draw the following conclusions.

The main criterion is the cost price and the cost/quality ratio. Methods complement each other, as FCD gives the technology, how to meet the set cost price.

The method of functionally cost design and target costing have a certain relationship at the stage of product design. FCD can be called the most important element of target costing, as they complement each other.

The method in the book "Innovation Monetization" works with the price of the product. Interrelation goes through the cost price (Price = Cost + Profit). The lower the cost of production, the higher the profit. The method provides ways to better understand the consumer.

All methods are good, but it is better to use a reasonable combination of them.

4. Use of FCD for snowmobile and cross-country vehicles
Here is an example of the use of FCD in the design of snowmobile and cross-country vehicles within the framework of the project on the development of the Arctic in the company "Russian Mechanics".

The essence of FCD at the stages of research and development is to prevent the emergence of functionally redundant costs and ensure the socially necessary level of quality of products.

The specifics of using FCD in the creation of new motorcycle products are as follows:
- design execution is carried out according to the scheme:
  Needs ➔ Goals ➔ Functions ➔ Elements;
- preliminary construction of a "tree of the purposes" of designing is provided;
- establishment of limits of expenses on functions, proceeding from their importance for consumers and complexity of realization is required;
- Technical and economic working out of decisions is carried out in parallel at observance of the established limits of expenses on functions and requirements to quality of their execution;
− Efforts are concentrated on prevention of occurrence of useless actions and the harmful phenomena in object, superfluous properties and unnecessary elements by check of level of the functional organization predetermining reliability and adaptability;
− orientation to multiple variants of execution of functions of a product is made, conditions for expansion of a field of search of decisions are created;

Let's consider a variant of application of FCD for snowmobile of "Russian mechanics" company.
"Russian Mechanics is a Russian company producing snowmobiles and motorcycles. Carries out designing, manufacture, marketing and service of made technics.

For example, let's take the snowmobile "Buran Leader" produced by the company "Russian Mechanics". The main function of the product is movement on snow. "Buran Leader" — the most affordable snowmobile, enduring, easy to operate and repair, confidently rides on deep snow, drags loaded sleds and performs the necessary economic tasks.

Schematically, let's depict the model of the product, based on the composition and number of required elements (parts) — material carriers of functions.

Example is a structural scheme of snowmobile (Fig. 1).

![Snowmobile Diagram](image)

**Fig. 1. Structure of the snowmobile**

Further the matrix of interrelation of the basic functions and elements of a product (snowmobile) is made, taking into account the cost price of manufacturing of details, the analysis of importance and significance of functions.

The criteria of quality estimation are chosen on the basis of results of definition of requirements to a product and an estimation of their importance (for example, accuracy, reliability, maintainability etc.).

The degree of performance of functions, i.e. satisfaction of the set criteria of quality, is established by an expert method, in the simplest case by assigning scores (from 1 to 3 points) on variants. The unsatisfactory performance of the function corresponds to 0 points.

After assessing the quality of performance of functions by variants, the compliance of function costs with the established limits is checked. Operational costs of functions are determined by expert way or direct calculation using the results of assessment of reliability of elements in the performance of functions. Variants meeting the requirements of cost limits are presented for further development.

The last is a complex estimation and a final choice of a variant of construction of a product.

The aggregated algorithm of carrying out functional and cost design for snowmobile is shown in Figure 2.
5. Conclusions

FCD as well as FCA develops and is used in different branches, if at first this method was applied only for perfection of let out products, increase of their technical and economic indicators, now it with success is used for perfection of designing, technology, the organisation of manufacture, improvement of management and planning, ordering of supply, etc.

FCD method is quite a popular technology, as it is used in many industries.

Advantages of the method:
- Better knowledge of product value enables you to make the right strategic decisions on the pricing of products, the right mix of products, the choice between the ability to produce or purchase independently, investment in research and development, process automation, promotion, etc.
- Greater clarity about the functions performed, which allows companies to focus more on management functions, such as increasing the efficiency of expensive operations; identify and reduce the volume of operations that do not add value to products.

However, the method also has disadvantages:
- The function description process can be overly detailed, and the model is sometimes too complex and difficult to maintain.
- Often the stage of collecting data on function data sources is underestimated
- The model is often outdated due to organizational changes.
- Implementation is often seen as an unnecessary "whimsy", not sufficiently supported by operational management.

Comparing FCD with other methods, it is possible to tell that functionally-cost designing perfectly combines with target costing and a method from the book "Monetization of innovations" as they well supplement each other at a stage of designing of a product.

FCD has shown itself to be a good example of snowmobile and cross-country vehicle design with the Russian Mechanics product. It helps to quickly identify the drawbacks of the constituent elements of the product and find the most effective solution to reduce costs while maintaining the main functions of the object.
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