Realization of the principle of evidence-based decision-making for the technology of rapid solidification rate of the melt

V A Vasiliev and S A Odinokov
Moscow Aviation Institute (National Research University), 121552, Moscow, Russia
E-mail: uks@mati.ru

Abstract. To improve the efficiency of the process of rapid solidification of the melt, it is necessary to use approaches from the quality management. It is proposed to apply the principle of "making decisions based on facts." To do this, explore the individual stages of the implementation of the principle. Each stage should include the necessary methods and tools for choosing a solution.

1. Introduction
In modern materials science the role of quality of materials increases. In perspective quality management, special attention is paid to the implementation of certain principles, such as customer orientation, process approach, etc. A special role for the management of technological processes is played by the principle “Evidence-based decision making”.

As a rule, in practice its implementation involves the selection of a quality indicator, the collection of necessary data, the processing and analysis of results, and the adoption of a decision. The implementation of such an algorithm allows to increase the probability of meeting the requirements. Increases the efficiency of processes and the entire system. To implement the principle, it is usually proposed to use statistical methods [1]. They are used for individual requirements in the quality management system. However, such solutions can solve only the frequent tasks of fast quenching control. It is necessary to use this principle as the basis of process control.

2. Research on the application of various control methods for high-speed solidification of the melt
In the study proposes a model for the implementation of this principle, which was formed with the improvement of the technology of high-speed solidification of the melt, shown in figure 1. It is characterized by developed recommendations for the implementation of individual stages, in general and individually, aimed at making an informed decision on the management of the process.

The technology of rapid solidification of the melt allows to obtain a wide range of materials with special properties [2, 3]. These studies were carried out to improve the technological process of production of solder brand P-14 and in the production of fiber austenitic steel grade 08X18H10T.

The analysis of the key process for the production of semi-finished products has been carried out and the multifactor structures of causal interactions have been determined at the appropriate stages, taking into account the main technological modifications used.

The following groups of indicators are defined that determine the structure and state of the process [4]:
1. Standard – based on regulatory requirements for processes in the quality management system.
2. Additional – related to recommendations in the field of quality management, including those determining the procedure for conducting statistical management processes.

3. Production (technological) – related to the conditions for ensuring the quality of the process: the environment for the process, with the fulfillment of the requirements of normative document.

4. Perspective – related to the development of processes, including signs of the best available technologies.

![Figure 1. Model to implement the principle of “evidence-based decision making”.

Production (technological) factors are the basis for establishing criteria for ensuring and managing the quality of processes, including for conducting standard internal audits or technological audits.

To rank the factors and select key quality indicators, a method of multivariate analysis is proposed, as well as an approach associated with the sequential decomposition of processes, determining the nature of the interrelationships of parameters of individual subprocesses and evaluating the impact on output properties of products.

To carry out the collection and storage of information, an approach is also presented aimed at creating a unified information space of the Quality Management System, which helps to detect and eliminate adverse conditions for manufacturing products based on the application of multivariate data analysis technology. It is proposed to stratify and store information in the data warehouse on four layers, depending on the level of reproducibility of the process.

The proposed three-stage model of testing and increasing the potential of the technological process is formed on the sequential use of the PDCA cycle. The stage “Audit project” or “Audit planning” assumes at the first stage (P1) the development of a set of organizational and technical measures,
including the formation and participation of a team of highly qualified specialists of the enterprise, planning actions. In the second stage (D1), a set of criteria and subcriteria necessary for conducting a technological audit is determined. The third stage (C1) involves the analysis of these criteria in order to preliminarily identify the likely evidence of a technology audit. The fourth stage (A1) involves the formation of a controlling stake for conducting a technology audit. The “Audit – Self-Evaluation” stage is carried out on the basis of control questions by the owner of the process, and includes the stages of planning self-assessment, conducting, monitoring, and actions, which also imply finding additional, own audit evidence. The “External Technological Audit” stage implies planning a review with account of the new process data and specifying the elements to be checked, performing a selective audit and summing up the results.

On the basis of the criteria tree, questionnaires have been developed for the structural units of the enterprise being inspected, which influence the quality assurance conditions of the process being audited.

At the stage of experimental studies, it is proposed to apply an iterative improvement in the quality of the process based on the polynomial dependencies of the parameters obtained by modeling using numerical methods [5].

To obtain products in stable conditions, the following algorithm is proposed for analyzing and managing the quality of the technological process:

- collection of statistics on the quality of the process, including the selection of indicators and control planning, primary processing and exclusion of sharply distinguished values;
- construction of a variation series, starting with the choice of the type of series and including the grouping of data, the calculation of statistical indicators, the direct construction and the initial assessment of the stability of the process.
- approximation of the distribution law of experimental data based on testing the statistical hypothesis about the nature of the distribution of data.
- conducting multivariate correlation and regression analysis.
- analysis of the availability of trends in quality indicators.
- assessment of process capability and stability, including the multiple choice of control charts.

These measures are aimed at developing a unified approach to the reform.

3. Results and discussion

As a result of the research, the following proposals were developed and put into practice:

1. The method is proposed for use at the stage of selecting the required data to identify key quality indicators based on the sequential decomposition of the process and assessing the contribution of the indicators of subprocesses to the output results and to the level of variation created.

2. The necessary groups of process quality indicators have been identified with emphasis on production (technological) indicators related to the quality assurance of the process.

3. The approach was developed to prevent inconsistencies based on the creation of a single information space in a multidimensional repository, based on the use and grouping of integral indicators of the quality of the technological process.

4. The three-stage model of testing and increasing the potential of the technological process, based on the sequential use of Deming cycles, has been formed.

5. The method of iterative quality management has been developed, based on a numerical algorithm for solving an inverse problem for determining dependencies by input and output parameters.

6. The method of iterative quality management based on numerical methods is proposed; it is necessary at the implementation stage and in the case of frequent changes in parameters.

7. The methodology for statistical analysis, evaluation and management of the process based on the consistent and interrelated use of a set of tools providing for the collection, processing, analysis of data to evaluate and confirm the stability of the process, as well as the corresponding methodical recommendations are proposed.
8. To control the quality of the technological process, recommendations on multivariate stability analysis based on the use of control charts based on the use of relative indicators have been established.

4. Conclusions
A new model for controlling the process of high-speed solidification of the melt has been proposed. She suggests using fact-based decision making. Each stage includes a set of new or modified methods for optimal control. The use of the model will allow us to consistently improve the quality of the processes and the quality of the metal fiber.

In the case of a complex process, it is necessary to select controlled characteristics. In addition, it is necessary to evaluate the possible effects of environmental factors. To control it is necessary to accurately select key parameters.

To collect information it is necessary to apply an additional procedure of technological audit. The entry of data into the information database should be accompanied by checking of unfavorable combinations of parameters and the exclusion of such situations.

To manage the process during the implementation phase, it is necessary to use an iterative method. At the next stages, a complex of interrelated statistical methods should be applied to analyze the stability of the process.

References
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