An Evolutionary Model of the Product Life Cycle: the Peculiarities of Adaptation

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Abstract. There are considering distinguished 13 stages of the product life cycle. They can be applied to a specific product in various combinations. PLM and CALS tools help you to carry out information support of goods at all stages of the life cycle. Manufacture of products for individual orders is a global trend. It enables the OS to move from mass marketing to marketing of customer requests, from the competition for market share to the competition for a particular buyer. This modern solution requires the use of tools which estimate the effectiveness of implementations of variability of goods’ sets. A significant and growing volume of information’ interaction of all participants in the product life cycle is proposed to be regulated by the tools of the blockchain technology. Smart contracts enable us to determine ways to solve these problems through the implementation of its advantages: autonomy; the trust; reservation; transmission speed; accuracy; cost savings.

1. Introduction
In recent years many theoretical and applied researches have been carried out in the context of the product life cycle which is also referred to as PLM (Products Lifecycle Management) abbreviation. The main idea of these papers associated with the creation of information solutions globally in order to support all stages of PLM from design to disposal and recycling of resources processes [1, 17].

In the same time PLM can consider the idea of CALS (Continuous Acquisition and Life Cycle Support) - an independent branch put into shape of ISO standard. The ideology of CALS was accepted by all the most developed countries: the USA, Great Britain, Germany, France, Sweden, Norway, Canada, Japan, Australia, etc. In Russian literature CALS is formulated as information support for processes of product life cycle. The effect of the introduction of CALS technology is based on the implementation of the fundamental principles [4, 18]:

- representation, processing, exchange and management of data in electronic form;
- re-use of data with minimum changes and expenses;
- optimization and unification of ways of presenting, processing and transmitting data about a product, process, environment;
- integration and optimization of information interaction of the participants of the product life cycle.
2. Actuality

The concept of PLM and CALS - technologies can be examined from the common basic positions of tracking the movement trajectory of each item of goods (if necessary) to improve the quality of the goods and the degree of customer satisfaction. Data presentation is regulated by international standards (ISO 10303 STEP (GOST R ISO 10303), NPDM (NATO PRODUCT DATA MODEL), etc.).

There are many organizations in the world that regulate the development of PLM and CALS technologies, in particular: ASME (American Society of Mechanical Engineers); NIST (National Institute of Standards and Technology); ANSI (American National Standard Institute); IEEE (Institute of Electrical and Electronic Engineers); EIA (Electronic Institute of America); EPRI (Electric Power Research Institute); UKCEB (UK Council for Electronic Business); CNAS (Canadian Nuclear Association Society) and others. In the field of international standardization of work is coordinated by international organizations, including ISO [15].

There is can be distinguished up to 13 stages of the living cycle of the product.
1. Marketing and market research (CRM).
2. Product design and development (CAD, CAE, CAD, CAM, PDM).
3. Production planning and preparation (MES, PDM).
4. Purchase of materials and components (SCM, PDM).
5. Production or provision of services (ASUP, APCS, ERP, MRP, MRP II, SCM MES, PDM).
6. Packaging and storage (WMS, PDM).
7. Implementation (CRM, PDM).
8. Installation and commissioning (CRM, PDM).
9. Technical support and maintenance (PDM).
10. After sales service (maintenance, repair and maintenance) activity or operation (PDM).
11. Recycling (PDM).

The “digital life history” of products cannot be tracked without an information system. Together with the above lifecycle stages there are abbreviations of automatic control systems have presented. They were widely applied in the context of product lifecycle management.

The economic situation in the world is dynamic and undergoes significant changes because of the influence of technology, the Internet and globalization. Hyper competition forcing companies to "pack" in the price of the possibility of a wider differentiation and goods. Current marketing trends include the following options: the movement from mass marketing to consumer-oriented marketing; from competition for market share to competition for a specific consumer. This is not a complete list, but it can be concluded that the stage of the product life cycle may be unique to a particular product and the kit may be operatively reviewed, depending on the specific situation in the market. To the manufacture of products for the individual transition orders - a variant of the general product differentiation in the market and there is a significant change in this matter, which covers an increasingly broad range of goods’ price categories [12, 20]. Mentioned approach (development of mass production on request), according to experts, leads to finishing of the mass production of standardized products, mass markets, marketing, forecasting, traditional methods of logistics and so on. [14]. Mass production of goods to order is appropriate, provided that their prices are comparable with prices for serial products. Formulation and solution of specific tasks designated aspect of the problem involves the detailed consideration of the following: the supply system which is based on personal customer requirements to complete product; application of special technologies and flexible production organization schemes; logistics and marketing based on the use of knowledge about consumers of goods.

3. Theoretical part

In the assessing economic efficiency of product life cycle processes one always must deal with efficiency and information technology assessment and information support systems. This efficiency estimation is directly related to economic and mathematical modeling [19].
Economic mathematical modeling can be applied in the following approach. And cereal productivity in configurations with indices \( k = 0, 1, \ldots, l \). In this case \( k = 0 \) corresponds to the basic configuration of the product. Demand for various types of product performance arises in a random manner with probabilities \( f_k, \sum_{k=0}^{l} f_k = 1 \).

Profit changes with time \( t \), according to some rule \( \Delta p_k(t) \).

The duration of manufacture of the product in the \( k \)-th configuration is equal to \( t(k) \).

When the transition is, on the execution of individual configurations \( \Delta FC_{flex} \) to ensure production flexibility.

Thus, the transition to the production of products for individual orders, as compared with the release of products in basic configuration, leads to the following change in profit:

\[
\Delta \prod = q \times \sum_{k=0}^{l} [f_k \times \Delta p_k(t(k))] - \Delta FC_{flex}
\]

where \( q \) – total quantity of products released.

4. Practical value

An important problem in the variability of bundles of a particular product is to harmonize the relationships of all participants in the production of goods. It is challenging because the final configuration of a product must be implemented taking into account all the technological features, logistics, marketing, etc. The blockchain technology and smart contracts provide tools for solving these tasks by using their capabilities: autonomy (smart contracts cannot be changed by third parties, since only their parties enter into an agreement); trust (all contracts are encrypted, stored in a public repository, the probability of their loss is negligible); reservation (cancellation of agreements due to loss of a copy is not possible); gear speeds; accuracy; cost savings [2, 3, 5, 8, 13, 21].

5. Conclusions

The traditional model of the product life cycle with a fixed set of stages evolves. It has been replaced by a variable set of stages, the variability of which is relevant throughout the cycle. The concept of PLM and CALS technologies is becoming one of the "trends" of modern production of goods. It proves by the widely implemented system of standards at the world level. One of the significant results of the application of these technologies is the transition to the production of products for individual orders. Nowadays the tools to translate the indicated processes into practice – the technology, the blockchain and smart contracts – are exist and rapidly developing.

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