The mechanism for the formation of a diversified production program of an enterprise, taking into account environmental and economic restrictions

T V Kiseleva¹, V G Mikhailov² and G S Mikhailov²

¹Siberian State Industrial University, 42 Kirova str., Novokuznetsk, 654007, Russia
²T. F. Gorbachev Kuzbass State Technical University, 28 Vesennyaya str., Kemerovo, 650000, Russia

E-mail: kis@siu.sibsiu.ru

Abstract. Modern environmental requirements for the quality of products and technological processes, as well as toughening environmental legislation require improvement of the existing organizational and economic mechanism for environmental management. The article discusses the statement of the problem and the block diagram of the algorithm for the formation of the production program of the enterprise, taking into account environmental restrictions. Based on the actual data of an industrial enterprise with a diversified production program, the developed algorithm was tested, which showed the effectiveness of its use in practical activities.

1. Introduction

The effective operation of an enterprise depends on many factors, one of which is the adequate formation of a production program in an unstable environment. In [1], the production program is defined as an effective plan for the production of various types of products in kind and in cost terms in a timely manner, taking into account the requirements for its quality, nomenclature and assortment and developed on the basis of an analysis of market conditions and internal production capabilities of the enterprise using scientific management methods.

The study [2] is devoted to the development of a mechanism for the formation of the production program of an industrial enterprise in conditions of unstable demand for products using mathematical models. This approach to the management of the production program allows us to ensure maximum efficiency in the use of production capacities in conditions of market instability.

The tightening of environmental requirements [3-7] determines the need for the formation of the production program of the enterprise, taking into account environmental and economic restrictions.

2. Materials and methods

The object of study is industrial enterprises with a diversified production program that have a diverse negative impact on the environment. The subject of the study is the procedure for the formation of the production program. The study is based on an analysis of modern literary sources on the functioning of the existing organizational and economic mechanism for environmental management and its possible improvement. With the aim of practical implementation of the author’s methodology, the developed algorithm was tested on the actual data of a large industrial enterprise. The work uses
elements of a system analysis and the results obtained by experts in the field of environmental management.

3. Results and discussion
The idea of the proposed approach is that for enterprises with a diversified production program, it is important to plan the release of these types of products by item and assortment positions, which to a lesser extent have a negative impact on the environment and the ecological and economic result of the enterprise [8-11]. The main limitations when using this mechanism are related to the specifics of the production program, which should have a certain “degree of freedom” when choosing environmentally appropriate types of products. Other possible restrictions may include strategic production facilities, as well as the uniqueness of technological equipment that cannot be redirected or disadvantageously to other types of products.

**Formulation of the problem.**
Given:
1. The existing production program of the enterprise.
2. Nomenclature and assortment positions of enterprise products.
3. Profit from the sale of products of a specific nomenclature or assortment position.
4. Environmental and economic indicators of production of a particular item or assortment position $P_{S,T}$.
5. Restriction: $P_{S,T} > E_{S,T}^*$,
   where $P_{S,T}$ is the profit from the sale of products of a particular nomenclature or assortment position, $E_{S,T}^*$ is the limit value of direct, indirect costs and risks associated with the elimination of the nomenclature or assortment position of the company's products.
6. The list of nomenclature or assortment positions of the enterprise’s products, which can be replaced by ineffective ones.
7. Criterion: annual economic effect of the enterprise ($EE_{FPP}^{S,T}$), mln. rub.

$$EE_{FPP}^{S,T} = \begin{cases} P_{S,T} - E_{S,T}^W, \\ P_{S,T}^* - E_{S,T}^{**}, \end{cases}$$

where $E_{S,T}^W$ - all types of costs associated with the production of a given nomenclature or assortment position ($PN_{S,T}$, $ED_{S,T}$, $F_{S,T}$ or $E_{S,T}^*$);
$P_{S,T}^*$ - profits from the sale of products replaced by an item or assortment position; $E_{S,T}^{**}$ - the costs associated with the replacement of the item or assortment position of products.

Required: to formulate the production program of the enterprise, subject to restrictions that maximize the criterion.

Figure 1 shows a block diagram of the algorithm for the formation of the production program of the enterprise, taking into account environmental and economic restrictions [12,13].

Figure 1 shows that in block 1, an analysis of the existing production program is performed. Block 2 shows a sequential review of each item or assortment position of the enterprise’s products ($P_{S,T}$) for which environmental and economic assessment is carried out. As noted above, this is true for enterprises that produce a large number of types of products that differ, in addition, by grades, classes, concentration of the content of the main or useful substance, etc.
Figure 1. The block diagram of the algorithm for the formation of the production program of the enterprise, taking into account environmental and economic constraints.
Block 3 is necessary for comparing $\Pr_{S,T}$ and fees for the negative environmental impact of a given $P_{S,T}$ ($P_{N_{S,T}}$), which is very important in connection with the prospective increase in this payment. Similarly, $\Pr_{S,T}$, is compared with the economic damage from environmental pollution ($E_{U_{S,T}}$) and environmental fines ($F_{S,T}$) associated with the negative environmental impact of a particular $P_{S,T}$ – blocks 4, 5.

Calculation of $E_{D_{S,T}}$, is carried out on the basis of well-known methods, including using the principles of EIA (environmental impact assessment). $F_{S,T}$ may be caused by a violation of environmental laws, the provision of false information about the negative impact on the environment and other factors.

Modern requirements for enterprises actively operating in the foreign market are associated with the need to use an environmental management system, including certification of products and processes according to the standards of the ISO-14001 series. In block 6, the compliance of this $P_{S,T}$ with the requirements of such a standard is checked. In logical block 7, the conformity of production to the criteria for using the best available technologies (BAT) by the enterprise to reduce the environmental burden on the environment is determined [14, 15], which is caused by modern environmental requirements, including the prospect of increased environmental payments.

In the case of a positive verification of $P_{S,T}$ on the basis of blocks 3-7, a decision is made to save it in the production program of the enterprise (block 8). If the results of the check in blocks 3-7 have a negative result, then in block 9, the direct, indirect costs and risks ($E_{S,T}$) associated with the liquidation of this $P_{S,T}$ are evaluated. The above restriction $\Pr_{S,T} \geq E_{S,T}^*$ is determining in the statement of the problem of constructing an algorithm for the formation of the production program of the enterprise. The costs considered can be caused, for example, by the loss of a market niche or by the need to solve socio-economic problems due to the closure of individual industries and the release of workers. Based on the assessment, the final decision is made (block 10) to save the existing $P_{S,T}$ in the production program of the enterprise (block 8) or to exclude it (block 11). After that, in block 12, the possibility of replacing the excluded $P_{S,T}$ with another type of product is evaluated. In logical block 13, the “profitability” of substitution $P_{S,T}$ is determined. In case of a positive result, in block 14, a decision is made to replace the excluded $P_{S,T}$ with another type of product with the subsequent formation of the final production program of the enterprise taking into account environmental and economic restrictions (block 15). If the substitution $P_{S,T}$ is unprofitable, then the production program of the enterprise is formed in a “truncated” form.

Result of the decision. The presented flowchart of the control program for the production program taking into account environmental and economic restrictions can be implemented at enterprises with a diversified production program, when environmentally hazardous components are used in the production of certain types of products or their varieties, as a result of which the economic damage and payment for negative impact are significantly increased on the environment and, as a result, the likelihood of environmental and economic risks increases. This algorithm was originally developed for such a large chemical enterprise as the Kemerovo KAO Azot, which produces more than 40 types of products, but can be used in other sectors of the economy, taking into account the considered features of the production program.

Table 1 presents, as an example, several types of products of KAO Azot enterprise (caprolactam, POD oil, acidic caprolactam production (CASP), brand A ammonium nitrate,
non-concentrated nitric acid of the 2nd grade), for which it is possible to accept decisions on the preservation, exclusion or replacement of a specific nomenclature or assortment position. The designations “+” or “−” indicate that the nomenclature or assortment position of products meets (does not meet) the established requirements. Profit from the sale of all considered types of products exceeds the values of fees (PN_{S,T}), economic damage (ED_{S,T}) and fines (F_{S,T}) for negative impact on the environment, and also complies with ISO-14001 environmental quality management standards.

Due to the fact that these types of products are produced without the use of BAT standards, in order to reduce or eliminate negative environmental impacts, a final decision is required on each of the considered item or assortment items.

Table 1 shows that caprolactam makes a decision on preservation in the production program, it is necessary to exclude POD oil and CASP, it is proposed to replace brand “A” ammonium nitrate with a new type of product (lime-ammonium nitrate) [16], and non-concentrated nitric acid 2nd grade partially replaced by another assortment position (nitric non-concentrated acid of the highest grade).

**Table 1.** An example of the implementation of the algorithm for the formation of the production program of the enterprise, taking into account environmental and economic constraints.

| The name of the nomenclature or assortment position of the company's products | Profit from sales PN_{S,T} > PN_{S,T}? | Profit from sales ED_{S,T} > ED_{S,T}? | Profit from sales F_{S,T} > F_{S,T}? | Products are manufactured to standards ISO-14001? | Products are manufactured to standards BAT? | Making a final decision on the nomenclature or assortment position of the company's products (abandonment, exclusion, replacement) |
|---|---|---|---|---|---|---|
| Caprolactam | + | + | + | + | - | abandonment |
| POD oil | + | + | + | + | - | an exception |
| CASP | + | + | + | + | - | an exception |
| Ammonium nitrate brand A | + | + | + | + | - | partial replacement on lime-ammonium nitrate |
| Non-concentrated nitric 2nd grade | + | + | + | + | - | partial replacement non-concentrated nitric acid top grade |

4. Conclusion
The study allows us to draw the following conclusions:

- various approaches to the formation and evaluation of the effectiveness of the production program of the enterprise, including the environmental and economic component; the statement of the problem of forming the production program is given taking into account environmental and economic constraints;
- a block diagram of the algorithm for the formation of the production program was developed taking into account the negative impact on the environment;
- analysis of well-known approaches to the distribution of environmental and economic resources, including the ongoing environmental costs in connection with their influence on reducing the level of environmental and economic risks, has been performed;
- the developed algorithm was tested, which showed that for caprolactam it is advisable to make a decision on preservation in the production program, and other products (AML oil, KSPK, brand A ammonium nitrate, non-concentrated nitric acid of the 2nd grade) should be replaced or excluded from production program;
- the developed algorithm for the production program formation is universal and has practical significance for enterprises of different industry sectors.
References

[1] Kushner A A 2010 Bulletin of the Astrakhan State Tech. Univ. Series: Economics 2 89–94
[2] Ajupov A A, Kurilova A A et al 2016 International Business Management vol 10 23 5625–28
[3] Novichikhin A V, Fryanov V N et al 2017 IOP Conf. Series: Earth and Env. Sci. 84 012036
[4] Tumin V M and Koryakov A G 2013 Middle East J. of Sci. Research 2013 vol 17 9 1350–55
[5] Zolotukhin V M, Gogolin V A et al 2017 IOP Conf. Series: Earth and Env. Sci. 50 012027
[6] Zolotukhin V, Belkov A et al 2017 E3S Web of Conf. 15 04015
[7] Tyulenev M A, Zhironkin S A et al 2017 Geotech. Geol. Eng. vol 35 5 2065–2077
[8] Burkov V N et al 2015 Studies in Systems, Decision and Control 10 117–154
[9] Poryadina V, Burkov V and Barkalov S 2018 MATEC Web of Conf. 170 01122
[10] Burkov V N et al 2015 Studies in Systems, Decision and Control 1-24
[11] Avdeev V P, Burkov V N and Kiseleva T V 2001 Avtomatika i Telemekhanika 3 118–125
[12] Mikhailov V G, Kiseleva T V et al 2017 IOP Conf. Ser.: Earth Environ. Sci. 66 012008
[13] Mikhailov V, Kiseleva T et al 2017 E3S Web of Conf. 21 02004
[14] Makarevich E, Papin A et al 2017 E3S Web of Conf. 21 02005
[15] Solodov V S, Cherkasova T G et al 2019 Coke and Chemistry vol 62 9 419–421
[16] Nabiev A A et al 2017 Universum: Technical Science vol 39 6