Regulation and stimulation of engineering innovation processes at machine-building enterprises

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Abstract. The paper is devoted to the substantiation of certain aspects of the system of regulation of activity and remuneration of process engineers. The research is based on a theoretical model for justifying management decisions based on comparing the costs and benefits of innovation. The object of observation is a machine-building holding within the state Corporation ROSTEC (Russia). Data from self-observations of the working hours of process engineers, their processing and personalized analysis in two projections (ordinary and innovative work) led to the conclusion that there is a resource of time for solving innovative problems and creating breakthrough technologies. The results obtained are taken into account when designing the process of forming remuneration for innovations, which includes three phases. The authors conclude that a well-founded system of regulation and stimulation of innovative labor processes makes it possible to significantly advance in the direction of activation of innovation.

1. Introduction
The results of research by economists show that the most important intangible assets of organizations are people, who are the heart of any innovation ecosystem [1]. People maintain a high level of personal creativity [2], form project teams to solve non-trivial tasks using the tools of the Fourth industrial revolution [3], produce and apply new knowledge in practice [4], and support an innovative corporate culture.

The ability to make management decisions depends on the involvement of employees in technological, marketing, organizational and environmental innovations. Statistical estimates of the total level of innovation activity in industrial production in Russia fluctuate at the level of 10.5-11.1% during 2006-2017 [5]. This is a low level that shows the presence of systemic problems in the organization of innovation processes. European countries show a higher level of innovation activity: Germany-61.5%, Belgium-52.8%, Finland-50%, France and Austria-41-43%, Bulgaria-21.6%, Poland-17.7%, Hungary-17.5% [6]. Manufacturing industries in Russia on average show a higher innovation activity of 21.3%. Only one in five (19.9%) machine-building enterprises takes part in technological, marketing and organizational innovations [5]. The article discusses two barriers to innovation in production activities – overloading employees with routine and lack of incentives. Their minimization will solve some of the qwerty effects and stimulate innovation.

The purpose of the article is to present the results of a personalized analysis of certain aspects of the system of regulation and remuneration of process engineers of the machine-building holding,
which is part of the state Corporation ROSTEC.

The object of observation was one of the machine-building enterprises in Novosibirsk (Russia). The company provides 75% of the market for its products in Russia. Further expansion of the market is limited to competitors. This was a prerequisite for the search for a new market niche in the format of product diversification, namely, an engineering center for the provision of high-tech services. The corporate competence of the new center is provided by the professional competence of the plant's engineers.

2. Background Results and Discussion

The participation of engineers in innovation activities is determined by their personal needs and a set of information about the expected costs and benefits of innovation [7, 8]. This decision to support innovation will look like this [9]:

\[ D = \begin{cases} 
1, & \text{if} \sum_{n=1}^{N} r_{n, \text{sub}} \leq \sum_{k=1}^{K} r_{k, \text{sub. ex}} \\
0, & \text{if} \sum_{n=1}^{N} r_{n, \text{sub}} > \sum_{k=1}^{K} r_{k, \text{sub. ex}} 
\end{cases} \]

where \( D \) is the the decision to support / resist processes (can take the value 1 or 0); \( r_{n, \text{sub}} \) are the subjectively estimated resources of the \( n \)-th type spent on implementing a solution to support/resist innovation; \( r_{k, \text{sub. ex}} \) are subjectively estimated expected benefits of the \( k \)-th type that can be obtained from the decision to support/resist innovation \( D \).

If innovations affect the entire workforce, then active communication in the group leads to the dissemination of information about the expected changes and the formation of the collective's total expectations at time \( t \) of the total expectations of the team [9]:

\[ I_{ex}(t) = \sum_{m} \sum_{j} i_{exmj}(t) \gamma_{mj} \]

\[ \gamma_{mj} = \begin{cases} 
1, & \text{if} \tau_{mj} \leq t - t_{incl.j} \\
0, & \text{if} \tau_{mj} > t - t_{incl.j} 
\end{cases} \]

where \( I_{ex}(t) \) are the total expected benefits of innovation by the team of engineers at the moment \( t \); \( i_{exmj}(t) \) are the expected benefits of the \( m \)-type by the \( j \)-m engineer; \( \gamma_{mj} \) is the inclusion multiplier for the benefits of the \( m \)-type \( j \)-th engineer (can take the value 1 if the engineer considers the benefit as a benefit from participating in innovations, 0 otherwise); \( \tau_{mj} \) is the waiting period for the benefits of \( m \)-type \( j \)-th engineer; \( t_{incl.j} \) is time when an engineer is included in the innovation process (the beginning of innovation development).

Systematic and consistent work with engineers begins with the regulation of activities for solving and supporting ordinary tasks and technologies. Creating a model for performing work at different levels of detail will allow organizing techniques and methods for solving individual tasks in the workplace of engineers, establishing quantitative characteristics of time spent on working with ordinary tasks and processes and evaluating the quantitative characteristics of time spent on working with innovative tasks and processes.

The accumulated experience of regulating the operations of ordinary technological processes does not allow determining the norms of time for innovative tasks. For specialists of intellectual labor, for
example, engineers of the services of the chief engineer of industrial organizations, «the system of microelement labor rationing is not applicable. The specifics of this category of employees should be taken into account. New approaches must be found» [10].

The task of determining the time spent on the work of engineers with ordinary and innovative tasks and processes was updated during the implementation of the project to change the remuneration system for the personnel of the selected observation facility.

The analysis of business processes made it possible to conclude that the engineers of the chief engineer's service perform the following types of work efficiently, namely, providing a full cycle of research and development work, development of design documentation, development of new equipment, technologies, parts, products, improvement of existing production technologies and preparation of comprehensive technological documentation, ensuring the safety of production and the environment.

3. Results and Discussion

Using the method of working day photography, the actual time spent on the work of engineers in the chief technologist's Department with ordinary and innovative tasks and processes was measured. For two months (nine work weeks) the process engineers kept diaries of self-observation. Process engineers measured and recorded the time spent on innovative and ordinary tasks and processes. In this way, we obtained 45 data sets for seven jobs of process engineers, which recorded the actual time spent on working with ordinary and innovative tasks and processes.

Calculation of arithmetic mean values, median and mode of available samples (Table 1) allowed concluding that the values obtained for each series do not differ significantly, and, therefore, the distributions can be considered normal.

| Working places of the chief technologist's service | The ordinary tasks and processes | The innovative tasks and processes |
|----------------------------------------------------|---------------------------------|----------------------------------|
|                                                    | Mathematical expectation, min   | Standard deviation, min          |
| The head of the group of rationing of materials    | 419,47                          | 39,03                            |
| The engineer-technologist of the of the group of rationing of materials and new equipment | 454,40                          | 9,67                             |
| The leading engineer-technologist of the of the group of rationing of materials and new equipment | 456,80                          | 7,76                             |
| Engineer-technologist for new technology           | 420,80                          | 19,33                            |
| The engineer-technologist of the new equipment     | 444,89                          | 13,52                            |
| The leading engineer-technologist                  | 420,80                          | 12,75                            |
| The leading process engineer in the technology Bureau | 336,62                          | 21,24                            |

The deviation of the total duration of observations by day is less than 1%.
Processing of the observation results allowed concluding that the working time of engineers is mostly spent on working with ordinary tasks and processes (figure 1).

Figure 1. Allocation of time spent by process engineers for ordinary and innovative tasks and processes.

This ratio of time spent does not allow technology engineers to focus on achieving the goals of the company's technology policy, stimulate the development of personal professional competencies, and create and implement innovations.

Regulation of ordinary tasks and technologies provides an opportunity to delegate authority and transfer a significant part of it directly to production units. In this case, the chief engineer's service engineers have a resource of time to solve innovative problems and create breakthrough technologies, can concentrate on developing plans for medium-term innovative development, and effectively manage innovations in divisions.

At the second stage of the research, the analysis of innovation incentives was carried out and the design of the process of forming the incentive part of remuneration for innovation was carried out. Initially, the amount of remuneration for process engineers consisted of the base part (salary), compensation payments (for example, for the danger and harmfulness of work) and the bonus part of remuneration. Initially, the award was not of a stimulating nature - there were no relevant parameters for evaluating the intellectual work of technologists. The system of the key performance indicators (KPI) was proposed in the development of the existing incentive system for the enterprise with a focus on results.

It was suggested to use two projection of labor productivity assessment such as operational (for evaluating ordinary processes) and strategic (for evaluating innovative processes). The strategic component of the KPI should ensure the involvement of enterprise specialists in the process of achieving the main goals of any business is the attracting and retaining consumers (customers), developing employee competencies across the entire palette of competencies (hard skills, soft skills and digital skills), diversifying sources and increasing revenue, reducing costs.

The authors proposed to form a stimulating part of the remuneration in three stages sequentially (Figure 2): designing of the KPI system, planning of the indicators for the upcoming period, assessment of the performance by KPI for the reporting period and calculation of bonus remuneration.
Input and output information flows ensure the execution of the proposed process.

Figure 2. Process of designing the incentive part of remuneration for employees of the enterprise

4. Conclusion
The results of the study clearly show that the regulation and stimulation of innovative labor processes of enterprise engineers can have an additional influence on the decision to include engineers in innovation activities. This will significantly improve the company's innovation climate. Today, the current activity of engineers involves solving too many ordinary tasks. Engineers have limited capacity to maximize the productivity of their intellectual assets. It is necessary to stimulate engineering innovation processes in machine-building enterprises and redistribute the time spent in favor of working with innovative tasks and processes. This will lead to increased production of technological, marketing, organizational and environmental innovations and an overall increase in the efficiency of all production processes of the machine-building enterprise.

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