DOI 10.15589/jnn20150608
УДК 330.131.7:62-135
Р93

THE DIAGNOSTICS OF RISK-CONTRIBUTING FACTORS OF PRODUCTION HIGH TECHNOLOGY ENTERPRISES AND THE METHOD OF COST REDUCTION IN TERMS OF GAS TURBINE ENGINES DEVELOPMENT

ДІАГНОСТИКА РИЗИКОУТВОРЮЮЧИХ ФАКТОРІВ ПРОМИСЛОВИХ НАУКОЄМНИХ ПІДПРИЄМСТВ ТА СПОСІБ ЗНИЖЕННЯ ВАРТОСТІ ВИТРАТ НА ПРИКЛАДІ СТВОРЕННЯ ГАЗОТУРБІННИХ ДВИГУНІВ

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Abstract. The diagnostics of main risk-contributing factors affecting the stable operation of high technology production enterprise and its competitiveness on the world market are carried out in this paper. Classification of threats is carried out with the expert assessment methods followed by the ranking of threats in order of importance. In this tideway, the threats weighting coefficients are calculated, as well as the concordance degree of expert evidences is analyzed, that consequently allowed to range the risks associated with the operation of production enterprises according to their degree of threat. Further in order to achieve the next goal a staged schedule for the development of a 25 MW gas turbine engine and the development of 32 MW new innovation of the enterprise was considered in the paper. The conclusion about the effectiveness of the new product implementation and cost reduction at certain stages of development is drawn.

Key words: risk-contributing factors; ranking; high technology production enterprise; innovative activity; gas turbine engines; risk management.

Аннотация. В статье рассмотрены основные риски, связанные с деятельностью наукоемкого промышленного предприятия, влияющие на стабильность работы последнего. Проанализированы этапы создания газотурбинных двигателей двух разных модификаций и проведена оценка стоимости затрат последнего внедряемого инновационного продукта по отношению к предшественнику, успешно конкурирующем на промышленном рынке.

Ключевые слова: рискообразующие факторы; ранжирование; наукоемкое промышленное предприятие; инновационная деятельность; газотурбинные двигатели; управление рисками.

Анотація. У статті розглянуто основні ризики, пов'язані з діяльністю наукоємного промислового підприємства, що впливають на стабільність роботи останнього. Проаналізовано етапи створення газотурбінних двигунів двох різних модифікацій і проведено оцінку вартості витрат останнього впроваджуваного інноваційного продукту по відношенню до попередника, успішно конкуруючого на промисловому ринку.

Ключові слова: ризикоутворюючі фактори; ранжування; наукоємне промислове підприємство; інноваційна діяльність; газотурбінні двигуни; управління ризиками.

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PROBLEM STATEMENT

The product competitiveness of the production high technology enterprise in the market is determined by rates of implementation of the latest scientific and technical approaches and the development of high technologies, by the efficiency of innovative processes. In today's world, large-scale innovation use in economic activity is one of the main sources of competitive recovery and sustainable economic growth [2]. Enhancement of the role of innovation potential in modern production has led to that the competition of enterprises in the world market is more and more moving into the area of innovation and improvement of products and technology of production.

Innovative activity is a process of strategic marketing, research and development, organizational and engineering process preparation, innovations development and execution, their implementation and commercial realization on the market for profit taking, spread to other areas. It aims to provide a new level of interaction between the factors of production due to the use of new scientific and technical knowledge [5].

To improve the competitiveness of products of the high technology production enterprise on the basis of innovation activity it is necessary to clearly state the purpose, to evaluate the competitive potential of the enterprise, to identify strengths and weaknesses and to develop a competitive strategy and measures for its implementation.

Now, in the conditions of the world financial crisis the financing of innovations and risks associated with the assimilation of innovative products are the main elements of the financial mechanism for the implementation of innovative activities [6, 7].

In this case, if the introduction of new innovations in the enterprise also solves the problem of cost reduction at the enterprise (because new projects are implemented and operate in the general system of the enterprise, and it saves on costs due to the parallel use of resources across multiple projects at the same time, as well as due to the use of existing resources in new projects), then the effect will allow us to save money in the budget period and to direct it to the production of competitive products and to the risk control as well.

LATEST RESEARCH AND PUBLICATIONS ANALYSIS

The risk as a pervasive phenomenon is common to all economic agents operating in market conditions. So the problem of developing a complex approach to risk management is especially urgent [2, 5, 7]. The manifold problem of enterprise risk management is to one extent or another reflected in scientific works of different researchers: J. M. Keynes, A. Marshall, O. Morgenstern, F. Knight, A. P. Algin, B. A. Raizberg and other scientists. However, because of the complex nature the enterprise risk management issues are still the subject of scientific debate.

In economic literature more prominence is given to accounting and cost-accounting aspects of cost management process, so the cost management concept is not widespread in domestic practice. The scientists have calculated that only 6% cost reduction at the enterprise can render the same additional profit as 33% growth in production volume and product sales. The cost management in the enterprise should be considered as a single coordinated set of interrelated daily actions aimed at saving resources and maximum return on them, as an innovative factor itself that is capable to increase the efficiency and competitiveness of the enterprise.

ARTICLE AIM

1. To consider the most important threats related to the operation of production high technology enterprises, classifying them by weight of influence on stability of the enterprise activities.

2. To analyze the impact of the introduction of a new innovative product into production on the possibility of reducing the cost value of the enterprise (for example, the manufacturing of gas turbine engines).

BASIC MATERIAL

For efficient organization of risk management at the production enterprises it is necessary to develop a classification of threats.

Currently there is no clear and structured integrated classification of threats in an production high technology enterprise (PHTE). Therefore the classification of threats according with the functional components of the PHTE is suggested. With this view an inquiry form was drawn up that includes the main threats of the PHTE, and an expert survey was performed.

Heads and specialists of the leading production enterprises were the experts.

Analysis of the suggested threats classification of PHTE was carried out using the weighting coefficients obtained by the expert methods of estimation. The experts were asked to rank threats of PHTE in the order of importance. In this case 10 experts were interviewed according to each threat of PHTE functional component.

A criterion of estimation is the significance (weighting) of risk, i. e. which of the listed threats of PHTE are the most and the least important for the stable operation of the company in the experts' opinion.

The first rank is assigned to the most significant threats to the PHTE.

As the rank is increasing the threats significance is decreasing. The last rank (depending on the number of threats in the functional component of PHTE) is assigned to threats which are of the minimum importance for the enterprise.

After processing the inquiry form for each indicator the rank totals (R_i) is calculated taking into account the opinions of all the experts:

$$R_i = \sum_{j=1}^{N} r_{ij}, \qquad (1)$$

where r_{ij} is the i-th threat rank assigned by the j-th expert.

To move from the rank estimates r_1, r_2 ... r_n to the weight coefficients (a_i) different formulas, in particular Fishburn's formula, can be used:

$$a_i = \frac{2(n - r_i + 1)}{n(n+1)}, \qquad (2)$$

where n is number of estimated objects.

This formula assumes linear weight decreasing from rank to rank.

Table 1 shows the classification of PNP threats obtained in result of the expert survey, and the calculated weighting coefficients.

The important point of the expert procedures is evaluation of concordance of experts actions and expert evidences reliability.

Most commonly for these purposes the coefficient of concordance is used, the value of which gives an indication of the degree of concordance of the expert opinion and, consequently, the reliability of their evidences.

In general, the coefficient of concordance (W) is determined using the expression (3):

$$W = \frac{12\sum_{i=1}^{n}\left(\sum_{j=1}^{N}\left[\!\left[r_{ij} - \frac{N([\![n+1]\!])^2}{2}\right]\!\right]\right)}{N^2(n^3 - n) - N\sum_{j=1}^{N} L_j}, \qquad (3)$$

where N is the number of experts; r_{ij} is the rank of the i-th threat assigned by the j-th expert; L_j is an indicator of related ranks of the j-th expert.

L_j value is determined by the formula:

$$L_j = \sum_{v=1}^{k_j} (k_{jv}^3 - k_{jv}), \qquad (4)$$

Table 1. Results of the expert survey

Functional component of PHTE	Threats names of PHTE	R_i	rank	a_i
1. Finance	Objective:			
	1. Circumstances outside one's control or similar to them in sense or sources of appearance (political, of macroeconomical nature, economical, national, religious issues)	34	3	0,2
	Subjective:			
	2. Inefficient budgeting of all enterprise activity aspects	20	2	0,3
	3. Unqualified enterprise asset management	10	1	0,4
2. Production	1. Imperfect production (noncompliance with time requirements of time, unable to turn out the competitive products)	14	1	0,4
	2. Inappropriate supplier of components, raw materials, expendable materials etc.	16	2	0,3
	3. Insufficient awareness about innovative technologies	36	4	0,1
	4. Inappropriate infrastructure	34	3	0,2
3.Marketing	1. Limitedness of market outlet	25	2	0,24
	2. Noncompliance of the products with market requirements	13	1	0,29
	3. Risks related to marketing development	39	4	0,14
	4. Insufficient awareness about turn of market	53	6	0,05
	5. Non-professional advertising	45	5	0,1
	6. Risks related to market conditions (exchange risks, price variance risks, competitive expansion risks)	35	3	0,19

where k_{jv} is the number of the same ranks in v group of the j-th expert; k_j is the number of groups of indicators with the same ranks of the j-th expert.

The coefficient of concordance W can vary between 0 (with the lack of concordance) and 1 (by the agreement of the ranking results of all experts). The concordance degree of expert evidences is considered acceptable if $W \geq 0{,}7$.

As a result of the calculations according to experts the most significant threats of the TNG were determined (Table. 3).

Ensuring the compliance of each functional component of PNP with the requirements may be achieved by carrying out an individual set of measures for each component.

It should be noted that all of the functional components of the PPP are closely interrelated. It is not possible to ensure the compliance of one of functional components which provides stability of the enterprise, apart from other components, with the required level.

For the stable operation of the enterprise in conditions of the existing risks the development of an innovative product is an additional risk [5, 8] but it is also an opportunity of the enterprise to release certain financial resources at some stages in order to return them to the production process with the obtained profit later. The process of creating a new innovative high technology product consists of several stages. So, the stages of gas turbine engine (GTE) development are:

Stage 1 — Work design documents (WDD) development for separate units and GTE in all.

Stage 2 — Technology panning.

– Manufacture of special tooling.

– Manufacture of materiel, engine units and special test rigs.

– Order and purchase of required materials and components.

– Assembly and installation of special test rigs.

Stage 3 — Test and operational development of separate units at special test rigs.

Stage 4 — Assembly of GTE test.

Stage 5 — Test and operational development of GTE test.

Stage 6 — Pilot production. Exploratory tests for total head values.

Stage 7 — Transfer of the documentation for batch production. Manufacturing of the main GTE.

Engines that will be discussed are two estimable competitive products on the market of gas turbines. UGT 25000 (25 MW) and UGT 32000 (32 MW) were produced in different time ranges but on the basis of one gas generator.

UGT 25000, the first IV generation engine, was created on the basis of UGT 15000 gas generator with the additional stage of the low-pressure compressor that raised the pressure ratio from 19 to 22in the engine. A new power turbine providing 25 MW engine power rating has been developed. The engine was developed almost over 9 years, from 1987 to 1996. The beginning of development and manufacture of the materiel fell during the last years of the USSR, but, nevertheless, the materiel was made rather quickly. However, in 1991 the funding was cut off, and the engine development was suspended until 1993, while there were new customers. Then the development was resumed and engine exploratory tests for total head values were carried out in April 1995. For the exploratory tests three pilot GTE were produced, but it was not enough to eliminate all possible risks in terms of engine reliability. Initially, the GTE often failed and the main operational development was performed in the operating conditions. Since 1996 the engine was transferred for batch production. To date, about 300 UGT 25000 GTE are produced that have been applied in the gas industry, power generation and marine power generation.

In the period of 2010-2012 in accordance with the results of marketing research a great need of the gas turbine market in 32-35 MW engines was determined, that laid the foundations of the development of UGT 32000 GTE in 2012.

UGT 32000 GTE was developed on the basis of UGT 25000 GTE taking into account the modernization of the corresponding components. As the diagram of development (Fig. 1) shows, the development of WDD has occurred much faster than the WDD stages of UGT 25000 GTD, which is associated with a higher degree of the design process computerization at the moment. Now the engine is in the process of manufacturing of the materiel and unit operational development.

Figure 1 shows that the UGT 32000 engine development steps are less long-term, it allows us to make the conclusion that the production cycle of the product is shorter.

The faster the accomplishment of the production engine manufacturing process (the shorter the production

Table 2. The results of concordance of experts' opinions

Functional components of PHTE	Coefficient of concordance
1. Finance	0,9
2. Production	0,81
3. Marketing	0,59

Table 3. The most significant threats of the TNG

Functional component of PHTE	Threats names of PHTE
1. Finance	Inefficient enterprise asset management
2. Production	Imperfect production (noncompliance with requirement of time, unable to turn out the competitive products)
3. Marketing	Noncompliance of the products with market requirements

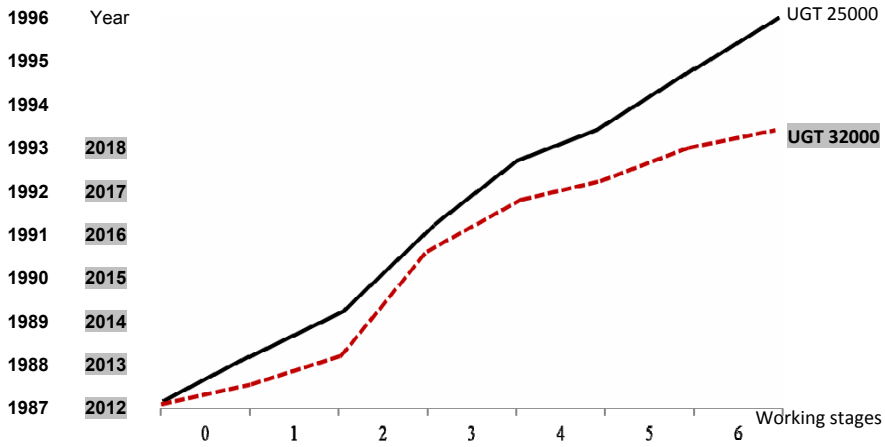

Fig. 1. Diagram of 25 MW and 32 MW engines development

cycle), that is one of the circuit elements of the current assets, the higher the speed of their turnover, the greater the number of turns they make.

The result is the release of financial resources that could be used to expand the existing production at the enterprise or to invest in innovative developments for creation or improvement the competitive GTE on the world market.

Production capacity is directly dependent on the duration of the production cycle. The production capacity means the maximum possible output of products in the planned budgeting period. Therefore it is clear that the less time is expended in production of one engine, the greater number of them could be produced over the same period.

If we take into account that the manufacturing cycle of 25 MW gas turbine engine was longer than that of the advanced design 32 MW engine, it is arguable that the UGT 32000 cost value for a certain financial period is lower.

CONCLUSIONS. 1. We have analyzed the most essential risks which affect the industrial high technology enterprise activity. On the basis of expert survey, we have suggested the risks classification on which in turn the prevention measures targeted on the stable operation of enterprise have been developed.

2. Summarizing the results of implementation of brand new product, we have found that the duration reduction of manufacturing cycle is the most important source of intensification and productivity enhancement. Due to the duration reduction we can lower the expenses and save the monetary funds for the future innovative investments.

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Надійшла до редколегії 28.11.2015
Статтю рекомендує до друку член редколегії ЗНП НУК
д-р техн. наук, проф. К. В. Кошкін