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HOW TO PROVIDE QUALITY REGENERATION OF MECHANICAL SYSTEMS AND PARTS?

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ABSRACT

Considering the limited resources of certain chemical elements, that are of the extreme importance for machine building, in many technologically developed countries industries the regeneration of damaged machine parts plays an important role. High prices of spare parts require from medium developed and undeveloped countries that their technical maintenance services devote greater attention to regeneration of damaged machine elements. In order to perform the successful implementation of quality system in regeneration of machine elements, it is necessary to define the goals, principles and the content of regenerating works, as well as the competence and responsibility for the system of quality.

Keywords: machine systems, quality, regeneration.

1. INTRODUCTION

Regeneration procedures are applied in various technical branches, as well as in medicine, dentistry, agriculture, mining industry, transport, building, textile and leather industry and almost all the areas of human interest and acting. It can be argued that there is hardly any technical branch in which regeneration has not found its place: in mechanical industry it is possible to regenerate majority of machinery systems and their parts (with the exception of those whose regeneration is technically impossible or economically unjustifiable); restoration and renovation of old buildings are well-known and recognized building works; recicling of various materials is highly-ranked in chemical industry; preservation of old books (the rare editions above all) is one of the common tasks in graphical industry; protection, vulcanisation and patching of pneumatics are widely used in rubber industry, and these regeneration operations are considered to be the most common ones.

Regeneration of worn machinery elements implies a series of operations which aim at restoring the lost working capacity indicators of a machinery element. The technological procedure of regeneration must provide the restoration of the worn part to its original measurements and the demanded surface quality. The restoration of the accurate geometrical shape of the machinery element must also be achieved, preservation,and, if possible, the improvement of the basic exploitational characteristics of the part material, its functionality, safety and reliability, and the life-span similar to that of the new part. The word regeneration originates from the Latin word regeneratio, which means renovation, restoration, re-establisment. This word is often confused with the word reparation , which originates from the Latin word reparatio, and has a similar meaning: mending, fixing, re-establishing,

renovation. The machinery part which has been subjected to quality regeneration, control and examination can certainly perform its function within the machine or mechanism.
The aim of each economic organisation is to maintain the continual production process , but with the lowest possible expenses. However, the production process may involve the difficulties which, at a certain extent, impair the established condition. The malfunctions which occur in machines, gadgets and installations along with other factors impede, or, even, cease the rythm of production. The unplanned stoppages come about, as a rule, in the periods of the most intensive production, i. e. when the equipment suffers the greatest load, thus causing huge economic losses.
In order to re-establish the normal condition as soon as possible and to diminish the impact of negative consequences of these stoppages, the plants are supplied with spare parts, which are storaged in warehouses and rapidly built in to replace the damaged ones, when such need arises. Of course, the spare parts provision demands that certain financial means be put aside. The 'safer' production is, the greater expenses are.
The analyses conducted by the experts in industrially developed countries have shown that the cost of manufacturing spare parts is five to ten times that of regenerating the old ones. The structure of annual expenses for storaging a spare part is given as follows:

✓ amortisation	10%
✓ the interest on invested financial means	9%
✓ growing out of date	5%
✓ the storage and handling expenses	5%
✓ the administration expenses	3%
✓ insurance	1%
▪ the overall storage expenses	33%

The above mentioned data obtained by the American expert lead to conclusion that the spare part which has been storaged in the warehouse for three years has practically doubled its value. It is assumed that the same analysis is relevant in domestic surroundings as well.
Besides, it is not always possible for the manufacturer to deliver the spare part immediately. When the expenses of providing the new part and the expenses between the moment of failure and the moment of delivering the ordered spare part are compared with the regeneration expenses, the result of comparison proves regeneration justifiable.
Regeneration of the damaged machinery elements involves a series of advantages which account for the increasing application of this procedure in industrial practice in most countries. Listing all the positive sides of regeneration is a difficult task, but some of them are given below:

- Increasingly complex machinery elements are being exploited in all industrial branches, which allows for the need of providing a great number of spare parts necessary for their maintenance. When it is impossible to provide new spare parts or to meet the delivery deadline, regeneration of damaged machinery parts considerably shortens the time which a failed machinery system spends in stoppage. The provision of new parts takes up ten times more time than the regeneration of the old ones.
- Regeneration completely eliminates great expenses of storaging spare parts, which sometimes mount to 30% of the price of the new part. Regeneration enables rapid overhaul of the machinery system without the necessary storage of spare parts.
- The time necessary for regeneration is considerably shorter than that needed for manufacturing new spare parts, which shortens the time necessary for carrying out overhaul and decreases the losses in the production cycle of the machinery system subjected to overhaul.
- The impeded provision of high-quality materials for manufacturing new spare parts is annuled with the application of regeneration.

- The cost of regeneration is considerably lower than that of manufacturing new machinery parts, while the quality and life-span are similar.
- Refinement of surfaces during regeneration can considerably prolong the life-span of the regenerated machinery part, which can be longer than that of the new spare part. There have been cases in which the life-spans of the regenerated parts were considerably longer than that of the new, serially manufactured machinery parts, sometimes even 2-2.5 times longer.
- The labour and material expenses are considerably lower, which accounts for the economical efectiveness of applying regenerative procedures.
- Regeneration serves to accomplish full employment of the capacities and technological possibilities of overhaul enterprises.

However, the predomonant factors for the introduction of regeneration are completely different in industrially developed and undeveloped countries. In industrially undeveloped and underdeveloped countries great advantage is given to regeneration of damaged machinery elements due to their inability to to invest largely in providing new equipment and spare parts by means of import. The spare parts for the outdated machinery systems, which are still in use in these countries, are not manufactured any more. Regeneration of the damaged parts of these systems enables their further exploitation. The high prices of spare parts demand that the technical services in undeveloped and underdeveloped countries give advantage to regeneration of damaged machinery elements.

Taking into account the limited resources of certain chemical elements, which are of enormous importance in mechanical engineering, regeneration of damaged machinery elements is given an important place in industry of many technologically developed countries. This specially applies to Ni, Co, Cr, W, Va, Mn, Mo, and other chemical elements. Even superfluous analysis have shown that great losses occur when a worn part of a steel-based alloy is discarded and substituted with a new one. Therefore, the application of regeneration methods helps these parts retrieve the demanded exploitational characteristics

If geometrical and quality parameters and life-span after the regeneration are analysed, all regenerated machinery elements can be put into three categories:

- The elements whose geometrical and quality parameters are fully retrieved, and life-span is similar to that of the new spare part.
- The machinery elements whose geometry is fully retrieved, and the application of the protective layer of great hardness and resistance to wear enables it to have the life-span longer than that of the new spare part.
- The machinery elements whose regeneration does not ensure the complete life-span because of the accumulation of residual stresses due to applied regeneration procedures, or changes in dimensions of regenerated surfaces.

Economical effectiveness of regenerating machinery elements is accounted for by losses in work and material considerably lower than those which occur during manufacturing new spare parts. From the aspect of economy, not all machinery parts are suitable for regeneration. Purposefulness of regeneration must be appreciated for each machinery part individually.

The modern regenerative methods must provide the fastest, cheapest and most reliable possible regeneration of exploitational characteristics of mechanical, hydrodynamic, pneumatic, electronic and other systems and their parts.

2. ORGANISATION OF THE PROCESS OF REGENERATING DAMAGED MACHINERY ELEMENTS

Regeneration of machinery elements, if it is centralised and carried out in big series, implies the use of specialised, highly-productive equipment and engagement of educated and expert personnel. The result is: the lowest cost of regenerated machinery elements with the longest life-span and reliability in

operation. According to the size of production (the number of identical regenerated elements), the level of centralisation and the place where the regeneration procedure is carried out, all machinery elements can be put into four categories:

- The machinery elements in mass use and subjected to centralised regeneration in specialised plants (e. g. shafts, gears, propeller shafts, bearings, etc.).
- The machinery elements of great overall measurements, which are expensive, but do not require huge regeneration costs. Their regeneration demands specialized equipment and qualified personnel. The typical examples include the blocks and heads of internal combustion engines, crankshafts and camshafts, reductor and gear housings and others. The regeneration of these elements usually takes place in overhaul workshops.
- The machinery elements which are not in mass use, and whose regeneration requires special technological procedures and is carried out in specialised overhaul workshops. Suchlike elements can be found in high and low-pressure pumps, compressors and turbo compressors, hydraulic and pneumatic components, brake system cylinders, etc.
- The constructive machinery elements whose regeneration does not require specialised workshops, but can be carried out in almost all production plants. They do not require specialised equipment (all operations are performed with universal gadgets and machines), but only expert and skillful personnel. The regeneration of these elements is carried out individually in most cases. This group comprises: reservoires, oil basins, lids, plates, frames, bolts, spindles, shells, pipes, flanges, pins, etc. Centralised regeneration of these elements is neither much needed nor possible.

Centralised and specialised regeneration allows obtaining high-quality regenerated elements at a lower cost. Correctly organised regeneration of the damaged machinery elements reduces the spare parts costs (provision and storage), employs the production capacities of overhaul and other plants, reduces the cost of machinery systems overhaul and helps them retrieve their function, i. e. shortens the stoppage period.

The available capacities, both material and human, of the overhaul workshops are of crucial importance for production organisation, the choice of optimal method for regenerating damaged machinery elements and its economy. Regeneration works demand big and versatile assortment of necessary equipment (the equipment for washing, degreasing, hard facing, machine processing, thermic and thermo-chemical strengthening procedures and galvanic protection). If overhaul workshops are equipped with more versatile, quality and modern equipment, it implies greater possibility of choosing the optimal regeneration method, better quality of performed works, and more economical regeneration of damaged machinery elements.

The equipment for control and examination of machinery elements prior to and after regeneration is of enormous importance for correct and economic regeneration. It is possible to plan optimal and reliable regeneration methods only for correctly diagnosed machinery elements. The examination and control after regeneration give an accurate picture of the quality of performed works and allow life-span assessment of regenerated machinery elements. It is a well-known fact that the overhaul plants in our country have very poor equipment in this respect, and that the existing examination and control means are rarely and unprofessionaly used.

The expert personnel consists of administrative and production staff and represents the personnel potential of the plant (workshop) which deals with regeneration. The administrative personnel gathers the experienced technologists with good knowledge of theory and practice, who determine the most optimal regeneration method, plan the adequate operations with the best processing regimes, with the application of the most suitable materials, machines, tools and instruments. The production workers need to be qualified, careful and neat in their work, and they have to adhere strictly to the planned processing regimes. Regeneration involves many different vocations, from defectors (people who deal with diagnostics-determination of the technical condition of damaged machinery elements), over all kinds of craftsmen who perform engineering works (machinists, lathe operators, milling machine operators, grinder operators and others) to welders and workers who do the washing, thermic processing and galvanisation, and finally controlors. Both structures, the technologists and production workers, have deliberately been put in the same group, since regeneration works make them interdependent like in no other area. In practice it is necessary that these two structures be complementary and cooperative exchanging their experiences and knowledge. It is the basic prerequisite for economical and quality regeneration.

3. IMPLEMENTATION OF QUALITY SYSTEM IN REGENERATION OF MACHINERY ELEMENTS

The required quality of the regenerated machinery element is achieved by using the following:

- suitable equipment, i. e. means of work (machines, tools and instruments),
- quality production materials and additional materials (for hard facing procedures),
- knowledge and working abilities of those who take part in realisation of the technological process,
- available technological information.

The changes in the above mentioned parameters, which happen in time, cause the quality of the regenerated element to become changeable. All the aforementioned factors must aim at surmounting the failure and recovering the operational capacity in the given time period with the least possible expenses, and with the use of available human and material resources, the defined procedures and the appropriate technical and technological documentation. The effort made in this respect represents the basis for improving the quality.

The standards of the series JUS ISO 9000 aim at establishing an efficient quality system, in order to allow more efficient dealing and an increase in the quality of the products. In order to enable a plant to implement the quality system efficiently and effectively, it must have at its disposal a larger number of its own hierarchically arranged documents on the quality system. Apart from that, a successful, efficient and long-standing quality system implies the following as well:

- that all the employees, from workers to managers, in their respective domains, understand, accept and implement the solutions depicted in the documents on the quality system,
- that the achieved level of implementing the quality standards of the series JUS ISO 9000 is maintained, i. e. that it should not be allowed to drop,
- that the quality system is continually developed and perfected.

These short terms are clearly defined, but their fulfilment demands resolution and engagement of all the participants in the production process. The fulfilment of the aforementioned terms is achieved through:

- the implementation of the standardised terms which refer to quality,
- the implementation of the international quality standards,
- adherence to technical and technological rules,
- adherence to organisational rules (centralisation and specialisation of the regeneration plants),
- the implementation of internal standards,
- the creation and implementation of the quality system,
- the application of the appropriate preservation and maintenance methods related to the means of work (machines, tools, instruments, the equipment for diagnostics, control, measuring and examination),
- the use of empirical knowledge and scientific accomplishments.

The permanent control as the only measure for maintaining the achieved level of the quality system is not enough. The quality system is maintained only with the aid of small, constant changes, aiming at improving the quality of the regenerated machinery elements.

The reason why quality administration has subdued the passive quality control is simple:quality administration allows active impact upon the technological process of regeneration, reducing the number of failed parts to a minimum. The correct quality administration may decrease material costs, prolong the life-span of the machines and tools necessary for carrying out regeneration operations, shorten the time needed for performing the procedure,improve the exploitational characteristics of the regenerated elements.

The goals of the quality system implementation are:

- ✓ the achievement of the planned and demanded quality of the regenerated part in the given time period and environment conditions,
- ✓ cutting down expenses in the work processes,
- ✓ reduction of the time which a failed system spends in stoppage,
- ✓ satisfaction of the regenerated part user,
- ✓ decrease in the number of complaints,
- ✓ faster and more successful adoption of new processes and regeneration methods.

The above mentioned goals are not easy to achieve, but it is possible to do so only through consistent:

- ❖ building of the quality into the product in all the functions of the plant (in the phase of development, preparation, processing and finalisation),
- ❖ conducting of systematic analyses aiming at ensuring the required level of the product quality (the product implies the regenerated machinery element),
- ❖ improvement in the expert knowledge of the regeneration process participants,
- ❖ introduction of the efficient system of quality administration,
- ❖ motivation to achieve quality,
- ❖ long-term (strategic) planning of the product quality development.

When making an effort to create and implement the quality system, it is of utmost importance to keep all the employees in the regeneration plant active, i. e. to eliminate the onlookers.

4. CONCLUSION

The regeneration practice imposes the need for creating and implementing the quality system, providing new technological equipment and elaborating modern regeneration methods, as crucial prerequisites for rational use of material and energy. The passive quality control, which is limited to checking and surveillance of the regenerated part, separating the operational from non-operational ones without going into the problems of regeneration operations, gives way to quality administration. The quality system documentation must be consistently implemented. It is necessary to use modern work organisation methods, which contribute to consolidation and success of the quality system.

The success of regeneration works organisation in the plants which do not possess the adequate equipment and expert personnel and in situations when regeneration is performed on the spur of the moment is rather questionable. These activities often turn out to be more harmful than useful. In these circumstances the final control is usually carried out when it is too late to correct the mistakes. Economical effectiveness and other advantages, which come from the application of regeneration procedures, are possible only if these works are accepted as an ongoing production practice, and not as occasional activities caused and imposed by parts failures and stoppages of the systems these parts belong to.

Conclusion: regeneration can be dealt with only by the plants which possess the suitable technical and technological equipment and expert personnel. Only professionals should expect to have success in regeneration activities.

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