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Analýza výnosnosti opráv poškodených častí stavebných strojov – ako ušetriť peniaze

Profitability analysis of reparation of the construction machinery damaged parts – how to save money

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Abstrakt:
V článku je prezentovaná analýza rentability – t.j. efektívnosti nákladov opráv poškodených častí konštrukčných zaradení. Posudzované sú jednotlivé častí zariadení, ako sú zuby nakladača, čepele na miešanie asfaltu, drviace elementy na kameň, nože na sekanie vegetácie, nože na etážovanie terénu, nože na hĺbenie, snežné pluhy a drviace kladivá. Užitočnosť povrchovej úpravy bola odhadnutá na základe efektívnosti nákladov. Väčšina z uvedených častí bola predmetom dlhodobých štúdií. Optimálna povrchová úprava bola stanovená prostredníctvom kontroly tvrdosti a mikroštruktúry zvarov. Cieľom príspevku je poukázať na výhody používaných technológii z hľadiska efektívnosti nákladov.

Abstract:
This paper presents review and analysis of the profitability – i.e. the cost effectiveness of reparation of the damaged parts in the construction machinery. The paper considers parts like loader's teeth, blades for asphalt mixing, impact beams of the rock materials crusher, blades for clearing the vegetation overgrowth, terrain-leveling knives, blades for trenching, snow ploughs blades and crushers hammers. The profitability of surfacing application was estimated based on the cost-effectiveness. Majority of the listed parts were subject of the long time studies accompanied by the corresponding experiments for checking the profitability of each of the applied surfacings, which were used to establish the optimal technology of surfacing by checking the hardness and microstructure of the executed weldings. The objective of this paper is to point to advantages of the applied technologies from the cost-effectiveness point of view.

1. Introduction

The objective of this paper is to present the review of the regenerated damaged machine parts, which was done by surfacing and to point to the economic validity of performing that regeneration, with respect to buying the new parts. Parts that were surfaced by this technology exhibit better results than the new parts in the majority of cases. Besides that, advantages of this technology are wider since they directly cause reduction of costs, the downtimes, reduction of stocks, etc. [1]. This paper covers regenerated parts of the construction mechanization whose regeneration technologies are presented in details in corresponding articles [2-14]. The cost effectiveness analysis was done for those parts as compared to costs of procuring the new parts.
There are several methods of techno-economic justification [2, 3]: Economic Method (MEC), Profitability Improvement Analysis (PIA), Machinery and Allied Parts Institute Method (MAPI), and the Method of the Net Present Value (MNPV). Each of those methods has its own criteria for estimates of the techo-economic justification and decision making about application of the optimal reparation technology of the damaged elements of technical systems. Those methods and criteria can be used not only for selection of the optimal reparation technology but for application of the optimal technology for manufacturing of the new working parts. Those methods are used for ranking of reparatory and manufacturing technologies and for decision making on selecting and application of the optimal solutions. Selection of the most economical version is done based on corresponding indicators of economic justifiability. Calculation of the economic effects obtained by different methods of reparation in evaluation of alternative technologies of the damaged parts reparation and MHF are two different categories. The form of effects by which one measures contribution of a certain technology to economic objectives is in accordance with criteria as requirements which express the tendency for achieving the outcome effects [2, 3].

In this paper are presented effects of the two alternative technologies of reparation of the damaged parts of the construction machinery:

1. *Technology of replacement of the damaged parts by the new spare parts,*
2. *Technology of reparatory surfacing (welding) of damaged used parts*.

Technology of regeneration of the damaged part can be considered from the standpoint of dependence on the instantaneous restraints from the two aspects: *available technologies* and *available funds* [2, 3].

From the aspect of *available technologies* the two alternatives are compared: to procure the new part or to repair the damaged one.

From the aspect of *available funds* one is acting respecting the criterion of maximal rationality.

Considering that the subjects of investigation are the two available technologies, the advantage is always given to technology which provides better techno-economic effects. As a criterion for evaluation of investing into those alternative technologies, namely as quantitative determination of the amount of funds, one uses parameters of *higher profitability* and *absolute rentability*.

2. Methodology for determination of cost effectiveness

When considering profitability the means of justification for applying the certain technology, from the general aspect of rationality, the most frequently used are the following three procedures: (i) *comparison of profitability as the ratio of revenues and expenditures*; (ii) *comparison of expenditures and realized savings due to their* *decrease* and (iii) *comparison of increase of the financial result due to increasing revenues as a result of expenditures' decrease*. In quantitative economic analysis the direct (net) revenues are estimated, as well as unpredicted expenditures, internal, external and multiplication effects [2, 3].

The new part procurement costs (T_{nd}) represent the sum of all the costs related to purchase (buying the new part, transportation costs, customs costs if the part is imported, taxes increase costs, storage and warehousing costs, etc.). Those costs are reduced for the amount of eventual selling of the damaged part (T_{lo}), while on the other hand they are increased due to additional costs (T_d) as a result of production downtimes, paying penalties due to exceeding the agreement's deadline etc.

The techno-economic justification for applying the reparatory surfacing technology of certain working parts of the construction machinery was determined by application of the profitability criterion, comparing that technology costs to costs of replacement of the damaged part by the new one. The considered working parts are usually purchased and stored in the maintenance warehouse as the spare parts; when the damage occurs during exploitation they are discarded and replaced by the new ones. In addition, the techno-economic analysis was conducted under the assumption that the organization of the maintenance function was done at an exceptionally high level. This would mean that the purchasing of the new part is always done on time and that the reparation of the damaged part is done on time, as well, thus at any moment in the warehouse there is a necessary number of spare parts available for replacement. This idealized approach enables obtaining the minimal economic effects of reparation technology application; in all other cases the positive economic effects are significantly higher.

Additional costs due to downtimes for replacement of the damaged parts were not taken into account in conducting this comparative techno-economic analysis for considered examples, since they are practically the same for both technologies and do not influence the final result. However, some additional costs had to be taken into account, like costs due to frequent replacements and downtimes due to shorter working life of the new parts with respect to the working life of the repaired parts, since those costs significantly influence the outcome of the economic effects determination. Those additional costs are pretty high, calculated per annum, what is usually done when determining the techno-economic effects.

3. Examples of executed reparations of the damaged parts

As emphasized earlier, the justification and profitability of application of the reparatory surfacing, considered in this paper, refers to reparation of the parts of the complex shapes. The techno-economic analysis was done for: loader's teeth, blades for asphalt mixing, impact beams of the rock materials crusher, blades for clearing the vegetation overgrowth, terrain-leveling knives, blades for trenching, snow ploughs blades and crushers hammers. This paper considers only analysis of the benefits of reparation technology application, while the complete technological procedures for determination of the optimal surfacing technology of concrete parts were presented in earlier papers [4-14].

The analyzed working parts are being procured according to purchasing plan, several times a year, i.e. savings for one piece could be multiplied by the number of pieces needed per annum to obtain the total yearly savings. Results obtained by this techno- economic analysis are presented in Tables 1 to 8.

3.1. Loader's teeth

Basic parameters for profitability calculation of the compared refurbishment technologies are:

- Base metal – steel cast iron 50Mn7 (DIN)
- Teeth mass – 8.6 kg/piece (average value)
- Number of teeth – 10 pieces (one set)
- Purchase price – 113.5 €/piece
- Filler metal - ABRADUR 58 and INOX B 18/8/6
- Purchase price – 15 €/kg
- Reparatory work price (N.H.) – 10 €/h
- Applied reparation procedure - MMA surfacing.

Significant parameters for comparison of alternative technologies:

- Exploitation time of the set of new teeth working with stones and aggregates is, on average, t_{end} = 1200 h of effective operation (determined in authors' own experimental investigations);
- Exploitation time of the surfaced teeth in the same operation conditions, on average t_{erd} = 4 200 h (determined in authors' own experimental investigations);
- Liquidation value of the worn teeth scrapped material is T_{lo} = 0.2 €/kg;

Quality (primary and secondary) of the repaired teeth is at least the same or better than that of the new teeth.

Significant costs for comparison of alternative technologies:

- Total costs of purchasing of one set of new teeth T_{nd} = 1210 €;
- Total costs of reparation of one set of worn teeth T_{rd} = 320 €;
- Total costs due to downtime (losses) in present conditions for this machine amount to T_d = 20 €/h.

Tab. 1 *Comparative techno-economic analysis of loader's teeth refurbishment*

Applied technology	Direct Costs of alternative technologies T_{nd} and T_{rd}, €	Profitability coefficient $k_e = \frac{T_{nd} - T_{rd}}{T_{nd}}$	Exploitation reliability coefficient $k_{ep} = \frac{t_{erd}}{t_{end}}$	Economic rationality coefficient $k_{er} = \frac{T_{nd} \cdot i_{hnd}}{T_{rd} \cdot i_{hrd}}$	Total costs per annum, €
Replacement (10 pieces)	1210	0.735	3.500	13.226	6021
Reparation (10 pieces)	320				1060
Direct savings	890 € (73.50 %)		Savings per annum	4961 € (82.40 %)	

3.2 Blades for asphalt mixing

Basic parameters for profitability calculation of the compared refurbishment technologies are:

- Base metal – steel cast iron GX210Cr12
- Blades mass – 3.6 kg/piece (average value)
- Number of blades - 64 pieces (one set)
- Purchase price – 43.6 €/piece
- Filler metal - E DUR 600 i INOX B 18/8/6
- Purchase price – 15 €/kg
- Reparatory work price (N.H.) – 10 €/h
- Applied reparation procedure - MMA surfacing.

Significant parameters for comparison of alternative technologies:

- Exploitation time of the set of new blades working in asphalt production is, on average, t_{end} = 360 h of effective operation (determined in authors' own experimental investigations);
- Exploitation time of the surfaced blades in the same operation conditions, on average t_{erd} = 1080 h (determined in authors' own experimental investigations);
- Liquidation value of the worn blades scrapped material is T_{lo} = 0.21 €/kg;

Quality (primary and secondary) of the repaired blades is at least the same or better than that of the new blades.

Significant costs for comparison of alternative technologies:

- Total costs of purchasing of one set of new blades T_{nd} =2 790 €;
- Total costs of reparation of one set of worn blades T_{rd} = 320 €;
- Total costs due to downtime (losses) in present conditions for the asphalt base machine amount to T_d = 3000 €/h.

***Tab. 2** Comparative techno-economic analysis of asphalt mixer blades refurbishment*

Applied technology	Direct Costs of alternative technologies T_{nd} and T_{rd}, €	Profitability coefficient $k_e = \frac{T_{nd} - T_{rd}}{T_{nd}}$	Exploitation reliability coefficient $k_{ep} = \frac{t_{erd}}{t_{end}}$	Economic rationality coefficient $k_{er} = \frac{T_{nd} \cdot i_{hnd}}{T_{rd} \cdot i_{hrd}}$	Total costs per annum, €
Replacement (64 pieces)	2790	0.609	3.000	7.677	560336
Reparation (64 pieces)	1090				183980
Direct savings	1700 € (60.90 %)		Savings per annum	376356 € (67.17 %)	

3.3 Impact beams of the rock materials crusher

Basic parameters for profitability calculation of the compared refurbishment technologies are:

- Base metal – steel cast iron GX120Mn12.1
- Impact beam mass – 300 kg/piece (average value)
- Number of beams - 4 pieces (one set)
- Purchase price – 2187.5 €/piece
- Filler metal - E Mn 17 Cr 13
- Purchase price – 15 €/kg
- Reparatory work price (N.H.) – 10 €/h
- Applied reparation procedure - MMA surfacing.

Significant parameters for comparison of alternative technologies:

- Exploitation time of the set of new impact beams of the stone crusher working in producing the rock aggregates from the lime stone, on average, is t_{end} = 150 h of effective operation, using both working surfaces; this is the maximum possible number of hours since the beams work with lime stone; when operating with other types of harder stones the time is significantly shorter (determined in authors' own experimental investigations);

- Exploitation time of the surfaced impact beams in the same operation conditions, on average t_{erd} = 320 h, using both working surfaces (determined in authors' own experimental investigations);
- Liquidation value of the worn beams scrapped material is T_{lo} = 0.42 €/kg;

Quality (primary and secondary) of the repaired beams is at least the same or better than that of the new beams.

Significant costs for comparison of alternative technologies:

- Total costs of purchasing of one set of new impact beams T_{nd} = 8750 €;
- Total costs of reparation of one set of worn beams T_{rd} = 2040 €;
- Total costs due to downtime (losses) in present conditions for the asphalt base machine amount to T_d = 1050 €/h.

Tab. 3 *Comparative techno-economic analysis of stone crusher's impact beams refurbishment*

Applied technology	Direct Costs of alternative technologies T_{nd} and T_{rd}, €	Profitability coefficient $k_e = \frac{T_{nd} - T_{rd}}{T_{nd}}$	Exploitation reliability coefficient $k_{ep} = \frac{t_{erd}}{t_{end}}$	Economic rationality coefficient $k_{er} = \frac{T_{nd} \cdot i_{hnd}}{T_{rd} \cdot i_{hrd}}$	Total costs per annum, €
Replacement (4 pieces)	8750	0.767	2.133	9.149	303940
Reparation (4 pieces)	2040				105000
Direct savings	6710 € (60.90 %)		Savings per annum	198940 € (65.45 %)	

3.4. Blades for clearing the vegetation overgrowth

Basic parameters for profitability calculation of the compared refurbishment technologies are:

- Base metal – steel 42CrMo4 (DIN)
- Blades mass – 300 kg/piece (average value)
- Number of blades - 40 pieces (one set)
- Purchase price – 23.8 €/piece
- Filler metal - E DUR 600 and INOX B 18/8/6
- Purchase price – 15 €/kg
- Reparatory work price (N.H.) – 10 €/h
- Applied reparation procedure - MMA surfacing.

Significant parameters for comparison of alternative technologies:

- Exploitation time of the set of new blades is t_{end} = 150 h of effective operation (determined in authors' own experimental investigations);
- Exploitation time of the surfaced blades in the same operation conditions, on average is t_{erd} = 600 h, using both working surfaces (determined in authors' own experimental investigations);
- Liquidation value of the worn blades scrapped material is T_{lo} = 0.21 €/kg;

Quality (primary and secondary) of the repaired blades is at least the same or better than that of the new blades.

Significant costs for comparison of alternative technologies:

- Total costs of purchasing of one set of new blades T_{nd} = 957 €;
- Total costs of reparation of one set of worn blades T_{rd} = 304 €;
- Total costs due to downtime (losses) in present conditions for this machine amount to T_d = 12.5 €/h.

Tab. 4 *Comparative techno-economic analysis of blades for clearing the vegetation overgrowth refurbishment*

Applied technology	Direct Costs of alternative technologies T_{nd} and T_{rd}, €	Profitability coefficient $k_e = \frac{T_{nd} - T_{rd}}{T_{nd}}$	Exploitation reliability coefficient $k_{ep} = \frac{t_{erd}}{t_{end}}$	Economic rationality coefficient $k_{er} = \frac{T_{nd} \cdot i_{hnd}}{T_{rd} \cdot i_{hrd}}$	Total costs per annum, €
Replacement (40 pieces)	957	0.682	5.000	15.735	17537
Reparation (40 pieces)	304				1550
Direct savings	636 € (60.20 %)		Savings per annum	15987 € (91.16 %)	

3.5. Terrain-leveling machine knives

Basic parameters for profitability calculation of the compared refurbishment technologies are:

- Base metal – steel 58CrV4 (DIN)
- Knives mass – 1.7 kg/piece (average value)
- Number of knives - 14 pieces (one set)
- Purchase price – 118.8 €/piece
- Filler metal - E DUR 600 and INOX B 18/8/6
- Purchase price – 15 €/kg
- Reparatory work price (N.H.) – 10 €/h
- Applied reparation procedure - REL surfacing.

Significant parameters for comparison of alternative technologies:

- Exploitation time of the set of new knives is t_{end} = 240 h of effective operation (determined in authors' own experimental investigations);
- Exploitation time of the surfaced knives in the same operation conditions, on average t_{erd} = 520 h (determined in authors' own experimental investigations);
- Liquidation value of the worn knives scrapped material is T_{lo} = 0.2 €/kg;

Quality (primary and secondary) of the repaired knives is at least the same or better than that of the new knives.

Significant costs for comparison of alternative technologies:

- Total costs of purchasing of one set of new knives T_{nd} = 1663 €;
- Total costs of reparation of one set of worn knives T_{rd} = 426 €;
- Total costs due to downtime (losses) in present conditions for this machine amount to T_d = 12.5 €/h.

***Tab. 5** Comparative techno-economic analysis of terrain-leveling machine knives refurbishment*

Applied technology	Direct Costs of alternative technologies T_{nd} and T_{rd}, €	Profitability coefficient $k_e = \frac{T_{nd} - T_{rd}}{T_{nd}}$	Exploitation reliability coefficient $k_{ep} = \frac{t_{erd}}{t_{end}}$	Economic ratio-nality coefficient $k_{er} = \frac{T_{nd} \cdot i_{hnd}}{T_{rd} \cdot i_{hrd}}$	Total costs per annum, €
Replacement (40 pieces)	1571	0.744	2.167	8.460	16178
Reparation (40 pieces)	426				2168
Direct savings	1145 € (74.40 %)		Savings per annum	14010 € (86.14 %)	

3.6. Trenching machine blades

Basic parameters for profitability calculation of the compared refurbishment technologies are:

- Base metal – steel 60SiMn5 (DIN)
- Blades mass – 10.6 kg/piece (average value)
- Number of blades - 24 pieces (one set)
- Purchase price – 118.8 €/piece
- Filler metal - E DUR 600
- Purchase price – 15 €/kg
- Reparatory work price (N.H.) – 10 €/h
- Applied reparation procedure - MMA surfacing.

Significant parameters for comparison of alternative technologies:

- Exploitation time of the set of new blades is t_{end} = 300 h of effective operation (determined in authors' own experimental investigations);
- Exploitation time of the surfaced blades in the same operation conditions, on average t_{erd} = 1600 h (determined in authors' own experimental investigations);
- Liquidation value of the worn blades scrapped material is T_{lo} = 0.21 €/kg;

Quality of the repaired blades is better than that of the new blades.

Significant costs for comparison of alternative technologies:

- Total costs of purchasing of one set of new blades T_{nd} = 3080 €;
- Total costs of reparation of one set of worn blades T_{rd} = 426 €;
- Total costs due to downtime (losses) in present conditions for this machine amount to T_d = 16.7 €/h.

***Tab. 6** Comparative techno-economic analysis of the trenching machine blades refurbishment*

Applied technology	Direct Costs of alternative technologies T_{nd} and T_{rd}, €	Profitability coefficient $k_e = \frac{T_{nd} - T_{rd}}{T_{nd}}$	Exploitation reliability coefficient $k_{ep} = \frac{t_{erd}}{t_{end}}$	Economic ratio-nality coefficient $k_{er} = \frac{T_{nd} \cdot i_{hnd}}{T_{rd} \cdot i_{hrd}}$	Total costs per annum, €
Replacement (24 pieces)	3080	0.685	5.333	16.934	29400
Reparation (24 pieces)	970				2090
Direct savings	2110 € (68.50 %)		Savings per annum	27310 € (92.89 %)	

3.7 Snow plough blades

Basic parameters for profitability calculation of the compared refurbishment technologies are:

- Base metal – steel C45
- Blades mass – 46 kg/piece (average value)
- Number of blades - 2 pieces (one set)
- Purchase price – 413.3 €/piece
- Filler metal - E DUR 600
- Purchase price – 15 €/kg
- Reparatory work price (N.H.) – 10 €/h
- Applied reparation procedure - MMA surfacing.

Significant parameters for comparison of alternative technologies:

- Exploitation time of the set of new blades is t_{end} = 150 h of effective operation (determined in authors' own experimental investigations);
- Exploitation time of the surfaced blades in the same operation conditions, on average t_{erd} = 900 h (determined in authors' own experimental investigations);
- Liquidation value of the worn blades scrapped material is T_{lo} = 0.21 €/kg;

Quality of the repaired blades is better than that of the new blades.

Significant costs for comparison of alternative technologies:

- Total costs of purchasing of one set of new blades T_{nd} = 810 €;
- Total costs of reparation of one set of worn blades T_{rd} = 270 €;
- Total costs due to downtime (losses) in present conditions for this machine amount to T_d = 15 €/h.

Tab. 7 *Comparative techno-economic analysis of the snow plough blades refurbishment*

Applied technology	Direct Costs of alternative technologies T_{nd} and T_{rd}, €	Profitability coefficient $k_e = \frac{T_{nd} - T_{rd}}{T_{nd}}$	Exploitation reliability coefficient $k_{ep} = \frac{t_{erd}}{t_{end}}$	Economic rationality coefficient $k_{er} = \frac{T_{nd} \cdot i_{hnd}}{T_{rd} \cdot i_{hrd}}$	Total costs per annum, €
Replacement (40 pieces)	810	0.667	6.000	18.000	22800
Reparation (40 pieces)	270				1640
Direct savings	540 € (66.70 %)		Savings per annum	21160 € (92.81 %)	

3.8 Stone crushers hammers

Basic parameters for profitability calculation of the compared refurbishment technologies are:

- Base metal – steel cast iron GX120Mn12 (DIN)
- Hammer mass – 16 kg/piece (average value)
- Number of hammers - 36 pieces (one set)
- Purchase price – 140 €/piece
- Filler metal - E Mn 17 Cr 13
- Purchase price – 15 €/kg
- Reparatory work price (N.H.) – 10 €/h
- Applied reparation procedure - MMA surfacing.

Significant parameters for comparison of alternative technologies:

- Exploitation time of the set of the new hammers is t_{end} = 320 h of effective operation (determined in authors' own experimental investigations);
- Exploitation time of the surfaced hammers in the same operation conditions, on average t_{erd} = 1200 h (determined in authors' own experimental investigations);
- Liquidation value of the worn hammers scrapped material is T_{lo} = 0.42 €/kg;

Quality of the repaired hammers is better than that of the new hammers.

Significant costs for comparison of alternative technologies:

- Total costs of purchasing of one set of new hammers T_{nd} = 5040 €;
- Total costs of reparation of one set of worn hammers T_{rd} = 1860 €;
- Total costs due to downtime (losses) in present conditions for this machine amount to T_d = 333.3 €/h.

Tab. 8 *Comparative techno-economic analysis of the stone crusher hammers refurbishment*

Applied technology	Direct Costs of alternative technologies T_{nd} and T_{rd}, €	Profitability coefficient $k_e = \frac{T_{nd} - T_{rd}}{T_{nd}}$	Exploitation reliability coefficient $k_{ep} = \frac{t_{erd}}{t_{end}}$	Economic rationality coefficient $k_{er} = \frac{T_{nd} \cdot i_{hnd}}{T_{rd} \cdot i_{hrd}}$	Total costs per annum, €
Replacement (2 pieces)	10080	0.630	3.750	10.160	103600
Reparation (2 pieces)	3720				16880
Direct savings	6360 € (63.00 %)		Savings per annum	86720 € (83.71 %)	

4. Conclusion

Authors of this paper have worked on the maintenance of equipment in industry and the construction mechanization for over ten years and were confronted with numerous problems related to refurbishment of the damaged parts of various technical systems; the objective always was to extend the working life of parts, which are usually very expensive and mainly imported. During that period very large number of reparatory works was executed on various parts of the construction machinery, made of different types of high quality steels. The recurring question always was whether to replace the damaged parts with the new ones or to repair them by application of certain technology. The easiest way to solve the problem always is to buy the new part. However, that requires spending considerable funds and the impermissible long purchasing time, what significantly extends the mechanization downtime and creates great losses in construction works. For solving those problems by reparation, one would require significantly lower funds but some additional manpower must be engaged. The downtime is significantly reduced and the working hours of men and mechanization are much better used.

When applying the reparatory and manufacturing surfacing one should expect the positive techno-economic effects only if those procedures were executed according to designed optimal technology, which must provide for all the necessary conditions for successful execution of those processes. Selection of the optimal hard-facing technology and its verification on models and real parts in exploitation conditions was presented in previous works by authors of this paper [4-14].

The objective of this paper was to present exclusively the economic aspects of the hard-facing reparation technology and to point to its numerous advantages.

Results of the conducted techno-economic analysis for the presented characteristic examples of performed reparation of the damaged mechanization parts of presented in section 3 point to the following facts:

- Almost all working parts of the construction mechanization can be repaired by adequate hard-facing technology;
- From the techno-economic aspect it is sensible to repair more than 70 % of all the damaged parts of the construction machinery;
- Even in the case when the reparation is done of small parts whose refurbishment would not require high costs, the direct net savings can reach tens of thousands of Euros per annum (without taking into account other factors which can cause additional savings);
- Reparation of large size and complex shape parts should be done even in the case that it does not produce savings per se, but the savings are realized later in exploitation by extended working life with respect to new parts;
- Working parts that are the so-called *bottlenecks* in the manufacturing process should always be repaired, since the downtimes cause excessively high additional costs;
- Reparation by hard-facing could be applied even for refurbishing of the completely broken-down parts of construction mechanization;
- In majority of cases the reparation technology produces better techno-economic effects than replacement of the damaged parts by the new spare parts;
- Reparation of the parts should be done on time, i.e. before the large loss of material occurs due to the wear process, since that would produce much better techno-economic effects and higher quality of the repaired parts;
- Better techno-economical effects are obtained during the organized reparation of large number of parts due to decreasing of the preparation and finalization times;
- Application of welding and hard-facing for the reparation jobs frequently produces better effects than some other known reparation procedures, since the former enable improvement of quality and multifold increase of working life of parts, as well as increase of their reliability;
- By applying the reparatory hard-facing it is possible to execute the multiple reparation, i.e. to repair the already repaired parts, what increases the economic effects;
- Reparation by hard-facing can frequently be done without dismounting (disassembling) the parts in the workshop or at a construction site, what is extremely important for the construction mechanization, since the downtimes are practically eliminated and the additional economic effects are realized.

Only the profitability method was used for analyses presented in this paper. However, the obtained results are reliable enough for decision making on justification for applying the reparatory welding and surfacing of the damaged parts of the construction mechanization. The conducted techno-economic analysis confirmed the results obtained by the profitability method. In applying this method it is of the utmost importance to determine the input parameters for economic calculations as best as possible, what was in all the presented examples done with high accuracy, since the data used were from the documentation from practice.

In the developed countries today is a great importance assigned to manufacturing costs and costs of maintenance of technical systems. The serious studies are performed to analyze causes and ways of decreasing the costs in production and services. Some detailed analyses show that for instance the car assembled of the spare parts would be two to three times more expensive than the newly manufactured one. Costs of purchasing and storage of the spare parts amount to more than 30 % of their original price, per annum. Purchasing and storage make about 10 % of the annual profit due to decrease of revenues, which could be used for other purposes. These are only a few examples that can provide an answer to the question whether to purchase the new spear part or to repair the damaged one. In addition, by applying the reparation, besides the direct savings, some indirect savings can be realized, as well. How important is the problem of reparation of the damaged parts is best stated by data presented in [3] where it is stated that by application of the reparatory welding and hard-facing of parts of the technical systems, saving on the annual level in all the branches of economy, could reach millions of euros, what can not be neglected in the times of the world economic crisis. From the standpoint of the techno-economic analysis, the technology of reparatory hard-facing is a complex set of mandatory procedures, which must be conducted for the reparation to be successful. The expected net benefit for the analyzed parts is exceptionally high, despite the fact that all the additional external and internals effects were not taken into account, which could even increase that benefit.

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