Gas transport organization management using statistical control methods and information technologies

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Abstract. The methodology and experience of researching the activities of a gas transportation organization (GTO) as a management object in the development of its quality management system using statistical control methods and information technology tools - the MC “Tracking system” are considered. Based on the data obtained using the system for the GTO under study, an analysis of the causes and sources of car downtime, their distribution in areas of responsibility (manufacturing plant, Russian Railways, technological zone, trader and others), as well as distributions within such zones, were made. Using control cards, control and normalization of the delivery dates of products and their tolerance values, in accordance with the international standard (the “three-sigma” rule), ensuring the delivery time beyond the tolerance limits in no more than three cases out of a thousand of such deliveries, were carried out. Based on the results of the analysis, recommendations were formulated for the modernization of the GTO activities to reduce costs caused by the downtime of cars. According to the data obtained, when comparing the activities of the GTO for 2017 and 2018, the effect was expressed in a reduction in costs of more than 24 million rubles.

1. Introduction
Improving the management of modern complex systems and technologies in order to increase their efficiency is an urgent problem in many areas, which is solved taking into account the specifics of the studied system and the application area.

The quality of management, in general, is achieved by ensuring it at all stages of the product life cycle. This process begins even at the stage of the idea occurrence and the development of project documentation. And it implies the consistent implementation of the complex of modern management functions: planning, organization, coordination, motivation, control and corrective actions.

This article is devoted to the methodology and experience of researching activities using the methods of statistical control and information technology of the activity of a specific control object - gas transportation organization (GTO) in order to increase its effectiveness and create a quality management system (QMS).

Statistical methods are a powerful means of obtaining new accurate knowledge about the studied objects for use in the tasks of their control and quality assurance \cite{2,3}. The role of these methods is especially noted in the international quality standards of the ISO series \cite{1}. They emphasized that the use of statistical methods is a necessary indicator of the presence of a QMS in an organization. Otherwise, if these methods are not applied, then even if there are a number of attributes of the QMS (quality policy, documented procedures, etc.), it is not necessary to talk about the existence of the
QMS in the organization [1]. In the study of modern complex multidisciplinary industries and organizations, the implementation of statistical control methods and an operational analysis of their results require the use of information technologies with appropriate methodological and algorithmic support [5,6].

The tasks of the considered GTO, which is a subsidiary of Rosneft, include ensuring the supply of petroleum products from their field to consumer plants for their further processing. Ensuring the quality of activities of such organizations at all stages of the supply chain of petroleum products [7] is of great importance for both producers and consumers. The requirements for such deliveries are their timeliness and cost minimization during transportation due to possible downtime of freight cars. The main indicator of the use of the car fleet is the turnover of cars - the time taken to complete a cycle of operations from the moment one loading begins until the next loading begins. For operational control of the downtime of cars (with a view to its subsequent reduction) and their causes, the organization operates the automated system of the MC "Tracking system". Using this system, by means of statistical control procedures (data stratification, Pareto diagrams, histograms, control charts, Ishikawa schemes), an analysis of the causes and sources of car downtime and their distribution by areas of responsibility (manufacturing plant, Russian Railways, technological zone, trader and others), as well as the distribution of downtime for reasons within such zones for 2017 and 2018, were made.

Figure 1 shows the cause and effect diagram of Ishikawa, reflecting a set of reasons that determine the downtime of cars under loading.

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**Figure 1.** Cause and effect diagram of the causes that determine the downtime of cars under loading.

Such a scheme clearly displays a list of causes and their impact at all levels of product delivery. It gives an idea of the factors that affect the final indicator of the object activities and their cause-effect relationships [2,3].

Table 1 and Figure 2 provide an example of the distribution of car downtime duration by zone of responsibility in 2017.
Table 1. Distribution of downtime duration by area of responsibility, 2017, days.

| Responsibility | Downtime |
|----------------|----------|
| Plant          | 3 142    |
| Russian Railways | 7 487   |
| Organization (GTO) | 15 709  |
| Technological  | 4 001    |
| Trader         | 901      |
| Overall result | 31 240   |

Table 2 and Figure 3 give the distribution of the car downtime value for their reasons in the framework of the GTO in 2017.

Table 2. The final distribution of the car downtime value for their reasons in 2017, days.

| Reason for downtime | Downtime |
|---------------------|----------|
| Loaded car awaiting departure | 7 271    |
| Selection of empty train for loading | 5 256    |
| Preparation of cars in washing and streaming station | 3 859    |
| Malfunction         | 2 804    |
| Loaded car in transit | 2 501    |
| Fleet surplus       | 1 859    |
| Loaded car awaiting discharge | 1 412    |
| Accumulation of cars before group/route departure | 1 311    |
| Increase in loading time on the overpass - a technological reason | 887      |
| Empty car awaiting departure | 840      |
| Absence of technical direction | 742      |
| Absence of a certified product | 723      |
| Awaiting transfer to non-working fleet | 595      |
| Relocation of a car from one station to another without access to the public railway tracks | 366      |
| Logistics/convention | 163      |
| Filling for sludge   | 159      |
| Accumulation of cars for relocation to other landfills | 149      |
| Increase in filling time on a overpass - lack of product | 113      |
| Reason                                                                 | Value |
|----------------------------------------------------------------------|-------|
| Absence of output from non-public railway tracks                     | 96    |
| Absence of locomotive traction                                       | 53    |
| Empty car in transit                                                 | 34    |
| Increase in filling time on a overpass - defect of computing center under overpass | 21    |
| Unsuitable for export                                                | 13    |
| Defect of product                                                     | 6     |
| Lease out/ Rental entry                                              | 4     |
| Buffer car                                                           | 2     |
| Heavy duty loading                                                    | 1     |
| **Overall result**                                                    | **31 240** |

**Figure 3.** Pareto diagram of the distribution of the car downtime duration for their reasons, 2017.

A graphical representation of such data in the form of Pareto diagrams clearly demonstrates which of the reasons dominate and how their contribution to the amount of car downtime during the current control changes for the subsequent adoption of measures targeted to eliminate or reduce the influence of such reasons [2,3].

On-line verification of the compliance of a random sample of terms \( n = 10 \) deliveries with the normal distribution law by the W-criterion, a positive result was obtained - the calculated value of the criterion \( W > W_{0.5}(10) = 0.938 \). This result was used to justify the selection of the tolerance value for delivery times according to the “three-sigma” rule [2,3].

Figure 4 shows a histogram of the distribution of the delivery number by the delivery dates according to the grouped data of a large sample of \( n=400 \) and 100 groups of \( n=4 \) deliveries each.
The histogram shows the presence of a long right tail of the distribution due to the available results with an extended delivery time of 13 to 20 days with an average value of 16.5 days, which took place and were recorded mainly on the right side of the control chart (Figs. 5 and 6).

Figure 4. Histogram.

Figure 5. Chart of average values.

Figure 6. Range chart.
On this chart, three monitoring time intervals can be visually distinguished: initial A, average B, and final C. Within each section, the total average \( \bar{X} = \frac{\sum_{i=1}^{k} X_i}{k} \) of arithmetic average \( \bar{X} \) by groups for each monitoring period can be interpreted as a kind of “norm” of delivery times in the GTO activities for this period time. This norm can be adjusted taking into account seasonal and weather conditions according to relevant data as was the case in Figure 5. The tolerance value for the indicator X with the normal distribution \( |D| = \bar{X} - A(n) \) R, \( A(n) \) is the value of the coefficient for samples of volume n, characterizes the range of possible values of the delivery time \( X_i \) for a specific control period, for which redistribution will fall no more than three (more precisely 2.73) deliveries per thousand of them [2,3].

Going beyond the upper bound for “delayed deliveries” deadlines can violate the rhythm and plan of the process of refining petroleum products, and going beyond the lower bound for deadlines can lead to an increase in the additional cost of storing petroleum products at the refinery.

As was mentioned, to control the downtime of cars and their causes in the GTO, a specialized complex MC “Tracking system” is used. With the help of this system, work was carried out to collect a large amount of information about the causes and downtime of cars during transportation. A fairly complete list of such reasons has been compiled (were presented in the figures earlier). An instruction has been developed for users, following which it is possible to enter the causes and duration of car downtime from the specified list every day, using the convenient interface with a set of special windows. Figure 7, as an example, presents one of the stages when entering the causes of downtime in the program.

![Figure 7. Selecting the cause of downtime.](image)

Based on the results of the analysis of the GTO activities for 2017 and 2018, recommendations were formulated for its improvement and efficiency increasing in order to reduce costs due to the downtime of cars. Among them is the use of the MC “Tracking system” for an operational assessment of the situation in the control process; ensuring the prioritization of loading own or leased fleet of cars; the use of this fleet at sites with a minimum loading time as part of the redeployment of the fleet and work with “short shoulders”. An analysis of the GTO activities in 2017 and 2018 showed that by reducing the downtime of cars, a reduction in corresponding costs of more than 24 million rubles is achieved.
Implementation of the development of the use of statistical control methods and the MC “Tracking system” with the aim of improving and increasing the effectiveness of the GTO activities are the methodological basis for creating the QMS of the organization in question. They essentially demonstrate the trial functioning of a similar QMS.

The considered approach to improving the management of the activity of the analyzed GTO can be recommended as a standard methodology for studying the activities of such organizations in order to increase its effectiveness and create a QMS.

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