IMPORTANCE OF MECHANICAL PARTS CLASSIFICATION IN ENGINEERING

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ABSTRACT: The classification of parts in industry is a very important factor for optimizing technological processes, reducing manufacturing costs and ensuring optimal technological flows. On the other hand, the organization of enterprises by equipping them with machines, equipment, tools, devices and testers, the ergonomic organization of workplaces are greatly influenced by the type of parts produced in a given organization. Taking into account at least all these needs, the criteria for classifying parts are varied, depending on the way of looking at the technologies, the time in which they are made and many other considerations. On the other hand, the role of all these classifications is to obtain parts with the lowest possible production cost, a key element in any industry and from which one most often starts in choosing a certain production process for the manufacture of a certain type of part.This article aims to bring a new perspective on the classification of parts in industry and in the field of research and is addressed to the leaders of organizations, specialists in the field.

KEY WORDS: criteria, parts, classification, additive, manufacturing,

1. INTRODUCTION

One of the important problems of industrial engineering is the realization of classifications of parts produced in this field, classifications that have as their main purpose the determination of the execution costs, the reduction of these costs. These particularly important problems must take into account that at present there are many more methods of obtaining parts compared to 60...70 years when production was based only on classical methods such as casting, plastic deformation or welding. These classifications must also take into account their entire life span which includes design, production, and recycling. This last stage is particularly important especially in the current contexts of the requirements of the sustainable development of society. On the other hand, the classification of engineering products is widely used for the unification, standardization and creation of a database so that this can be optimally achieved through certain well-known processing processes which means reduced costs. Classification of products and their elements as production items allows, preparation of technological processes of production, development of standard technological processes, basis for means of technological support of products.

Thus it becomes very important to carry out a methodological approach to building a classification of products for each stage of their life cycle that imposes its own requirements on the product, depending on the functional role it performs. These requirements are represented by the corresponding characteristics of the product that should constitute distinctive features. Again, compared to previous periods of time the problem of classifying products, regardless of the stage of its life cycle, consists in their immense, constantly growing variety and the large number of design features of products. This problem, which arises at the operation stage, is exacerbated even more at the production and recycling steps.

2. PROBLEMS IN MECHANICAL PART CLASSIFICATION

In order to achieve maximum productivity of production processes, to reduce implicit costs, it becomes very important to develop a methodological approach to building a classification of products for each stage of their life cycle that imposes its own requirements on the product, depending on the functional role it performs. These requirements are represented by the corresponding characteristics of the product that should constitute distinctive features. Again, compared to previous periods of time, the problem of classifying products, regardless of the stage of its life cycle, lies in their immense, ever-growing variety and the large number of product design features. This problem, which arises in the operating phase, is exacerbated even more in the production and recycling phases.

The realization of classifications of parts should begin with the presentation of the characteristics of parts that directly influence the technological processes at each stage of the product life cycle. Information about the characteristics of the part is presented in the drawing. These characteristics include the geometry of the part, its dimensions, accuracy requirements, roughness and hardness of the material. The listed characteristics of the parts directly affect the processes of the stages of its life cycle in different ways.

At the operating stage, the characteristics of the part are determined by the functions that the part performs during its operation.

In general, a part has two main functions:

- the role of a base part, a support on which other parts are mounted, for example, the frame of a machine tool;
- direct participation in fulfilling the functional role of the part.

For example, a gear wheel in a gearbox is designed to transmit rotational torque, a seal to provide sealing, a guide to ensure movement along a rectilinear trajectory, etc. Each function performed by a part imposes corresponding requirements on it. The role of the part in the creation of an assembly imposes requirements regarding the geometry of the part, its dimensions, precision of execution, roughness, hardness and during operation an additional requirement is necessary, for example regarding the resistance to breakage, wear resistance, fatigue resistance which affects not only the support quality of the system but also the rigidity, strength of the part. Precision and roughness affect the quality of the assembly, the way the parts "fit" in the creation of the assembly, the workflow. Hardness affects the resistance, rigidity of the structure.

In the manufacturing step, the characteristics of a part, which directly affect the manufacturing technologies, include the geometry of the structure, dimensions, precision, roughness and machinability of the material. The geometry of the part structure influences the choice of machine tools that ensure the manufacture of all surfaces of the part. The characteristics of precision and roughness determine the choice of the precision level of the machine tools, and the dimensions determine the overall dimensions of the machine tools. The characteristics regarding the hardness of the material from which the part is made and its machinability determine the useful processing methods. On the other hand, the number of parts required, which is reflected in the production of unique, small series, large series, mass parts, also determines the degree of automation of the machines, therefore the choice of universal machine tools or numerically controlled machine tools, for example. This is implicitly reflected in obtaining optimal production costs.

In the recycling stage of parts that have ended their life cycle, the recycling technology is influenced by the geometry of the part, sometimes by the devices necessary to extract the parts from the assembly in which they functioned, by the dimensions of the part, which affect the choice of technological equipment and the hardness of the part material, all of which affect the choice of the method of destruction of the part.

It should be noted that in the classification of parts it is considered both as an object that ensures the functioning of an assembly but also as the resulting element of a production process.

A useful methodological approach is the one for creating a classification of parts at each stage of their life cycle. As distinctive features at all stages of the product life cycle, the following characteristics of the part can be taken:

- type of geometry of the part design,
- dimensions,
- precision
- hardness of the material.

The roughness of the surface of the part is not included in the listed characteristics, since in the vast majority of cases it is associated with the accuracy of the part.

When creating the classification of parts at all stages of their life cycle, the distinctive characteristics, their sequence, according to the list presented above, will be considered. Under these conditions, the main difference in the classifications of parts at different stages of the life cycle will be the difference between the division of the ranges of extreme values of each characteristic into a different number of intervals and their values. This is due to the different influence of the characteristics on the processes of different stages of the product life cycle. For example, a change in the accuracy of a part by 2...3 hundredths of a mm does not mean significant changes in the technology of manufacturing parts, but these changes in accuracy during the operating stage may turn out to be unacceptable. This is why the range of the accuracy value of the part during an operation will be divided into several classes. After determining the composition of the distinctive features and their sequence, it is necessary to divide the ranges of extreme values of the distinctive features by the number of classes and their values. The greatest difficulties in dividing the range of characteristic values into ranges arise when the feature is not described by a number. The geometry of the part structure is an example of such a feature. For example, a part can be an object of rotation, a body, a lever, and so on.

From this point of view, a possible classification of parts according to their geometry can be made like [1]:

- complex shapes;
- round rods;
- hollow cylinders
- revolution parts with intersecting axes
- levers and forks

If we try to solve this problem, considering each version of the geometry of the part structure, then there will be countless variants. Therefore, they must be grouped according to a certain similarity criterion.

In this case, the problem of determining the similarity criterion arises when dividing the types of geometry of the part structure into groups. But at the same time, at each stage of the part life cycle, due to the difference in their processes, the similarity criterion may be different.

During the operation of the part, which performs its functional role, the determination of the similarity criterion should be based on the influence of the geometry of the structure on the functioning of the system. At the production stage - the effect on the manufacturing technology, and during recycling, their influence on this last stage of the product life must also be taken into account.

3. PART CLASSIFICATION CRITERIA

As previously mentioned, the part classification criteria must take into account all the life stages of a part. In general, these are: the design stage, the production stage, the operation stage and finally the recycling stage at the end of the operating period [2,3,4].

3.1 **Functional criterion**

The first stage of the existence of a part, product is considered to be the design stage. In this, a very important criterion appears, which is the basis of its operation and which refers to the function that a part has. This criterion helps engineers understand how the components contribute to the overall performance of the mechanical system. Thus, the following types of parts that must be designed can be listed depending on where they will be integrated:

- structural parts – this type of parts provides support and stability to the mechanical system. Columns, beams, frames, frames can be listed from this category.
- mobile parts – these allow movement in the designed mechanical system. Among them, we can list gears, shafts, bushings, bearings.
- connecting parts - these parts are used to join different components. Thus, this category can include screws, nuts, rivets, chains, belts
- control and measurement parts - these parts are used to regulate and maintain stable operation of the mechanical system as it was designed. Examples include sensors and actuators, valves.

3.2 Classification based on the materials from which the parts are made

The material used to manufacture the parts also plays a significant role in their classification. For choosing the optimal material, a very important method is known called the optimal values analysis method that takes into account many properties. The most commonly used classification is:

- metal parts are widely used in mechanical systems due to their high strength and durability - the most commonly used metals are steel, aluminum and titanium.
- non-metallic parts are often used in applications where weight reduction, corrosion resistance or electrical insulation are required - non-metallic materials often used are plastics, ceramics and composites.
- hybrid parts offer the advantages of both materials and are becoming increasingly common in modern mechanical systems - these parts are manufactured from a combination of metallic and non-metallic materials.

3.3 Classification based on the technological process of obtaining the parts

The technological processes used to manufacture the parts can also be used as a basis for this classification as the manufacturing processes have different capabilities, advantages, disadvantages, limitations, which influence the possibility of obtaining different surfaces, quality, cost and delivery time. Thus, there can be:

- parts obtained by casting - these parts are produced by pouring molten metal into a mold, at room temperature or at elevated temperatures, at atmospheric pressure or high pressures, by various casting methods and then allowing them to solidify. Cast parts are often used in applications where complex shapes and large volumes are required but also as unique parts.
- parts obtained by plastic deformation - this method is distinguished by the use of two technologies, namely free deformation or deformation in the mold. Plastic deformation can be performed cold or hot. The final shape is obtained by deforming the metal using compressive forces in general. Forged parts are known for their high strength and toughness.

parts obtained by welding: These parts are produced by joining two or more metal parts using welding processes, such as arc welding, gas welding and laser welding. Welded parts are often used in applications where high strength and reliability are required.

Machined Parts: These parts are produced by removing material from a workpiece using machining processes such as turning, milling, and drilling. Machined parts are known for their high precision and accuracy.

4. ADVANTAGES OF MECHANICAL PART CLASSIFICATION

By performing a classification of parts in a mechanical system and including them in certain classes, several benefits arise such as:

- improved design efficiency - by classifying parts according to shape, function, material and manufacturing process, engineers can quickly identify the most suitable components for their project. This reduces the time and effort required for design and development.
- improved production efficiency - part classification helps manufacturers optimize their production processes by grouping similar parts. This reduces setup time, tooling costs and production time.
- easier maintenance and repairs - when parts are classified, it becomes easier to identify and replace defective components. This reduces downtime and maintenance costs of the mechanical system.
- better inventory management - part classification allows for better inventory management by classifying them according to their type, size and use. This helps reduce storage costs and ensure the availability of the right parts when needed.

As the production of parts becomes more diversified, more uncertainties arise in their classification and although parts classification offers many benefits, it also presents some challenges, including:
- complexity of mechanical systems - modern mechanical systems are becoming increasingly complex, with a large number of components and subsystems. This makes it difficult to accurately classify all parts.
- evolution of production technologies - the rapid advance of technology leads to the development of new materials, manufacturing processes and new shapes of parts. This requires continuous updates of the parts classification system.
- lack of standardization - as there is a lack of norms and standards regarding parts classifications across different industries, this can lead to confusion and inefficiencies in the design, manufacture and maintenance of mechanical systems.

5. CLASSIFICATIONS IN ADDITIVE MANUFACTURING TECHNOLOGY

Additive manufacturing and 3D printing are general terms that cover a wide range of technologies, from prototyping or small-scale production, to 3D structures from digital files. The solid modeling component of computer-aided design (CAD) is the basis of additive manufacturing. This modeling data is used by additive models to create layers with very thin cross-sections, being used to manufacture complex shapes and surfaces, very difficult to obtain by conventional methods. The development of additive manufacturing techniques emerged in response to the demand for printing complex models at high resolutions. A very important factor in the development of additive manufacturing is represented by rapid prototyping. Additive manufacturing can be divided into three main technologies[5,6]:
- sintering, which involves increasing the temperature of the material without turning it into a liquid, thus resulting in complex parts;
- melting, which involves the use of electron beams to melt powder;
- stereolithography, also known as photopolymerization and which uses a laser with ultraviolet light.

The following are presented, in a certain sense, the criteria that govern additive manufacturing. Thus, depending on the technology used, the following parts manufacturing methods can be distinguished:

- Fused Deposition Modelling (FDM)
- Stereolithography (SL)
- Binder Jetting (BJ)
- Powder Bed Fusion (PBF)
    - Selective Laser Melting (SLM)
    - Direct metal laser sintering (DMLS)
    - Electron beam melting (EBM)
- Laminated Object Manufacturing (LOM)
- Direct Energy Deposition (DED)
    - Depunerea metalelor cu laser (LMD)
    - Laser engineering Net-Shaping (LENS)
    - Electron beam freeform fabrication

Depending on the material used to obtain the parts, the classification presented in Table 1 can be achieved.

Materialul folosit	Procesul De FA	Material
Powder	Selective Laser Sintering	Thermoplastic Material, Metals, ceramics
	Selective Laser Melting	Metal
	Electron Beam Melting	Metal
	laser metal deposition	Metal
	Direct Metal Laser Sintering	Metal
	LENS EBF3 Directed Energy Deposition	Metal, alloys Metal, alloys
	Binder jetting	Metal, alloys, polymers
	Cold spray Spray-ere la rece	Metal, alloys, polymers
Fillament	Fused Filament Fabrication	Tehermoplastics
	Wire Arc Additive Manufacturing	Metals
	Freeze-form Extrusion Fabrication	Ceramics
	Robot casting	Ceramics
Liquid	Stereolithography	UV resin hardened
	Multi-Jet Modeling	UV-cured acrylic
	Rapid Freeze Prototyping	water
Solid Sheet	Laminated Object Manufacturing	Metal, Plastic

Another type of classification found in additive manufacturing is based on the technological parameters used during the parts manufacturing processes. Thus, the following classification results:

- Geometry-based parameters;
  - Nozzle size
  - Filament diameter
- Process-based parameters;
  - Print bed temperature
  - Print speed
- Structural parameters
  - Layer thickness
  - Filling geometry

- Filling density
- Raster angle
- Raster distance

3. CONCLUSION

The article tries to very briefly address a very vast and complicated issue that mainly aims to reduce costs and increase the quality of parts obtained in the industry. For this, several criteria for classifying parts obtained through classical processing technologies but also the relatively new method of obtaining them through additive manufacturing are presented.

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