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APPLICATION OF TRIZ IN ROBOT MANUFACTURING

Abstract. TRIZ is an effective instrument for engineering problem solving. Examples of the TRIZ application in manufacturing are considered in this paper. An application of ARIZ-based method of finding technological solutions for production of industrial robot parts is represented.

Key words: TRIZ, ARIZ, manufacturing, robot, NX.

Introduction

Modern robots are complicated technical systems consisting of many components. High accuracy, low price and fast manufacturing of all parts are essential for successful modern production, especially for high tech products. Very often parts of robots have custom shape, which is difficult to produce by standard methods and requires creative approach to the technological process.

Theory of TRIZ

TRIZ is "a problem-solving, analysis and forecasting tool derived from the study of patterns of invention in the global patent literature".[1] It was developed by the Soviet inventor Genrich Altshuller as an algorithmic approach to the invention and improvement of technical systems. Literally, it is an acronym of Russian "theory of the resolution of invention-related tasks". TRIZ helps to ensure repeatability, predictability and reliability to the problem-solving process based on logic, data and research, rather than on intuition, and provides a range of strategies and tools for finding creative solutions.

Practically, four steps are needed to solve a specific problem with TRIZ:

1. Define a problem.
2. Generalize it to the conceptual problem (contradiction).
3. Find the conceptual solution for the generalized problem.
4. Adapt the generalized solution to the specific problem.

[1] Hua, Z.; Yang, J.; Coulibaly, S.; Zhang, B. (2006). "Integration TRIZ with problem-solving tools: a literature review from 1995 to 2006". International Journal of Business Innovation and Research. 1 (1–2): 111–128. doi:10.1504/IJBIR.2006.011091. Retrieved 2 October 2010

The main idea of using TRIZ when traditional method does not work is represented in figure 1. Conceptual problems in TRIZ are called "contradiction", so the conceptual solution is to eliminate the contradictions.

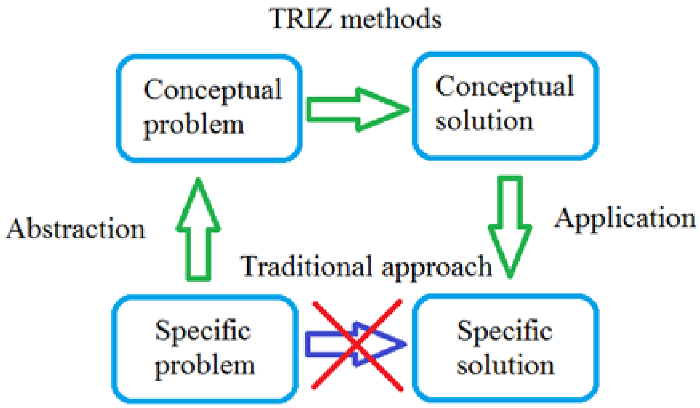

Figure 1. Concept of TRIZ

Methodology of TRIZ

TRIZ considers three categories of contradictions: administrative, technical and physical (or "inherent").

Administrative contradiction are not really engineering, they are contradiction between the needs and abilities. For example, we want to produce some parts but we do not have equipment for that or do not know how to do it. This contradiction can be solved by studying or some management decisions.

Technical contradictions is an inverse dependence between parameters or characteristics of a machine or technology. It mean that the improvement of one parameter of the system leads to degradation of another one. For example, in robot manufacturing many parts should have high accuracy and surface quality class, which need to be measured carefully. However, for custom shaped parts these parameters are hard to measure with regular instruments like calipers. There is a contradiction (generalized problem): increasing complexity of the parts increases also complexity of the measurement.

The key technical contradictions are summarized in the TRIZ Contradiction Matrix with standard solution, which can be useful in simple cases. For our case, the matrix cell in row "accuracy of measurement" and column "complexity of control" points to several principles, among them the Copying Principle, which states "Use a simple and inexpensive optical copy with a suitable scale instead of an object that is complex, expensive, fragile or inconvenient to operate.".[2] From this generalized solution, the solution of our specific problem might be

[2] Altshuller, Genrich (2005). 40 Principles:Extended Edition. translated by Lev Shulyak with additions by Dana Clarke, Sr. Worcester, MA: Technical Innovation Center. ISBN 978-0-9640740-5-7

taking a high-resolution image of the part. A screen with a grid might provide the required measurement.

Physical contradictions are contradictory physical requirements to an object. It mean that the system should have some quality and the opposite one at the same time. For instance, in gears teeth should be hard, because the contact stress bearing capacity is proportional to the square of the tooth surface hardness. Nevertheless, to increase the flexural strength, the tooth should be viscous. Therefore, the contradiction is that the tooth should be hard and not hard at the same time.

Physical contradictions can be solved with the TRIZ separation principles, which means separating the contradictory requirements according to basic categories of Space, Time and Scale. In our case, separating parameters of the gear in space, we can make the surface of the tooth hard, using coating, induction hardening or other methods, and still have a viscous core.

ARIZ for manufacturing problems

For more complicated problems another method of TRIZ can be used - algorithm of inventive problems solving or ARIZ. It is a list of about 85 step-by-step procedures of identifying and resolving contradictions.

The key idea of ARIZ is ideal final result (IFR) - the ultimate idealistic solution of a problem when the desired result is achieved by itself. For example, the ideal manufacturing process is to get the part without any process and the ideal workpiece is equal to the final part. Closest to the perfect workpieces can be obtained by die casting or additive technology.

Parts of industrial robots are usually complicated to reduce the weight of construction. Typical part of a robot is shown on figure 2. This body part was topologically optimized using Siemens NX and has slots for a bearing and a drive shaft. Junctions here must be accurate but the whole part should not be expensive.

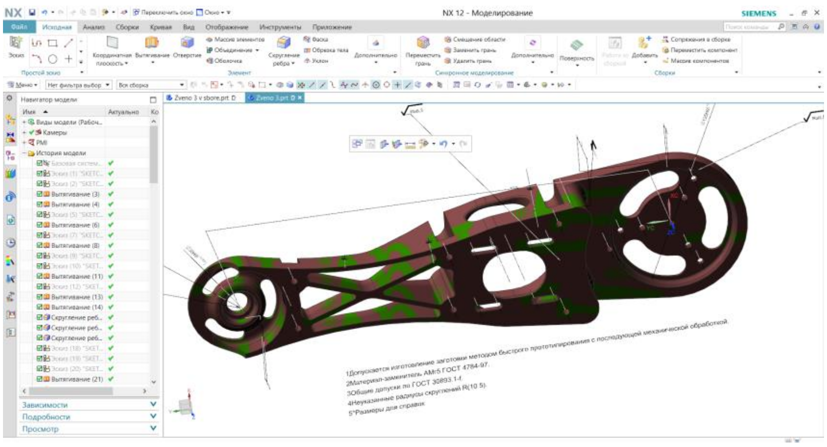

Figure 2. Body part of a robot, initial optimized part

Producing such parts by regular methods like milling are not always possible or can take a lot of time and wasted material. Casting is too expensive way for a small amount of parts. 3D-printing is cheaper but cannot provide enough accuracy. According to ARIZ, a physical contradiction can be formed: the part has to be accurate (to perform the work in the system) and has to be raw (to be cheap in production).

Using space separation principle, the initial part was divided in NX into three parts, which are shown on figure 3. Two of them have simple configurations and can be produced by milling with high quality. The third one has a complicated shape and can be 3D-printed with a little further development. All parts are made separately by different ways and then assembled together with bolts.

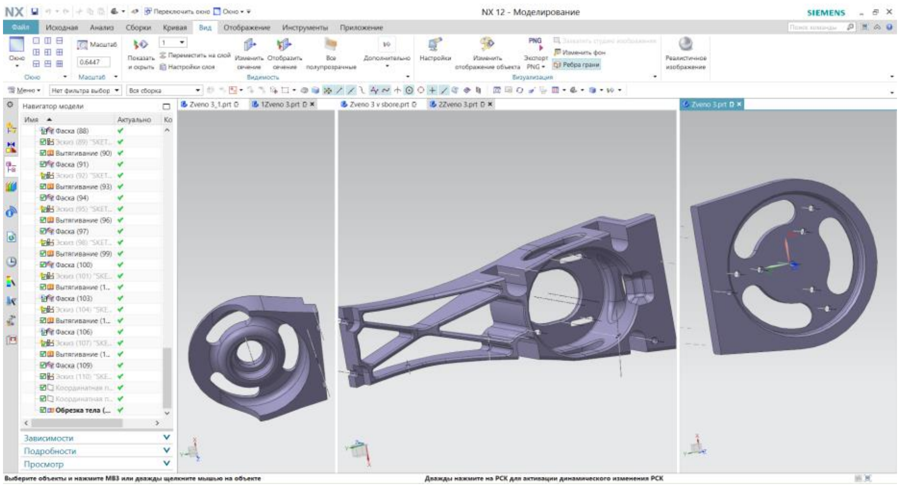

Figure 3. Body part of a robot, divided into three parts

Conclusion

Methods of TRIZ can be used in any field. This has been demonstrated using a real life case of manufacturing a complicated robot part. Many big corporations such as Samsung, Rolls-Royce, GE and Mars apply TRIZ in their projects to reduce costs and improve quality of their products.

References

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