

Standard quality support in technical equipment repair

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Received 7 December 2010

Abstract. The necessity for technical equipment repair and its economic efficiency is substantiated. The quality of technical equipment repair is assessed on the basis of technological (manufacturing) criteria that are provided at machinery repair, and on the basis of performance (consumer) criteria that are displayed at machinery usage. The necessity and means for improving the quality of technical equipment repair on the basis of the experience of development and introduction of the quality system for machinery repair are shown.

Key words: repair, quality, criteria, quality system.

The necessity for machinery repair. Limited government reserves of fuel and materials cannot provide sufficient reproduction of machine park by means machinery construction and along with its preservation require development of repair industry, which requires much direct labour and materialized labour. Machine components fail at different time, therefore the requirement in machinery repair arises at different operation moments. Repair ensures normative reliability of machinery during all their working life. Machinery repair allows to use the preserve use value in form of remaining life of its components. Machinery modernization carried out during repairs, allows to considerably draw nearer the time of physical depreciation and obsolescence of machinery as well as to improve its technical level and adjust it to the new requirements of usage. Repair is economically expedient. About a quarter of repair fund components are not worn out or are worn within permissible limits and can be reused at the cost of 2-3%, and about a half of components can be used after restoration at cost price of 15-30% of new components cost respectively. Components restoration saves a great number of materials, energy and labour.

The present state of repair industry is characterized by deterioration of quality of repaired machinery. Only 40-60% of machines and 10-40% of their component units reach normative post-repair operating time (Pic. 1). Marks in form of circles in diagrams correspond to normative operating time and quantity of component units out of production.

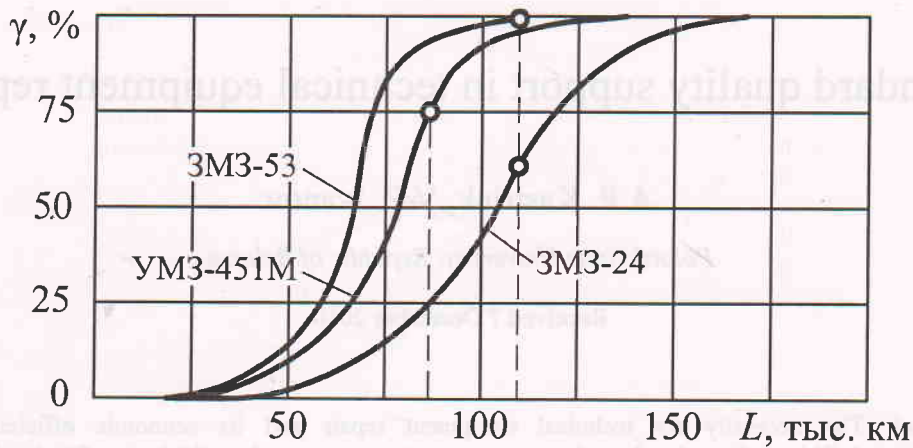


Fig. 1. Repaired components share γ , % of components out of service at accrued operating time L .

Quality criteria are subdivided into technological (manufacturing) and performance (consumer) (Table 1.). Criteria of the first group are ensured at machinery repair, they considerably influence criteria of the second group that are revealed and supported at the use of a machine according to its intended purpose. At that a number of technological parameters value require stiffening with the aim of improvement of performance criteria.

Table 1. Criteria for technical state of machines and their components

Product	Criteria	
	Technological	Performance
Components	Surface purity Chemical and structural composition of a material (core and friction surfaces) Relationship and shape of surfaces Linear and angular dimensions Roughness (microgeometry) of surfaces Progressive motion components weight Weight distribution with respect to rotation axis Walls tightness	Wear resistance Static capacity Fatigue resistance Rigidity Corrosion resistance Heat stability Durability
Assembly units	Closing dimensions Assembly efforts and instants Progressive motion products weight Weight distribution with respect to rotation axis and inertia Joints tightness	Durability
Aggregates	Closing dimensions Assembly efforts and instants Running in of friction surfaces Parameters of processes (motion, velocity, acceleration, time etc.) Torques Joints tightness	Balance Operating sound Walls vibration Temperature of basic parts walls Consumption and pressure Corrosion resistance

	Adjustment characteristics (allowances, displacement, efforts, pressure, medium consumption etc.)	Harmful substances emission Durability and reliability
Machines	Relationship of machine components Assembly efforts and instants Composition, width, strength and smoothness of lacquer coatings Tractive values Braking values Adjustment characteristics (allowances, displacement, efforts, pressure, medium consumption etc.)	Safety in use Fuel consumption for operating time unit Dynamic characteristics Ride comfort Controllability Marketable state Driver's operating conditions Environmental contaminants emission Corrosion resistance Durability and reliability

Quality assessment. Quality of machines repair can be assessed by the share of technological criteria (Table) that are within normative limits. In case the share is 60 %, 80 % post-repair resource with respect to new products can be achieved. At present, according to our estimation, the share of the criteria which values are within normative limits is 20–25 %.

Quality improvement aspects. In spite of the complexity of the problem of repair quality support, the directions for its solution are as follows. As the first step it is necessary to take into account and analyze all the technological criteria with their normative values for components, assembly units and aggregates. These criteria determine the unconditional quality level and include geometrical, structural, and physico-chemical values. The second step is to allocate and use the means and procedures of repair that can ensure the mentioned criteria. It is possible that the existing at an enterprise techniques will not be enough to ensure the values in a range of parameters. It will be necessary either to purchase the lacking, as a rule, expensive means or to allocate respective work at other enterprises on cooperation conditions.

The normative quality level of repaired machines can be obtained by means of development at an enterprise of a quality system for machinery repair (QS MR) and its introduction into production.

Quality system for machinery repair – variety of workers actions regulated by an enterprise standards, necessary for obtaining normative quality of repaired machines and its continuous improvement.

The specified standards of an enterprise determine the objective of QS MR, its functional and organisational structure, processes and resources, required for quality control at machinery repair.

The aim of the system is to reach the values of repaired machines quality not less than normative and exceeding respective values of machines produced by leading repair enterprises of the branch. The tasks of the system is to create conditions for such production output.

Conditions of production implicate that work places must be provided with quality materials, semi-finished products, and components, that certified fault-free repair means are used, that the production process is carried out in due order and according to a specified pattern, that the modes of product treatment conform to requirements of technological processes, that there is properly trained and certified personnel, and production quality control.

Functional structure of the system is determined by worker's activity and their interaction on quality assurance support. These functions are subject to the objective of the system and include: planning, control, management and continuous improvement of production quality. The system operation is connected with resource consuming and is assessed on the basis of criteria.

Quality planning consists in defining the requirements for production and working out of measures for these requirements achievement.

Quality control includes a multitude of actions within managerial control of an enterprise for the system objective achievement. All workers at an enterprise are involved in the activities for the objective achievement, but officials of the enterprise bear the responsibility for the general quality management.

Quality control – types and measures of activity of enduring fulfillment of requirement to production quality. Such activity provides both for technological processes control, their adjustment, date acquisition and isolation of causes and removal of causes of unsatisfactory quality.

Quality improvement is a continuous activity of an enterprise workers, aimed at production quality improvement, and perfecting of components of production and quality system.

Organisational structure is determined by relations and interaction of workers at an enterprise, their responsibility and authorities. Limits of responsibility for quality and authorities of each worker with description of cases in which the worker has to interact with other persons are determined by Regulations on divisions (workshops, departments) and job descriptions.

System for stimulation of workers at an enterprise responsible for production quality takes into consideration both responsibility limits of the personnel for work execution influencing the quality, and the results of such work.

The modern QS MR is built in accordance with requirements of standards ISO 9000 [1-3]. The major principles of creation and operation of QS MR are as follows.

Competitiveness of repaired machines, increasing of labour productivity and improvement of economic indicators of an enterprise due to product market extension and increasing profitability of production sales are achieved by means of continuous and systematic improvement of technological processes and organisation of production. Such improvement is favoured by a modern quality concept [4], that includes:

- availability of a policy in the sphere of quality;
- replacement of a number of suppliers (with respect to every type of purchased materials, semi-finished materials and products) for a long-term relations with one supplier;
- continuous evolutionary quality improvement due to improvement of quality system, resource base and organisational structure of an enterprise, elimination of quantity indicators;
- elimination of complete control of production quality and introduction of sampling methods;
- introduction of new methods of management of an enterprise and its divisions and assessment of personal characteristics of employees;
- systematic training and retraining of all the personnel at an enterprise.

Quality policy as a description of the aim and major principles of QS MR is determined by the head of an enterprise who allocated the responsibility for functioning of quality system components among the enterprise employees. Each employee performs his own functions, which he is responsible for.

Quality policy is implemented at target organisational and technical programmes for assurance and improvement of production quality, effective for a year or a number of years.

At development of QS MR it is considered that the basic requirements to products quality are established by the customer. Marketing research of consumers' demand and supply are carried out at an enterprise. The research results are included in specification requirements. The principle in action is: not to sell the manufactured products, but to produce what is being sold!

QS MR operates in interaction with other systems of preproduction and production assurance – structural, technological, organisational, supply and sales. This means that QS MR is an integral part of the system of an enterprise management and operates as its component part.

QS MR action is extended to the stages of productive cycle which an enterprise deals with: from demand analysis to its utilization at the end of useful life.

QS MR contributes to continuous improvement of machinery repair. To implement this principle the content of quality improvement should be defined, the improvement should be justified, motivation should be stimulated and personnel should be trained in the area of quality control.

Introduction of QS MR eliminates the featurelessness of machinery being repaired as well as its components. The system is aimed at prevention of problems, not at overcoming their consequences.

QS MR provides for certification both of personnel and of an enterprise.

QS MR is set out in form of documents that present the system components, their functions and requirements to them. Form of the system documents is established by each enterprise independently. The documents are available for users, their requirements are specific and unequivocal. Some documents are kept by the employees who they are developed for.

All the QS MR components are subject to regular internal and external audit. This is necessary for reliable functioning of the quality system and the enterprise management certainty in the fact that the designated aim is being achieved. Audit is carried out in accordance with a schedule developed by the personnel.

QS MR shall be regularly analyzed and assessed by the enterprise management. The basic information sources about the system operation are regular reports by heads of plant divisions and audit reports. A person authorized for quality generalizes the reports and prepares a report to the enterprise management at least biannually. The report contains the answers to the questions: are the basic regulations on the quality policy complied with? are the consumers satisfied with production quality? is the aim of the enterprise in the area of quality being achieved? what is the reputation of the enterprise on the market? is the current system for detecting and removing the reasons of existing or potential discrepancies efficient? The report is adjoined by suggestions on quality system improvement.

Production monitoring is acquisition of data on its state during repairs at the enterprise and subsequent stages of life cycle outside the enterprise. A repair enterprise draws information about the quality of repair of its products from the following sources:

- operational inspection of products;
- register of defects detected during acceptance tests of machines and aggregates;
- list of defects detected during warranty period;
- data from supporting sectors, that use the repaired machines and collect data on their failures;
- Data on accrued operating time and condition of aggregates and machines for overhaul repair;
- data on post-repair operating time of machines subject to write-off.

Product labeling is the procedure of making marks and labels on products being repaired (restored) for the purpose of their accounting. Machines, aggregates and some components are usually labeled. Components that have an effect on safety and reliability of repaired aggregates are labeled. The fact of products labeling is reflected in repair documents on the products. Specifications contain the information on the way of labeling: code and type of marks, forms of running schedule for a component and technological passport of an aggregate or a machine. Labeled products are accounted.

Traceability of products means location of place and time of repairs that resulted in defective products output as well as identification of employees who carried out the work and assessed it.

Labeling and traceability procedures identify the usage and location of defected products. Traceability must ensure retrospection of the inflow of repair fund, materials, semi-finished goods, and spare parts, implementation on technological procedures of repairs as well as determination of location, conditions and operating time of products.

Concrete defects are defined and removed with the aim of elimination of their recurrence with the help of corrective actions; feasible defects are eliminated with the help of preventive actions.

Elimination of defects causes is connected with changes in specifications to materials, semi-finished goods, and marketable products, technological procedures and organisation standards, storage and transportation of goods.

Corrective and preventive measures are developed on the basis of all the types of production tests, testing certificates of procedures discipline, audit results, suggestions on improvement of technological processes, proceedings of "Quality day", write-off certificates for defective production, cases of production output according to special sanctions, detection of defects during warranty period.

Enterprise certification is a package plan for defining its potential for machinery repair in accordance with requirements of normative and repair documents. Certification is subdivided into two types – planned and inspection. Production is certified within factory and state certification. Separate workplaces (procedures) are certified, by results of which a decision on the state of production divisions, then workshops, and finally – the whole of the enterprise.

Production certification includes inspection of repair and technological documentation, knowledge and capability of employees for assurance of specification requirements, production order at workplaces, equipment state, accessories (including that of equipment) and measuring means.

At inspection of repair documents adequacy of requirements to production quality is established. Further it is established if all the requirements of repair documentation are considered in specifications and ensured by them.

Skill grade of a worker must not be lower than the grade of the job carried out. Knowledge within qualification requirements, as well as knowledge of the structure of the product being repaired, procedures of its repair, possible causes of defects and measures for their prevention is checked. A worker must show the skill to take measurements indicated in specifications.

At equipment control the presence of fixed-schedule repairs and their implementation is checked. Selectively technological precision of machines according to developed techniques using available accessories is checked. Employees at auxiliary production must show their skills related to equipment inspection for its technological precision and repairs. Inspectors pay attention to lubrication of machinery and its filling with lubricant coolants.

At production accessories inspection fulfillment of the schedule of control of technological precision, availability of techniques and necessary organisation standards for the control is checked. Selectively, some samples of accessories are inspected.

Measuring tools shall be inspected in accordance with the schedule. There should be no measurement tools on working places that are not indicated in specifications or with expired term of inspection.

And, finally, randomly select aggregates or machines accepted by Quality Control Department at warehouse. The product's control values are measured and compared with their normative parameters. In such a case partial dismantling of the product is possible.

Enterprise certification presupposes periodic production testing.

Requirements to the quality system being developed as well as its structure are specified in the Standard ISO 9001. Model list of an enterprise standards forming QS MR is outlined in Table 2.

Table 2. Enterprise standards in the sphere of quality

Standards group	Standards name
Management responsibility	General responsibility of management Management responsibility in the sphere of quality.
Quality planning	Nomenclature and procedure of quality planning
Contract analysis	Marketing activity organisation at an enterprise Procedure of contract elaboration and its execution
Project management	Requirement specification development and endorsement Production development and output procedure. Project management. Field supervision.
Documents management	Accounting, keeping, circulation of design and technological documents Quality system documents management
Purchases	Supplies of machinery and machinery and its procedure
Marketable products management	Management of products supplied to consumer Identification and traceability of products
Processes control	Development and implementation of logistic measures Preproduction planning Production scheduling Day-to-day production management Working out, ratification and introduction of technological documents Procedures discipline control Development, production and testing of technique means Technological service and maintenance of technological equipment Procedure o equipment inspection for technological precision Technological accessories inspection for technological precision Special processes management procedure Procedure for factory «Quality Day»
Tests and control	Incoming inspection of materials, semi-finished goods and products Product control in the course of production process Finished products tests
Management of control, measurement and testing equipment	Metrological support of production Accounting, inspection, storage and maintenance of measurement means
Control and tests status	Control and tests status

Undue products management	Undue products management Corrective and preventive actions Development, implementation and assessment of corrective measures assessment
Handling operations, storage, packing, preservation and supply of products	Procedure of inflow acceptance, storage, and on-site relocation of materials, semi-finished goods and spare parts Acceptance procedure for finished products to a warehouse, its storage, accounting and shipping. In-plant containers circulation procedure
Management of quality data registration	Management of quality data registration
Internal quality audit	Internal quality audit procedure
Training of personnel	Training and professional development of employees
Production service	Warranty service Examination of customers' claims and reclamations
Statistical methods	Statistical methods in quality control

Conclusions. Normative quality in machinery repair will be achieved at such organisation when the values of all the quality parameters of components, assembly units, aggregates and machines are within specified limits. Such organisation is created by means of development and introduction of quality system of machinery repair on the basis of standards ISO 9001.

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