Journal of the Technical University of Gabrovo

https://mc04.manuscriptcentral.com/jtug

SEARCH OF MULTIFUNCTIONAL VEHICLES USING THE VENN DIAGRAM AND MORPHOLOGICAL ANALYSIS

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ARTICLE INFO

Article history:
Received 16 August 2022
Accepted 5 September 2022

Keywords:
morphological analysis, Venn diagram, technical idea, transport, innovation

ABSTRACT

The article is devoted to one of the directions of the search for technical ideas in the methodology of scientific and technical creativity on the example of the creation of multifunctional vehicles on land, water and in the air using a system-morphological approach and a three-level Venn diagram. Consider interesting examples for movement in non-standard situations. The proposed considerations can be useful for students, graduate students and engineering and technical workers when searching for creative and innovative ideas in various branches of the national economy.

1. INTRODUCTION

Any enterprise focused on obtaining profit in the conditions of competition and challenges of time is interested in creating new equipment that has its own life cycle. Powerful factors causing the replacement of one type of product by another are the improvement of technologies, fashion challenges, the use of economic and ecological sources of energy, materials, multifunctional use, etc. Any branch of industry, if it does not develop, is not improved, does not flexibly adapt to the requirements of the times, in the conditions of increased competition, it will definitely turn out to be unsustainable in the modern world and doomed to degradation. Moreover, with the appearance of new types of products, the period of use of existing products will be constantly shortened. Therefore, in the process of creating a new product, it is necessary to search for new ideas with a further chain of sequential implementation by stages: selection of ideas, analysis of production and sales opportunities; product development; research products; checking the state of the market; organization of mass production [12]. Back in the Stone Age, Man began to use simple tools to facilitate physical labor, food and fire. From the moment of the invention of the wheel, Man began to look for ways and means of his movement, in order not to walk, but to create various means of transport for the transportation of people, things and various loads on land, water and above them, and, in particular, in order to reduce the time of covering long distances, overcoming obstacles, adapting to the terrain and climatic conditions. The search for new vehicles and especially multifunctional ones determine the relevance of these studies using modern approaches.

2. ANALYSIS OF PREVIOUSLY CONDUCTED RESEARCH

In the work of P. Hill [12], a method of generating ideas based on a diagram of ideas is proposed, which, according to the author, due to its clarity, helps to increase the flexibility of thought when searching for different solutions to a problem or task. For the case of finding an idea for creating a new transport system, a diagram of ideas is given, which provides for the listing of various areas of use, subareas, small headings, etc. The more detailed the diagram, the greater the probability of extracting useful ideas from it, and the visual presentation of some ideas contributes to their clearer understanding, which prompts the designer to a more creative approach. The given diagram is not complete and allows you to supplement it with new ideas. But it gives more options than associative methods [5,7,11,13].

The most widespread systematic method of generating ideas is the method of morphological analysis [4,6,7,9-11,13,14], which, depending on the morphological features and alternatives for each feature, gives a very large number of options, which makes it difficult to formalize the selection of the best solutions from astronomical set [1,2,8].

3. RESEARCH RESULTS

In contrast to earlier studies, it is proposed to consider only those vehicles that do not require railway tracks, movement under water and in space. Research is aimed at finding such constructive and design layouts of vehicles that, in conditions of flexible production and using the modular principle, significantly reduce material and energy costs. The process of finding hybrids of multifunctional vehicles (land ***L***, water ***W***, air ***A***) can be represented graphically using a three-level crossing model (Fig. 1),

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which corresponds to the ratio ***1₃ (LWA) 3₂ (LW, WA, LA) 3₁ (L, W , A)*** and the three-level Venn diagram (Fig. 2) [3].

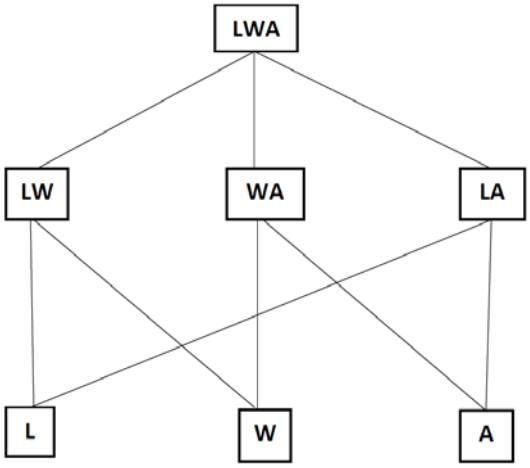

Fig. 1. A graphic representation of the creation of hybrids of multifunctional vehicles

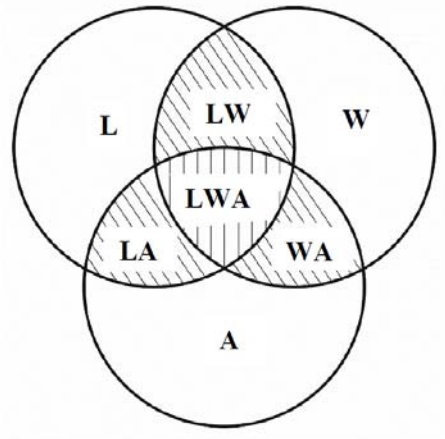

Fig. 2. Three-level Venn diagram

For three morphological features (land L, water W, air A), we will build a morphological model in the form of Table 1 and a morphological matrix.

Table 1 *Morphological table of vehicles*

1. Land	2. Water	3. Air
L	**W**	**A**
1.1. Car	2.1. Ship	3.1. Plane
1.2. Bus	2.2. Catamaran	3.2. Helicopter
1.3. No	2.3. No	3.3. No

Morphological matrix of vehicles

$$M_v = \begin{vmatrix} 1.1 & 2.1 & 3.1 \\ 1.2 & 2.2 & 3.2 \\ 1.3 & 2.3 & 3.3 \end{vmatrix}$$

The total number of variants of structural and design layouts of vehicles will be N_v = 3 x 3 x 3 = 27. We will represent the following tuples - morphological formulas *:

X_1 = 1.1 – 2.1 – 3.1
X_2 = 1.1 – **2.2** – 3.1
X_3 = 1.1 – **2.3** – 3.1
X_4 = 1.1 – 2.1 – **3.2**
X_5 = 1.1 – **2.2** – **3.2**
X_6 = 1.1 – **2.3** – **3.2**
X_7 = 1.1 – 2.1 – **3.3**
X_8 = 1.1 – **2.2** – **3.3**
X_9 = 1.1 – **2.3** – **3.3**

X_{10} = **1.2** - 2.1 – 3.1
X_{11} = **1.2** - **2.2** – 3.1
X_{12} = **1.2** - **2.3** – 3.1
X_{13} = **1.2** - 2.1 – **3.2**
X_{14} = **1.2** - **2.2** – **3.2**
X_{15} = **1.2** - **2.3** – **3.2**
X_{16} = **1.2** - 2.1 – **3.3**
X_{17} = **1.2** - **2.2** – **3.3**
X_{18} = **1.2** - **2.3** – **3.3**

X_{19} = **1.3** - 2.1 – 3.1
X_{20} = **1.3** - **2.2** – 3.1
X_{21} = **1.3** - **2.3** – 3.1
X_{22} = **1.3** - 2.1 – **3.2**
X_{23} = **1.3** - **2.2** – **3.2**
X_{24} = **1.3** - **2.3** – **3.2**
X_{25} = **1.3** - 2.1 – **3.3**
X_{26} = **1.3** - **2.2** – **3.3**
X_{27} = **1.3** - **2.3** – **3.3**

* alternatives that differ from option X_1 are highlighted in bold

The analysis of the synthesized options shows the following: option X_{27} is rejected due to impossibility of implementation; 6 options X_9, X_{18}, X_{21}, X_{24} - X_{26} are designed to perform one function (car, bus, plane, helicopter, ship, catamaran); 8 options X_1, X_2, X_4, X_5, X_{10}, X_{11}, X_{13}, X_{14} are assigned to perform three functions; the other 12 variants are designed to perform two functions.

You can increase the number of options by expanding the morphological model.

For example, in Table 1, for the sign of air, add alternative 3.4. Airplane-helicopter and take connection **X_{28} = 1.3 – 2.3 - 3.4.** We will get a hybrid that was created in the USA under the name of a convertible (Bell V-280 Valor model) [15].

Among the proposed options there are many interesting ones, for which we will give examples.

Example 1. X_6 = 1.1 **– 2.3 – 3.2** (car-helicopter): the car drives along the highway, approaches a destroyed bridge over the river, stops, the driver switches gears from the engine to the propeller located on the roof of the car, the latter rises up and flies on the opposite side of the river.

Example 2. X_{16} = 1.2 - 2.1 **- 3.3** (bus - ship): the need for urgent transportation of vacationing tourists from the island, where the tropical rains began, to the mainland.

Example 3. X_8 = 1.1 **– 2.2 – 3.3** (car – catamaran): a catamaran is attached to the bottom of the car, which allows you to cross deep depressions with water or swim across rivers without difficulty.

Example 4. X_2 = 1.1 **– 2.2 –** 3.1 (car – catamaran – plane): the car body is made in the shape of an airplane fuselage, to the bottom of which a catamaran is attached, the wings can be folded over the fuselage; it is possible to move on land and water, as well as fly.

After the selection of the best idea and the economic justification, they proceed to the design process, which is multivariate at the stages of development: the technical task; technical proposal; sketch, technical and working projects.

4. CONCLUSIONS

1) The process of designing new equipment is complex and represents a consistent solution of multi-level, multi-cycle, multi-criteria and multi-extreme problems of synthesis, analysis and measurements, starting from the choice of an idea and ending with the creation of a structure with optimal parameters.

2) The construction for which an optimal, or at least a rational idea is chosen, will be optimal.

3) It is worth remembering that a designer who focuses on an analogue, including a foreign one, which corresponds to the highest world achievements, automatically condemns his future equipment to fall behind.

4) The proposed idea generation approach can be used to create any technique.

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