12/2016

# PRODUCTION ENGINEERING ARCHIVES

PRODUCTION ENGINEERING ARCHIVES

*ARCHIWUM INŻYNIERII PRODUKCJI**PRODUCTION ENGINEERING ARCHIVE,*
***Vol. 12, No.3***

**Editor' office:** Institute of Production Engineering
Faculty of Management
Czestochowa University of Technology

**Publisher:** Printing House
The Managers of Quality and Production
Association

**Existsince4th quarter 2013**

Journal ***PRODUCTION ENGINEERING ARCHIVES*** is the internationalplatform of the scientific exchange within the theory of the production engineering systems organizing and functioning theory.The area of interestfocuses onthe following systems:production, quality, total machines maintenance, environmental protection, occupational health and safety, human resources management including elements ofinnovationandcontinuous improvement.Publishedworksincludetechnical,economic and social issues.



Editor:

| | |
|---|---|
| **Editor's address:** | Instytut Inżynierii Produkcji, Wydział Zarządzania, Politechnika Częstochowska, Al. Armii Krajowej 19B, Poland, tel. +48 34 3250 333 |
| **Editor's e-mail:** | journalarchive@qpij.pl<br>Published: 300 pcs |



**The press and the cover:**
Publishing and Advertising Agency Edytor Ltd.
ul. Gałeczki 61, 41 – 506 Chorzów, Poland
e-mail: office@edytor.pl

Quick Druk S.C.
Łąkowa 11, 90-562 Łódź
e-mail: quick@druk.pdi.pl

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2016, Vol. 12, No. 3, pp 2-4
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: 01.09.2016 Accepted: 11.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4rd quarter 2013**

# Analysis of FRP bars used as reinforcement in concrete structures

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**Abstract.** In the design and construction of building and engineering structures, it is of utmost importance to provide their reliability and safety. The use of FRP (Fiber Reinforced Polymers) bars as reinforcement of structural concrete elements could help reducing the typical defects of reinforced concrete and increase its strength parameters. In the paper the selected FRP bar characteristic properties are presented and advantages derived therefrom are specified. Furthermore, the most commonly used in construction types of FRP bars, depending on the raw material used during the production process are listed. In addition, the possibility of recycling of elements reinforced with FRP bars is presented and compared with traditional reinforced concrete (reinforced with steel bars). The production method of FRP bars (pultrusion) is shown. Moreover, the advantages and disadvantages of using this method are discussed.

**Key words** – Fiber Reinforced Polymers, reinforcement, concrete, characteristic properties, production process, pultrusion

## 1. Introduction

The most important requirements concerning building and engineering structures include ensuring reliability and safety. According to the applicable standard Eurocode (EN 1990: 2002) both these requirements should be provided not only during implementation, but duringthe whole time of existence of the structure. The reliability and safety of the structure are specified depending on its function and the place of its achievement. In accordance with the theory of limit states, during the assumed time of operation of the facility, and depending on its defined operating conditions, it is unacceptable to exceed the ultimate limit states (ULS) or serviceability limit states (SLS) (BASZKIEWICZ K., SELEJDAK J. 2014, BRÓZDA K., SELEJDAK J. 2015, RUNKIEWICZ L. 1999). At present, in the construction industry two structural materials dominate, namely steel and concrete. However, rapid advances in technology allows to introduce new structural solutions in the construction sector increasingly. Nowadays composite materials are an attractive alternative to traditional building materials. In the view of developments in the availability, those materials are used progressively. Composites are used not only as piece of equipment, but also as structural elements or internal reinforcement of concrete structures. Moreover, composite materials partially reduce the limitations of traditional structural materials, relating to the strength parameters or assembly difficulties (BASZKIEWICZ K., SELEJDAK J. 2015, SELEJDAK J., BRÓZDA K. 2016).

## 2. Composite materials as reinforcement in structuralconcrete elements

One of the ways of improving the strength parameters of structural concrete elements is the use of reinforcement in the tension zone. The resulting material (reinforced concrete) combines the advantages of its constituent materials. Steel is typical reinforcing material, used as rods (MADAJ A., WOŁOWSKI W. 2002).

The alternative solution for the traditional steel reinforcement, which solves many problems (e.g. resulting from the corrosion), are FRP (Fibre Reinforced Polymer) bars. Depending on the raw material used during the production process, there are four basic types of FRP bars (BASZKIEWICZ K., SELEJDAK J. 2015, REJMENT M., TRAPKO T. 2014):

- Glass Fiber Reinforced Polymers (GFRP),
- Carbon Fiber Reinforced Polymers (CFRP),
- Aramid Fiber Reinforced Polymers (AFRP),
- Basalt Fibre Reinforced Polymer (BFRP).

The FRP bars are characterized by a number of very good properties, which are shown in Table 1. Furthermore, utilization of those bars is far easier than that of traditional reinforced concrete, where before reuse it is necessary to separate the reinforcement from concrete.This extraction is important especially when the material is classified as hazardous waste (KLIMECKA–TATAR D. 2015). It is impossible to reuse the reinforced steel if polluted concrete is left. In the case of recycling concrete elements reinforced with FRP bars, it is possible to crush concrete with reinforcement – there is no need to extract the reinforcement from concrete (BRÓZDA K., SELEJDAK J. 2015, SELEJDAK J., BRÓZDA K. 2016).

## 3. Production process

A suitable production process of the composite materials, i.e. the proper connection between the resin matrix and fiber reinforcement, is a condition for obtaining the appropriate material properties. The special production process ensures total impregnation of the fibres and a very high degree of curing. In order to obtain the optimum strength parameters, the pultrusion method is used to produce FRP bars. (BASZKIEWICZK., SELEJDAK J. 2015). The schematic of production process of FRP bars is shown in Fig. 1.

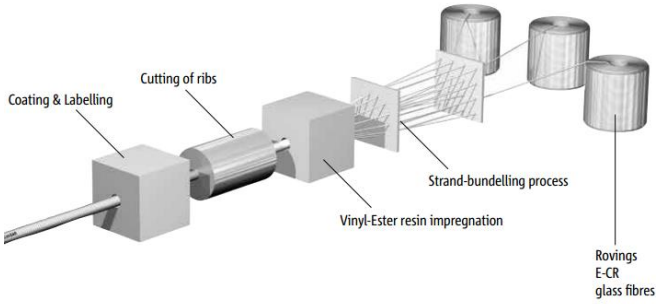


*Fig. 1. Schematic of the production process(pultrusion) of FRP bars*

*Source: study based on Schöck ComBAR – Technical Information, 10/20/2016*

*Table 1. The FRP bars characteristic properties and attendant advantages.*

| Characteristic properties | Advantages |
|---|---|
| High tensile strength | – Possibility to reduce the diameter of the bars,<br>– Reduction of the dead load |
| High resistance to the corrosion | – Increased durability,<br>– Possibility to reduce the concrete cover,<br>– No need to perform frequent maintenance and repairs |
| Very low thermal conductivity | – Reduction of heat loss |
| Electromagnetically, electrically and electrostatically neutral | – It does not cause disruptions (e.g. during industrial equipment work),<br>– The ability to assembly in areas exposed to the effects of electromagnetic fields. |
| Similar coefficient of thermal expansion of concrete and FRP bars | – Reduced risk of reinforcement and concrete damages under the influence of temperature changes |
| Low density | – lightness,<br>– easy transportation,<br>– facilitation of reinforcing process |

*Source: study based on (SELEJDAK J., BRÓZDA K. 2016),(REJMENT M., TRAPKO T. 2014)*

Tapes, which consist of a bundle of parallel fibers, are pre-bonded together by a sticky substance around the rovings. Next, expanded tape is placed in a tub filled with a thermosetting resin. Fiber bundles prepared in such a way are pulled through a special extruder to cut the ribs. When the element has the final shape, bar is coated and impregnated by synthetic resin. The production speed in this method reaches up to several tens of meters per hour (BASZKIEWICZ K., SELEJDAK J. 2015, JAREK B., KUBIK A. 2015).

In pultrusion method only straight bars are produced – there is no possibility of obtaining curved elements. For example, stirrups are produced by using a polypropylene pipe, which is filled with reinforcement (fibers) and matrix (resin). After obtaining desired shape, thermal curing follows. This method allows to obtain high strength parameters comparable to straight bars (BASZKIEWICZ K., SELEJDAK J. 2015).

## 9. Summary

It is necessary to ensure reliability and safety, during designing and realization building and engineering structures.The appropriate structural and material solutions are considered as early as at the design stage. Those solutions include reduction of dead load of the structure, while the large load capacity is maintained, or, furthermore, the parameters of the permissible load (capacity) are increased. In order to achieve increasing strength parameters of reinforced concrete it is possible to use FRP bars as reinforcement of structural concrete elements.

The FRP bars are characterized by very good properties and much easier recycling in comparison with traditional reinforced concrete. Good strength parameters result from the proper production method – pultrusion. High strength fibers are pulled out through closed chamber,where subsequently are impregnated with a synthetic resin.The pultrusion method is useful only in straight bars production.This method allows to obtain the best results in the production of high-strength materials used for reinforcement of concrete. Moreover, the production speed in pultrusion methodreaches up to tens of meters for one hour, which can lead to the dissemination of the method and falling prices of the finished product.

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***PRODUCTION ENGINEERING ARCHIVES***

2016, Vol. 12, No. 3, pp 5-8
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: 01.09.2016 Accepted: 11.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4rd quarter 2013**

# Improvement of working environment conditions in the logistic terminal

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**Abstract**The authors of this article analyse and propose improvement of safety and health at work in the transshipment terminal of a logistics company. The character of the place means that workers are exposed to constant overload of their musculoskeletal system, which is defined in the process of transporting the cargo of considerable weight. After analysing changes in the conditions of safety and health at work on selected positions were proposed. Qualitative research using the observation method, as well as the quantitative approach after changes in working conditions show the change of attitudes of employees to their work and higher performance. After a year of the proposed changes, a decision was made to introduce them also into external companies and for employees working in the cargo transshipment terminal.

**Keywords** - improvement of working conditions, work quality and productivity, safety,

## 1. Introduction

Building and shaping the culture of safety and health at work is an ongoing process as the achievement of a real change is extremely difficult and gradual. Quality and efficiency of safety changes must be made in each business, and all employees need to be involved in this process. Health and safety management systems are an intricate part of the overall company management system. The implemented system is a collection of effectively interacting elements that shape the policy of health and safety in the organization.

Regardless of the profession, the employee is always exposed to hazards that can cause a partial or long-term injury. All the factors of work environment shape occupational hazard that must be estimated for each position. The ordinance of the Minister of Labour and Social Policy of 26 September 1997 (Journal of Law of 2003, No. 169, item 1650 as amended) §2 point 7 defines what the occupational risk is. It is the probability of harmful occurrences associated with work which may result in losses of different type, especially connected with adverse health effects due to occupational hazard in a given working environment or resulting from the way work is performed.

Each element of work environment should be estimated and corrected in case of anomalies. The expert team analysed the working environment at the transshipment terminal of a logistics company. The analysis of working conditions was the reason to take action to improve the quality and productivity.

## 2. Analysis of health and safety conditions at the transshipment terminal

The scope of activities on the transshipment terminal of the logistics company focused around:

- unloading,
- loading,
- reloading of goods.

Within the area of transshipment terminal there are different types of shipment which are difficult to categorise in terms of size and weight. The variability of the load each time shapes other working conditions, and other risks to which workers are exposed. Regulation of the Minister of Labour and Social Policy on health and safety in manual handling asserts the following:

*§ 21 1. Gross vehicle weight of cargo shipped on the carriage on the flat hard surface, plus the mass of the buggy cannot exceed:*

*1) 350 kg - on a 2-wheel buggy,*

*2) 450 kg - on a 3- or 4-wheel buggy.*

*2. When moving the load on the carriage on the slopes greater than 5% ,the weight of the load, including the weight of the buggy cannot exceed:*

*1) 250 kg - on a 2-wheel buggy,*

*2) 350 kg - in a 3- or 4-wheel buggy (Journal of Law of 2003, No. 169, item. 1650 as amended).*

Variability of weight and size of transported goods by a pallet truck exposes an to overload of the musculoskeletal system. That is why diversity of cargo is important as weight and volume influence directly the tension of individual muscle groups.

The cited regulation prohibits unloading, loading and reloading of goods which exceed 450 kg by casual workers ( in the plant 4 – wheel buggies are used). However, it is difficult to imagine the functioning of a transhipment terminal where each commodity over 450 kg would be transported by a truck. The analysis resulted in a change of working conditions at the terminal. The team of experts on health and safety at the transhipment terminal indicated that the vast majority of goods weighing more than 450 kg were carried by employees with the use of HPTs.

Training and lectures by health and safety inspectors outlined a new policy and showed the existing and future threats in the workplace after making changes in the work environment. Showing good practices and positive habits is the key to achieve the goals. Training prepared employees for a change, and they were also familiar with the new procedures associated with the use of electric pallet trucks.

The use of electric pallet trucks gave rise to a change in the culture of safety and health at work. The scope of changes significantly transforms the work environment at the transhipment terminal of the logistics company. The actions taken by auditors led to the following situation:

- the worker was exposed to transporting goods over 450 kg on the hand pallet truck,
- the productivity of employees improved (goods over 450 kg are transported more quickly, without the involvement of another employee or a forklift),
- the quality of work improved (using electric pallet trucks meant that the employees themselves could move goods more than 450 kg, which meant more room for other goods.

A team of experts on health and safety conducted quantitative research among employees of the terminal a month after the changes were implemented. The survey covered all the staff members directly affected by the change.75% of the employees assessed the change that took place at the transshipment terminal of the logistics company positively. The hand pallet trucks are still used, but the introduction of their electric counterparts provided and opportunity for an employee to individually assess the way of cargo transportation. For more details see: Dobosz M., Saja P., Pacana A., Woźny A., *Improvement of health and safety conditions at selected workplaces – on the example of transshipment terminal of a logistics company,* [in:] Production Management and Engineering Sciences, London 2016, s. 55-59.

## 3. Implementation of the electric pallet trucks at the terminal

The implementation of the changes concerning the improvement of working conditions and their adaptation to the applicable regulations of safety and health at work forced employers to purchase electric pallet forklifts. It is worth noticing that the actions of the employer and the inspector are not limited solely to the purchase of electric pallet trucks. Their use is associated with changes in the terminal area. These activities centred around:

- an organization of the room for accumulators, where the trucks will be loaded,
- examination of the explosive atmosphere and installation of the hydrogen detector which is isolated during the change of electric pallet trucks,
- separation of space for trucks storage,
- training of personnel.

The actions taken by management and a safety inspector helped to reduce the potential failure in meeting the standards of goods carriage by terminal staff and drivers.

Figure 1 shows the room of accumulators of electric pallet trucks and manner of their distribution in the transhipment terminal of a logistics company. According to the guidelines and regulations of work, electric forklift can be used only by those employees who currently are forced to carry bulky goods or goods whose total weight exceeds 450 kg.

Such a change seemed reasonable sonly the appointed workers could enter into the room of accumulators to connect the truck to recharge. Placing of all electric pallets in one room allowed an easy analysis of the state of charge after each shift.

## 4. Diagnosis of the problem in the use of electric pallet trucks

Changes made in the transshipment terminal of the logistics company helped to improve the safety and quality and productivity at work during the transport of goods. Safety audit carried out after one year showed some inconsistencies in the way electric pallet trucks are used by terminal staff and drivers. The failure to comply with work regulations and safety policy was at once with to-day. Employees overused electric pallet trucks, which resulted in an employee carrying an empty pallet.

The cause of the problem should be sought in the high turnover of staff and transferring some of the tasks to external companies, in which the policies of the terminal and safety policy were not implemented. According to employees of external companies, these rules do not apply to them, and the activities taken by them are consistent with the principles of safety and agreed to with their employer. Communication chaos between employees from external companies and employees of the terminal caused the situations in which a worker was using electric pallet truck full shift or until battery depletion. These actions resulted in not placing the electric pallet in a storage place to charge. Consequently, people responsible for loading the trucks needed to look after them throughout the terminal. It is worth noticing that there were also the situations in which trucks were not charged for another shift.

The inclusion of employees of external companies to use electric pallet trucks without adequate training and instructions was the wrong action. Irregularities resulted in a re-examination of the state of safety, which showed that the original problem of transporting goods weighing more than 450 kg hand pallet truck returned.

## 5. Improvement of the use of electric pallet trucks at the terminal

An audit of the safety team~~,~~ who initiated the improvement of the transshipment terminal of the logistics company led to the relocation of the electric pallet trucks. According to the auditors, the current changes will not be applicable when trucks are used either by casual workers or employees from external companies. High staff turnover results in the lack of cooperation among employees while loading and unloading goods. Therefore, a team of experts suggested that the employees should control one another. Self-control carried out on the loading ramps will improve the efficiency and quality of the use of electric pallet trucks.

The proposed changes concerned the berth of electric pallet which were moved from the place near accumulators on the area between ramps reloading. Assigning of a specific electric pallet truck to various loading ramps made employees of the terminal, and employees from external companies control each other while using these trucks. The measures taken by the auditors contributed to:

- greater self-control of staff in the use of electric pallet trucks,
- greater self-control of charge condition of electric pallet trucks,
- reduction of the overuse of eclectic trucks to transport goods below 450 kg or empty pallets,
- co-operation between the employees working at the adjacent loading ramps.

The modification introduced by the team of experts is presented in Figure 1. The comparison of the state after the first change shows that, clearly, it was not applicable in the case of organizational changes at the transhipment terminal of the logistics company (ULEWICZ R., MAZUR M., 2015, ULEWICZ R., CIUK W. 2006, ULEWICZ R., NOWICKA-SKOWRON M. 2016, KADŁUBEK M. INGALDI M., 2016).

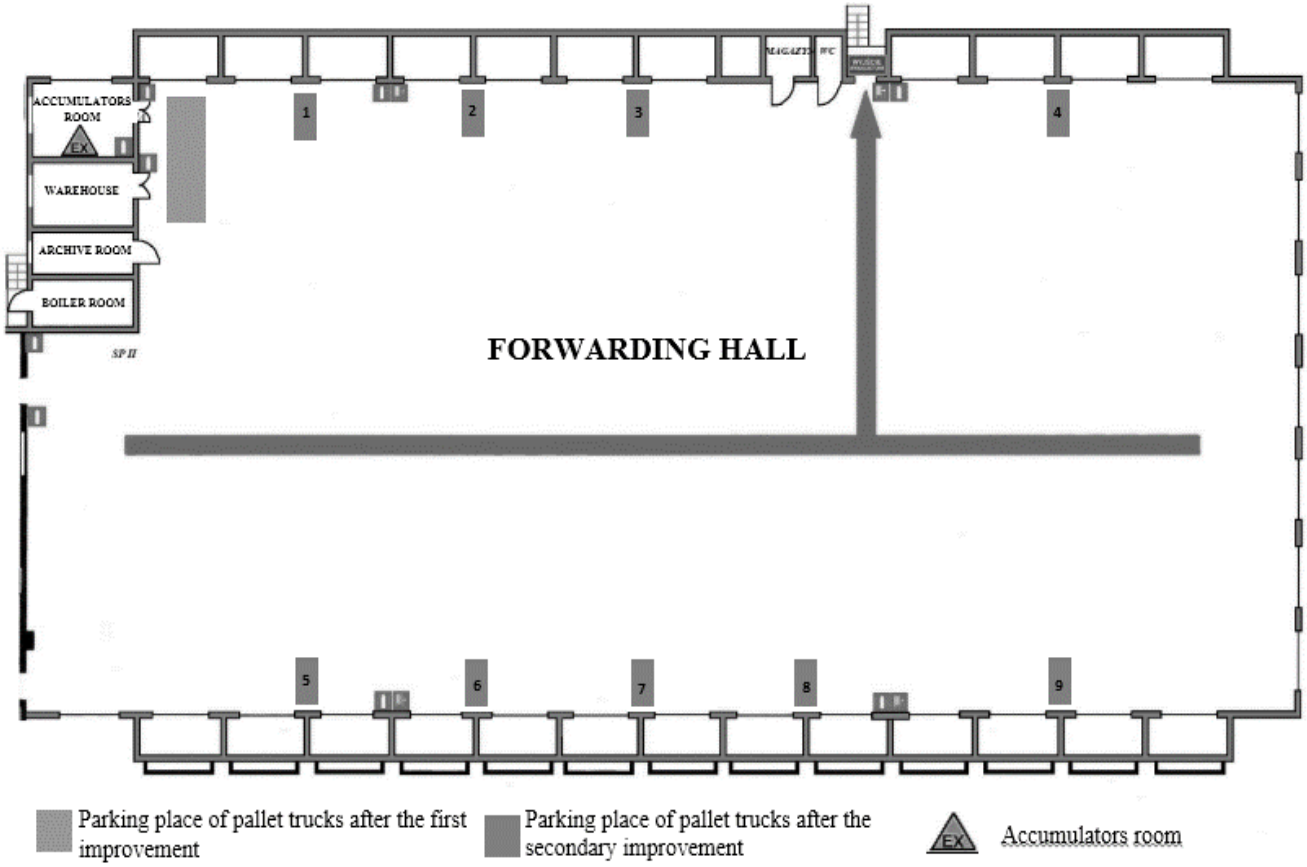


*Fig. 1. Location of accumulators and electric pallet trucks after the primary and secondary improvement.*

*Source: Own study*

## 6. Conclusions

Actions taken at the transshipment terminal logistics company confirmed that the process of improvement was a continuous process. The organizational changes in the terminal area (by the introduction of external companies) were carried out improperly, since they were not included in the labor and safety policy. The role of the employer and the safety inspector is cooperation with all employees in the company. The actions carried out by a team of experts enabled greater involvement of workers in the process of inspecting the safety and health at work.

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***PRODUCTION ENGINEERING ARCHIVES***

2016, Vol. 12, No. 3, pp 9-13
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: 01.08.2016 Accepted: 12.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4rd quarter 2013**

# Revitalization of the damaged machine parts by hard facing as a way of saving funds

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**Abstract** The objective of the research, presented in this paper, was to demonstrate the superiority of the hard facing as the revitalization technology of various damaged machine parts. The analysis of the two different revitalization methods of the damaged machine parts is presented – the replacement of the damaged part by the new – spare part and reparation by hard facing. The comparison is done on the example of hard facing and replacing of damaged loader's teeth. The paper presents a method for calculating costs of the two revitalization technologies based on their profitability and their comparison. That method could be applied for similar calculations for any machine part, with smallest or no adjustments. The paper presents a verification of advantage of applying the hard facing as the machine parts reparatory technology with respect to the other revitalization technology. The savings realized by application of hard facing reparation of the loader's teeth reach 73.5 % for one set of teeth and 82.40per annum of the costs for purchasing the new spare parts. The analysis was conducted under an assumption that organization of the maintenance function is at the exceptionally high level so that the purchasing of the new part/repairing of the damaged one is always done in time. This idealized approach was adopted since in that way one obtains the least economic effects of the reparatory technology application with respect to replacing the part with the spare one. In any other case the economic effects would be significantly higher, namely even more positive in favor of the hard facing revitalization technology.

**Key words** – Revitalization technology, hard facing, costs, savings, profitability, loader's bucket teeth.

## 1. Introduction

During the exploitation of various machine parts the wear of their surfaces is inevitable. Causes of damages could be different and they were the subject of previous research of this group of authors (ARSIĆ D. et al. 2016a, ARSIĆ D. et al. 2015, LAZIĆ V. et al. 2015b, 2016), as well as others (ŽUROVSKI W. 2012 ). Considering that the damages have to be removed so that parts could be used again without any impediments, it is necessary either to replace or to repair them. The reparation of parts is seldom simple. However, as it turned out, one of the most reliable methods of parts' revitalization is hard facing. Besides the realization of favorable mechanical characteristics of the parts repaired by hard facing, significant savings of financial resources can be achieved by application of that technique.

The objective of this paper was to illustrate how the savings can be calculated and to point to additional possibilities for application of hard facing. The example for analysis of savings was hard facing reparation of the loader's bucket teeth. The complete hard facing procedure - the selection of welding parameters, filler

metal and the heat treatments prior to and post hard facing, is presented in details in (LAZIĆ V. et al. 2014, MARKOVIĆ S. et al. 2011, MUTAVDŽIĆ M. et al. 2008, 2012).

The techno-economic justification of a certain process can be calculated and/or evaluated by various methods. The most known methods are Profitability Improvement Analysis method (PIA), Method of Economic Efficiency (MEE), the Life Cycle Cost method (LCC), Machinery and Allied Products Institute method (MAPI) and the Net Present Value method (NPV), (LAZIĆ V. et al. 2014, ARSIĆ D. et al. 2016b, WASSERMAN R. 2003, WILD J. et al. 2012). Each of those methods has its own criteria for estimates of the techno-economic justifiability of a certain technology for revitalization of the damaged machine parts. The decision is made by application of the optimal one. The same methods can be used for decision making on the optimal technology for manufacturing of the new parts, as well. Selection of the most profitable technology is done based on indicators of the economic justification. Calculations of economic effects that would be realized by application of some other reparation methods and by reparatory hard facing (RHF) belong to two different groups of economic categories. The form of the economic effects, by which the contribution of a certain technology is evaluated, must be in accordance with the criteria, which express the tendency to realize certain outcome effects (ARSIĆ D. et al. 2016b).

The economic effects of the two different technologies for renewal of various working parts are considered in this paper, namely replacing the damaged parts by the new spare parts and reparatory hard facing of the damaged parts.

When initiating the revitalization procedure of the damaged part, it must be kept in mind that this process is always restricted by different factors, the most important being availability of needed technology and of the financial resources (ARSIĆ D. ET AL 2016). What concerns the available technology, the two alternatives – to purchase the new part and to revitalize the damaged one are compared. When considering the available financial resources, on the other hand, the criterion of maximal rationality must be obeyed.

When the two technologies are being compared, the advantage should always be given to one which produces the better techno-economic effects (WILD J. et al.2012). The criteria for evaluation of investments into either of the two alternative technologies, namely to determine the amount of money to be spent, are parameters: higher profitability and absolute viability.

## 2. Determination of the hard facing reparation profitability

In the case when the most frequently used procedures are applied as the justifiability measures for application of a certain technology, the best analysis method is the profitability of that technology. The procedures are as follows: comparison of profitability as the ratio of incomes and expenses; comparison of costs and realized savings due to those costs' decrease; increase of the financial results by income increase due to costs' decrease. In quantitative economic analysis the direct (net) gain is estimated. One has to also take into account the so-called unexpected costs, as well as internal effects and multiplication effects (LAZIĆ V. et al. 2014, ARSIĆ D. et al. 2016b, WILD J.et al. 2012). The net profit calculation goal is to express the general rationality principle if the new technology is introduced.

The costs of procuring the new part ($C_{np}$) represent the sum of all the costs accompanying the purchase – the new part's price, the transportation costs, customs costs – if the part was imported, the VAT costs, keeping and storage costs, etc. Those costs are reduced for the amount obtained if the damaged part is sold ($C_{ld}$). However, those costs should be increased for an amount of additional costs ($C_a$) due to different reasons – downtimes in production, penalties for the overdue deliveries, etc. The costs of procuring the new part are being determined based on the company's documentation.

The analysis of the techno-economic justifiability of the reparatory hard facing of damaged machine parts according to the profitability method, performed in this paper, consisted of comparing costs of reparation to costs of replacement of the damaged parts by the new spare ones. Such partsare generally purchased and kept in a maintenance storage as spare parts. Thus, when a part is damaged in exploitation, it can be replaced by a spare one. At the same time, a damaged part is deducted and discarded.

This analysis is also conducted under an assumption that organization of the maintenance function is at the exceptionally high level, meaning that the purchasing of the new part is always done in time. The same is assumed for reparation of the damaged part. So, it is assumed that there is always sufficient number of working parts in storage ready to be used for replacement of the damaged one. This approach is somewhat idealized. The reason why is it selected is that in such a way one obtains the least economic effects of the reparatory technology application with respect to replacing the part with a spare one, whichwould illustrate the superiority of the former technology with respect to the latter one. In any other case, those economic effects would be significantly higher, namely even more positive.

The additional costs, due to downtimes during the single replacement of the damaged part by the new or the repaired one, were not taken into account in this techno-economic analysis. Those costs are almost the same for the two technologies and do not significantly influence the final conclusion of the analysis. However, they have to be taken into account in the analysis if the larger number of replacements is done. The reason is that the new parts have shorter working life than the repaired ones, which means that the number of replacements is bigger if the parts are replaced by the new ones, than by the repaired ones. That then significantly increases the replacement costs and that strongly influences the final conclusion of the techno-economic analysis in favor of reparation technology. Generally, the additional costs, which are pretty high, are calculated per annum. That is usually done in calculating the economic effects of a certain technology (WILD J. et al. 2012).

## 3. Profitability analysis of the damaged loader's teeth reparation

Here is presented only the techno-economic analysis of justifiability of the damaged loader's teeth reparation, while the compete procedure of the revitalization by hard facing is presented elsewhere (LAZIĆ V. et al. 2015).

The analyzed working parts are, according to the purchasing plans, procured several times per anum, i.e. the savings realized per one piece should be mulitplied by the number of replacements and thus the savings per anum would be obtaind.

The techno-economic effects were calculated according to the following parameters:

- total costs for purchasing of the new part $C_{np}$, €;
- total costs for reparation of the damaged part $C_{rp}$, €;
- the profitability coefficient

$$c_e = \left(C_{np} - C_{rp}\right) / C_{np} \; ; \tag{1}$$

- the exploitation reliability coefficient:

$$c_{ex\,rel} = t_{e\,rp} / t_{e\,np} \; , \tag{2}$$

where $t_{e\,np}$ and $t_{e\,rp}$ are the effective operational time of the new and repaired parts, respectively;

- the economic rationality coefficient:

$$c_{ec\,rat} = \left(C_{np} \cdot i_{h\,np}\right) / \left(C_{rp} \cdot i_{h\,rp}\right), \tag{3}$$

where $i_{h\,np}$ and $i_{h\,rp}$ are the limiting wear of the new and repaired part, respectively;

- total costs per/annum $C_{ann}$, €;
- direct savings per piece $S$, € and
- direct savings per annum $S_{ann}$, €.

## 4. Results and discussion

The basic parameters for profitability calculation of the compared revitalization technologies of the damaged loder's teeth, shown in Figure 1, were:

- 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 (Catalogues of base and filler metals);
- purchase price – 15 €/kg;
- reparatory work price (norm hour(s)) – 10 €/h;
- applied reparation procedure – MMA welding.

The parameters that are important for comparison of the two technologies were:

- exploitation time of the set of the new teeth working with stones and aggregates is, on average, $t_{expnp}$= 1200 h of effective operation (determined in authors' own experimental investigations);
- exploitation time of the surfaced teeth in the same operation conditions, on average $t_{exrp}$= 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 was at least the same or better than that of the new teeth.

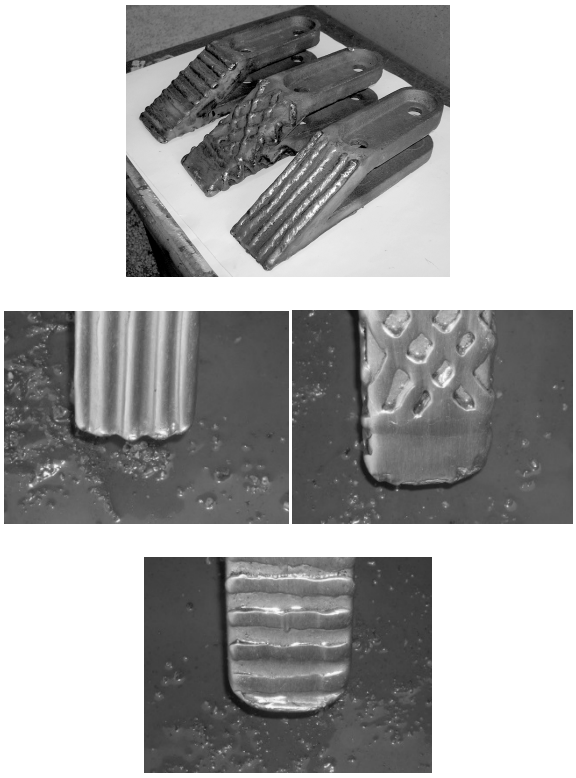

*Fig. 1. The damaged (above) and repaired (below) loader's teeth.*

The costs that are significant for comparison of the two technologies were:

– total costs of purchasing of one set of the new teeth $C_{np}$= 1210 €;
– total costs of reparation of one set of worn teeth $C_{rp}$= 320 €;
– total costs due to downtime (losses) in present conditions for this machine amount to $C_{dt}$ = 20 €/h.

The calculated values of all the coefficients and savings are presented in Table 1.

Table 1. Loader's teeth revitalization

| Applied technology | $C_{np}$, $C_{rp}$ € | $c_e$ | $c_{ex\ rel}$ | $c_{ec\ rat}$ | $C_{ann}$ € |
|---|---|---|---|---|---|
| Replacement | 1210 | 0.735 | 3.500 | 13.226 | 6021 |
| Reparation | 320 | | | | 1060 |
| Direct savings | $S$ = 890 € (73.50 %) | | $S_{ann}$ = 4961 € (82.40 %) | | |

From the presented results one can clearly see the superiority of the reparation technology with respect to replacement of the damaged teeth with the spare ones.

Direct savings per one set of teeth is 73.50 % with respect to new parts' purchasing, while the annual savings are even bigger (82.40 %) due to larger number of teeth sets being damaged and replaced/repaired.

## 4. Conclusion

The profitability based method for calculating the savings realized by the reparation technology of the loader's bucket teeth is presented in this paper. Analysis of savings showed that the savings realized by this revitalization technique could be as high as 82 % of the new parts costs, on the annual level.

Besides the direct savings, expressed in money, revitalization by hard facing also provides savings in down times of the construction mechanization, recycling of the damaged parts and above all, savings due to increased working life of the repaired part with respect to the brand new one.

According to this principle, the savings could be calculated for other machine parts that could be revitalized by hard facing, with respect to purchasing the new parts or any other revitalization technique.

### Acknowledgement

This research was partially financially supported through realization of project "Research Center of the University of Žilina" - ITMS 26220220183 and grants TR 35024 and ON174004 from Serbian Ministry of Education, Science and Technological development.

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***PRODUCTION ENGINEERING ARCHIVES***

2016, Vol. 12, No. 3, pp 14-18
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: 17.08.2016 Accepted: 10.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4rd quarter 2013**

# Cost of product functions using analysis of value

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**Abstract**. The value of use is a specific notion but of a great generality that makes the product be regarded as a complex system that transforms itself in time, thus undergoing evolution. Therefore, the product is important not in itself, but for the sake of the requirements it satisfies and ~~for~~ the functions it provides. In the analysis of value there are connections of a technical nature that implicitly lead to connections of an economic nature. Thus, the method of the "analysis of value" will actually examine the cost of product functions, the aim of the method being the balance of functions costs on the basis of their importance for the product. Identifying the functions represents one of the important stages of the analysis of value. The difficulty in fixing the functions derives from the fact that there are not any rules clear enough for this activity, but only principles.

**Key words** – analysis of value, product functions, value of use

## 1. Introduction

The analysis of value (*AV*) is a complex method of products examination~~,~~ used for improving the correlation between the value of product use and cost. Symbolically, the value can be defined by the relation:

$$AV = \frac{VI}{P} \quad (1)$$

where:

*AV*-analysis of value

*VI*-value of use

*P*-price of the product

The value of use means the utility of a product and thanks to it, this can satisfy a necessity. The price expresses the value admitted by the market. For making things simpler, cost is used instead of price. The cost represents the monetary expression of expenses with production means and with the working force necessary for obtaining a product (INGALDI M., JAGUSIAK-KOCIK M. 2014).

The improvement of a product can be done by the variation of value of use or of cost:

a) utility grows together with costs decrease,
b) utility grows and costs remain constant,
c) utility remains constant, but costs decrease,
d) utility grows in a higher degree than costs.

The value of use is a specific notion but of a great generality that makes the product be regarded as a complex system that transforms itself in time, thus being in evolution.

Therefore, the product is important not in itself, but for the requirements it satisfies and for the func-

tions it provides. In the analysis of value there are connections of a technical nature that implicitly lead to connections of an economic nature. Thus, the method of the *analysis of value* will actually examine the cost of product functions, the aim of the method being the balance of functions costs on the basis of their importance for the product.

Identifying the functions represents one of the important stages of the analysis of value. The difficulty in fixing the functions derives from the fact that there are not any rules clear enough for this activity, but only principles.

## 2. Product function description

The function is an essential characteristic of the product in comparison with the environment and the user. It is a constituent of the value of use and it can be done by the help of a material bearer.

The functional approach of the product represents the essential characteristic of AV. According to this conception the product is a sum of elementary functions that confer on it the predicted value of use.

According to their measuring nature and possibilities, functions are divided into two groups:

- Objective Functions - measurable technical dimensions; they are objectively intercepted by the user; they are objectively perceived but not objectively determined depending on the users' preferences;
- Subjective Functions - technical dimensions are hardly measurable or immeasurable; they are not identically observed by users; they are formed on the hierarchical system according to a statistic enquiry among users, having psycho sensorial effects as a basis.

For a correct characterization of functions it is necessary for the following rules to be respected:

R1 - The description of the main function must be stated in such a way in order not to repeat the same characteristics using other words.

R2 - The correct definition of the auxiliary functions.

A function is considered auxiliary if it does not add the value of use and it conditions by its existence the performance of one or more main or base functions;

R3 – Avoiding the description in general terms;

R4 – Clear differentiation in comparison with the product necessity;

R5 – Strict differentiation between the function and the domain of product use;

R6 – Do not mistake the function with the technical dimension;

R7 – Do not mistake with the technical solution.

In the phase of the analysis of a new product, viewing the fixing of its performances, the technical dimensions of functions are established according to the limits fixed on the basis of the study of the real social necessities.

The technical dimensions of secondary functions are fixed on the basis of knowing the extent they condition the main ones.

Fixing the cost of every element that is a constituent of the under units, by which the product performs its functions, allows their economic dimensioning.

The management expenses can be allotted to every constituent according to some criteria or in the total cost of functions, by taking into consideration their level of importance.

Performing the examinations of the analysis of value needs:

- fixing the relative positions of functions;
- the weight of every function in the value of product use.

For this purpose it is necessary for the functions to be compared among themselves. The comparison is done on the basis of the evaluation done by the users by the help of a previously fixed score.

The points are given by the beneficiaries of the product or by a representative number of users (BORKOWSKI S., SZKLARZYK P., KLIMECKA-TATAR D. 2013) . Only the main functions are to be compared:

Viewing the ordering according to the level of importance, the following stages are to be covered:

- a matrix is to be formed on which all the main functions of the examined product are entered.
- points of importance are given to each of them, considering that by the score 2 the most important are evaluated, by 1 the ones that have the same importance and by 0 the least important ones.

- the functions are compared between themselves, two by two, by taking into account the three possibilities of score mentioned above.
- a point is marked on the diagonal of the matrix because each function is compared to itself;
- the score is totalized vertically and the weight is calculated in percentages.

Inside AV, the notion of production cost of the product functions is operated. The total production cost results from summing the costs necessary for the performance of every function of the product.

The production cost represents the sum of manual labour costs $C_{man}$, material $C_{mat}$ and management $C_{reg}$, according to the relation (2).

$$C_{prod} = \sum_{1}^{n} c_{imat} + c_{jman} + c_{kreg} \quad (2)$$

The cost does not equal the value of the product. It can grow without necessarily adding the value. In this case the economic value of the product decreases.

Inside the examinations of IV the production cost can be differently structured in comparison with the relation presented above, resulting in the sum of:

$$C_{prod} = \sum_{1}^{n} c_{\min} + c_{sci} + c_{smn} \quad (3)$$

where:

$C_{min}$- minimum cost of product fabrication

$C_{sci}$ - extra costs due to the imperfect conception and assigning of some useless functions and characteristics.

$C_{smn}$- extra costs caused by techniques and inadequate production methods, costs due to the unproductive manual labour and the machines standing by.

After the calculation of the cost of every function, its weight is fixed in the total cost of the product.

## 3. Case study of the *AOR 170* Product

**Information Collecting**

The R 170 product is used at the SLK class (sports cars – 2 doors).

It is composed of:

- door design (ger. Türenzierstab R 170);
- superior and inferior console (ger. AbdeckungOben R 170; Abdeckungunten R 170);
- ashtray lid (ger.Ascherdeckel R 170 );
- change gear design (ger. Schaltkulisse R 170);
- change gear handle (ger. Schalthebel R 170).

The study went deeply into the superior console (ger. AbdeckungOben R170) AOR 170.

Type of wood used for the AOR 170 fabrication are Nut-tree root and Chest-nut tree.

**Fixing the functions of the classified list**

Fixing the list takes into consideration the role of this under unit at the achievement of the product value of use.

Description of functions is follow:

A - The Esthetic Function: It plays an essential role by the fact that the AO R170 "superior board cap" product is a design product.

B - Elements Assembling: It is the function by which the functional elements (buttons for different commands) are positioned and fixed.

C - Ensures the resistance of the habitat: For performing this function the AO R170 product undergoes some tests of "Älterungsprüfungen" plastic tractions.

D - Anticorrosive: Willing to ensure a functioning period as long as possible the AO R170 product is tested by climatic tests.

**Fixing the level of importance**

The level of importance of every function for the AO R170 product is fixed following the research done over the beneficiaries' requirements by comparing the functions two by two. If a function is preferred to another one, it gets 1 as a mark from the product beneficiaries, if not, 0 (zero). In case of indifference, the functions get 1.

It is noticed that the A - Esthetic Function has the biggest weight in the value of use, so the greatest contribution to the utility of the product.

**Analysis and Evaluation of Existent Situation**

*Technical Dimensioning of Functions*

As the functions express the essential qualities of the product, they correlate to the technical parameters and with their constructive characteristics.

The technical dimensions express the performances of the analysed product. The measuring unit will be fixed for every function so that it can measure the essence of function that is what characterizes and differentiates the considered value of use.

*Economic Dimensioning*

A. Fixing the cost structures of the AO R 170 product

The cost structure of a product is fixed according to the stage at which the product presents itself: conception, project, prototype or it is executed in series in case the analysed AO R 170 "superior board cap" product is already included in the fabrication process.

The costs that this product implies all along its technological process are pointed out in Table 1.

*Table 1.Costs Distribution on the Technological Flux of the AO R 170 Product*

| **Cost Elements** | | TOTAL | of which on functions | | | |
|---|---|---|---|---|---|---|
| | | | A | B | C | D |
| 1. **Materials** | Semi-finished | 143368 | 42868 | 25200 | 32000 | 43300 |
| | Tehnological | 74065 | 30070 | 20330 | 1050 | 22615 |
| **MATERIAL COST** | | **217433** | **72938** | **45530** | **33050** | **65915** |
| 2. **Manual Labour** | | | | | | |
| veneer | | 41126 | 12184 | 11630 | 9112 | 8200 |
| pressing | | 48020 | 24842 | - | 23178 | - |
| injecting | | 93696 | 22708 | 53125 | 17863 | - |
| varnishing | | 108151 | 86435 | - | - | 21716 |
| polishing | | 97662 | 20123 | 63401 | - | 14138 |
| milling | | 61295 | 20524 | - | 40771 | - |
| fitting | | 67217 | 20145 | 22713 | 24389 | - |
| TOTAL MANUAL LABOUR | | **517167** | **206961** | **150869** | **115283** | **44054** |
| TOTAL COST | | **734600** | **279899** | **196399** | **148333** | **109969** |

*Source: own study*

It is noticed that the A and B functions are sub dimensioned and the D function is over dimensioned, therefore it is imposed the reduction of the D function cost.

## 7. Results and discussions

For reducing the cost of the D function, that is the reduction of the material and cost with the manual labour in the varnishing and polishing department we took the following measures in comparison with the measures predicted by the DPV procedure.

- In comparison with the b) measure of the "DPV" procedure because the polishing samples have not been the best, a better sample has been drawn up, finally ordering two samples of this type. Thus, 40€ have been invested.
- We calculated the time of improvement by infrared of the default parts that determined the same DPV time with a cost of 1, 6 € to 200 parts.

*Table 2. Situation Following the Improvement of the D Function Cost*

| No. | **Name** | TOTAL COST | | **FUNCTION COST** | |
|---|---|---|---|---|---|
| | | Old | new | old | new |
| 1 | Material Cost | 7,013 € | 6,19 € | 2,12 € | 1,3 € |
| 2 | Manual Labour Total | 16,68€ | 15,99€ | 1,42€ | 0,736€ |
| | **TOTAL** | 23,69€ | 22,2€ | 3,54€ | 2,056€ |

*Source: own study*

Thus the functions weight in the total cost will present itself as follows:

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*Table 3. Functions Weight in Total Cost*

| **Function Code** | **Function Cost (ROL)** | **Level of importance *n*** | **Functions weight in total cost *P=f(Ct)*** | | |
|---|---|---|---|---|---|
| | | | ***initial*** | ***IST achieved*** | ***SOLL planned*** |
| **A** | **279899** | **4** | **38** | ***40,7*** | ***40*** |
| **B** | **196399** | **3** | **27** | ***28,5*** | ***30*** |
| **C** | **148333** | **2** | **20** | ***21,5*** | ***20*** |
| **D** | **63753** | **1** | **15** | ***9,3*** | ***10*** |

*Source: own study*

## 9. Summary and conclusions

In the current competitive environment, innovation, quality, and costs control there are necessary elements for companies' competitiveness. However, these elements no longer represent effective factors of differentiation and advantageous positioning with regard to clients.

Today, companies urgently need to reduce conception, planning and manufacturing delays. They also need to increase their response and anticipation ability in order to improve productivity (KARDAS E. 2016, PAULIKOVA A. 2016).

These new challenges give prominence to the role of the company information system as strategic element which brings potential improvement of performances.

Companies will want to invest in integration tools and control data exchange in the production environment to increase reactivity.

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***PRODUCTION ENGINEERING ARCHIVES***

2016, Vol. 12, No. 3, pp 19-21
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: 17.07.2016 Accepted: 13.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4rd quarter 2013**

# Effect of finishing process on the surface quality of Co-Cr-Mo dental alloys

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**Abstract:** Preparatory procedures for the material have a significant influence on the surface stereometry of the material. This study investigated the effect of the electropolishing process on the surface quality of metallic prosthetic constructions based on Co-Cr-Mo alloys. It has been found that the process of electropolishing prevents to excessive development of the surface of a material and consequently improves surface quality.

**Key words** – biomedical engineering, surface roughness, casting alloy, quality

## 1. Introduction

Biomedical engineering is an interdisciplinary field of knowledge whose main goal is the constant development of medical techniques. An important problem frequently considered as negligible is the quality control of each component in the manufacturing process of prosthetic work and influence of its properties on fitting to the patient's mouth (BIAŁAS A. 2008; PANEK H., BARZYK M., NAWROT P., NAPADŁEK P., ŚPIKOWSKA-SZOSTAK J. 2009, HĘDZELEK W., URBANEK M., WASIAK W. 1998/1999, JOSEPH D. BRONZINO 2000). Regardless of the type of product (elements of prosthetic restorations) the primary factors in achieving a high quality are: technical aspects, material selection and quality of service (DRAGO C., PETERSON T. 2014, KOCHANEK-LEŚNIEWSKA A., CIECHOWICZ B., WOJDA M., MICHALIK R. 2012., POLAK A.2015). During the production of the final product a number of inconsistencies may occurring the production process; from bad design due to the use of improper methods during the manufacturing process, to the use of different methods of finishing treatment (mechanical or chemical treatment) (KEDICI S. P., AKSUT A. A., KILIÇARSLAN M. A., BAYRAMOGLU G., GOKDEMIR K. 1998, KHAMIS E., SEDDIK M., 1995, LIN M. H-Y., BOWERS B., WOLAN J.T., CAI Z., BUMGARDNER. 2008, MAKOWSKA J. D. WALCZYŃSKA A. 1990).

The aim of this study is to demonstrate the relationship between the use of the electropolishing process and the quality of the surface layer of prosthetic construction.

## 2. Experimental

For research the dental alloy - Collado CC has been used. This type of alloy has chemical composition $Co_{59,0}Cr_{25,5}Mo_{5,5}W_{5,0}$and a low content of elements such as Ga (3.2%) Nb, Fe, B (less then 1%) is an alloy without Ni and designed to perform metal structural work (i.e. partial dentures).

As the most famous process often used in the final treatment metallic construction for smoothing and cleaning surface, replacing the traditional mechanical processing is electropolishing (GUPTA K.P. 2005), the tested sample has been subjected to electrolytic polishing process.

Parameter determining the speed of the electropolishing process (chemical processing) include current density, in this study, the current density was $i = 0.25 A/cm^2$. The working solution was a glycol aqueous solution of sulfuric acid and hydrochloric acid for a constant temperature of 30 °C and the process was continued for 10 minutes. The measurement results were compared to an untreated sample (Table 1).

The paper presents the most representative results of surface topography casting of alloy based on Cr-Co-Mo. In the paper the roughness analysis is performed - surface roughness measured with pin profilometer (Taylor Hobson), measuring section 4 mm for each sample. To better illustrate the results of surface roughness the 3D images with optical microscope Olympus (with EPI overlay) were carried out.

*Table 1. Determination of Collado CC based Cr-Co-Mo alloy samples*

| Dental Alloy - Collado CC | |
|---|---|
| **current density *i*, A/cm$^2$** | **symbol** |
| 0 | 1 |
| 0.25 | 2 |

*Source: own study*

## 3. Results

In Figure 1 the determined surface profiles for sample 1(non-treated) and 2 (after electropolishing process, $i$ = 0.25 A/cm$^2$,$t$ = 10 min) are presented. With respect to the profilometry roughness measurements the roughness parameters recorded during analysis are shown in Table 2. For comparison a set of the parameters i.e. *Ra*, *Rz* and *Rt* was taken into account – as in the previous works of the team (RADOMSKA K., PAWŁOWSKA G., KLIMECKA-TATAR D. 2015a,b,c). The parameter *Ra* is the arithmetic mean deviation of roughness profile (arithmetic average of absolute values), *Rz* parameter indicates the amount of roughness by 10 points (expresses the sum of the maximum value of profile peak height on the profile curve, and the maximum value of profile valley depth in a sampling length), and the parameter *Rt* determines the total amount of the profile.

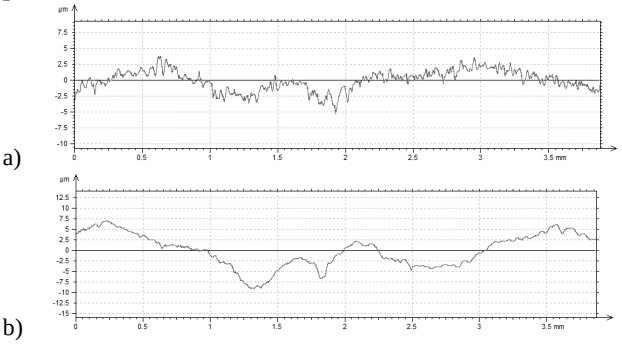


*Fig. 1. Analysis of the local areas (profile) of dental alloy Collado CC: a) sample 1 without electropolishing; b) sample 2 after electropolishing process*

*Source: own study*

*Table 2. Selected surface roughness parameters determined for Collado CC based Cr-Co-Mo alloy samples*

| Parameters | Sample 1 | Sample 2 |
|---|---|---|
| *Ra*, µm | 1,23 ± 0,09 | 0,84 ± 0,07 |
| *Rt*, µm | 9,00 ± 0,47 | 6,27 ± 0,38 |
| *Rz*, µm | 8,02 ± 0,09 | 4,35 ± 0,01 |

*Source: own study*

From the obtained results, presented in Table 2 and graphically in Figure 2, results are that the surface of sample 2 is substantially smoothed by the applied chemical treatment.

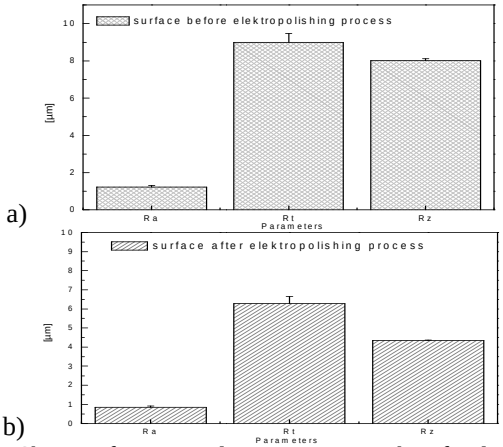


*Fig. 2. Change of Ra, Rz and Rt parameters values for dental alloy Collado CC: a) sample 1 without electropolishing; b) sample 2 after electropolishing process*

*Source: own study*

The confirmation of the results are 3D images of studied surfaces. Pictures were taken with an optical microscope with EPI overlay at 50X magnification. As a result of electropolishing, surface of the sample 2 is significantly smoother (Fig. 3).

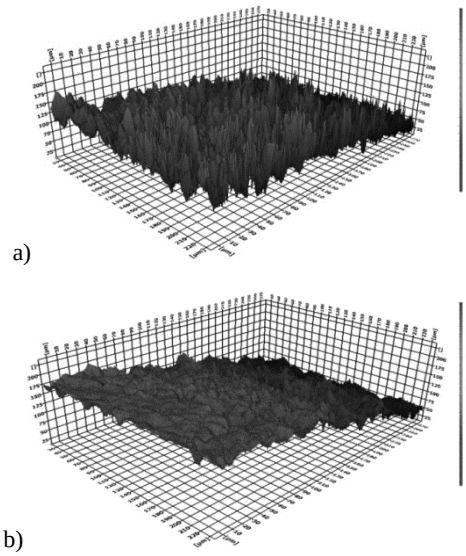


*Fig. 3. Surface topography image of dental alloy Collado CC: a) sample 1 without electropolishing, b) sample 2 after electropolishing process*

*Source: own study*

## 5. Summary and conclusions

After the electropolishing process, the roughness parameters are significantly lower than those of the starting sample. Microscopic examination confirmed that this process contributes to the smoothing surface of the prosthetic construction and improve product quality.

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***PRODUCTION ENGINEERING ARCHIVES***

2016, Vol. 12, No. 3, pp 22-29
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: 17.08.2016 Accepted: 17.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4rd quarter 2013**

# Unbridgeable gap between evolution of blueprint codes and communication – paradigm changing in production

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**Abstract** The traditional 2D drawing (hand drawing) in engineering has a commonly known communication code. These communication codes (type of line, width of line or other marks) makes the engineering communication easier, faster and safer. In the last couple of decades new computer aided design and manufacturing methods have been developed. The communication has been changed. This article aims to investigate the gap between software development and rules of communication. Although software support has developed the communication codes and basics have not been significantly changed. 2D drawing code is not yet fully included in modern 3D CAD software. Automatic 2D drawing generation from 3D computer models results problems, for example in sections, cuts and break-outs. This paper shows the most common problems and makes recommendation through harmonisation of the communication codes.

**Key words** – blueprints, design, communication, engineering

## 1. Introduction

Description of complex shapes is very difficult. That is why technical drawings are generally accepted as a special language to describe shapes and sizes. The drawing creates a connection between the designer, the manufacturer and the operator. If the link is not correct, the information cannot be passed, or can be passed incorrectly (STASIAK-BETLEJEWSKA, POTKÁNY, 2015). It is, therefore, necessary for the application of drafting standards to minimise the error in data transmission over the connection (Fig. 1).

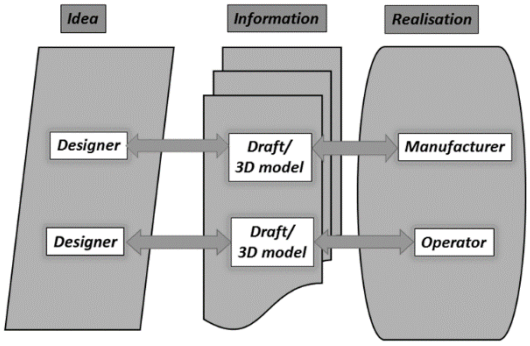


*Fig. 1. Communiaction chain in Egnieering*

*Source: own study*

As spoken and written language changes, the drawing standards also keep evolving in times. The first graphical representations can be found in the caveman era, in the form of cave paintings (Fig. 2).

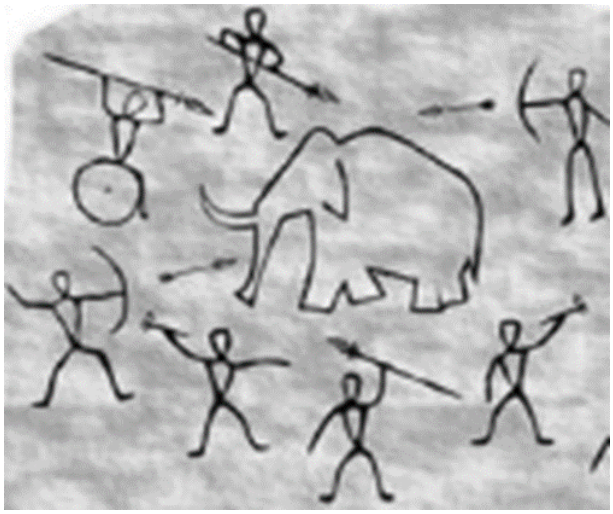

*Fig 2. Cave drawings of prehistoric man*

The cave drawings of prehistoric man also captured the images of a slice of reality. By using these drawings, previous experience was recorded and recalled; the animal was likely to be recognized which had to be faced while hunting. Therefore, it contributed to overcoming fear, and provided opportunity to prepare for the fight. The image, thus, became source of information. Of course, in this case it is only a two-dimensional depicting, a visual display performance. A significant progress in the area of visual representation has been brought by Leonardo da Vinci (1452-1519). In his paintings, effort can be seen to show the objects and shapes in three dimensions and an excellent application of perspective depiction (Fig. 3). The shapes are shown clearly by perspective depiction, but there is no satisfactory information about the exact dimensions.

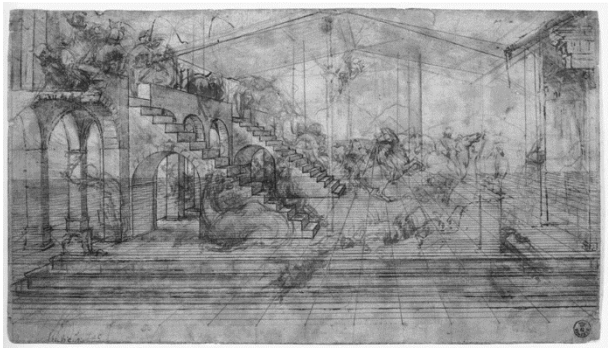

*Fig. 3. The Adoration of the Magi (Leonardo)*

During his whole life, Leonardo always attempted the most accurate representation possible. In his late works, he used different colours to show distances and depth sizes. For example, it is not ice able above the shoulder of Mona Lisa; the farther the part, the darker the blue colour. The section representation of technical drawings are also indebted to Leonardo (Fig. 4). What is more, he also used the modern sense of the word broken-up-sections and half-sections.

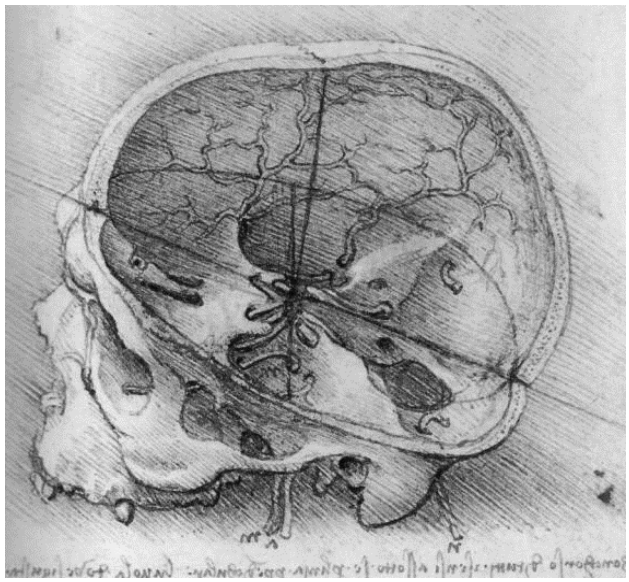

*Fig. 4. Anatomical section (Leonardo)*

However, engineering applications are usually very complex structures, to represent them, Leonardo also had to choose the 3D geometry method (Fig. 5).

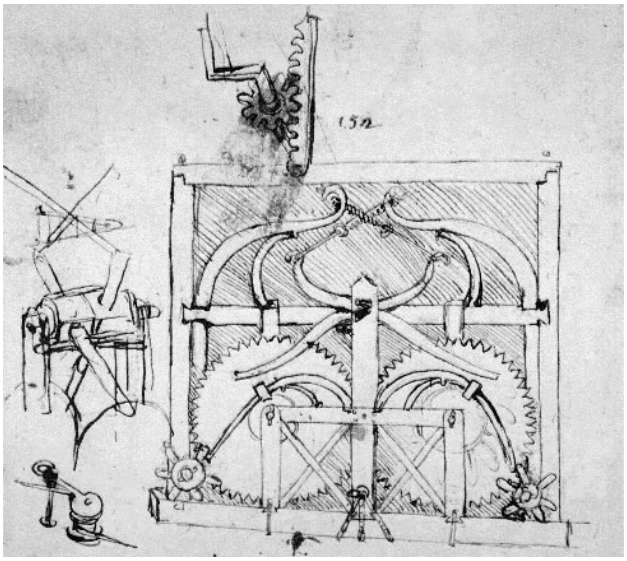

*Fig. 5. Leonardo's self-propelled cart (Leonardo)*

In Fig. 5. it can be observed that he tried to present the operation of the device where the mechanism and specific details can be also seen, for example gear linkage. Unfortunately, this plan could only be realized five hundred years later. The basics of the currently used code of mechanical representation evolved in the early twentieth century. The first monochrome copy procedures spread by this time and the rules were adapted to them. Instead of the previous use of various colours, line colours became only black. Different functions were signed by various types and thickness of lines. The views are basically plane projections, the rules of revealing internal details are created for handmade drawings. This regime was used in a significant part of the last hundred years.

In the last twenty years thanks to the modern 3D CAD-systems and the rapid spread of coloured printing and copying the system of rules seems to have become limited. (LOVAS L., 2010) Nowadays, the planned parts are designed by the level of the freehand sketches. They are created as a 3D model in a CAD system immediately after the development of the main topology and function (COMPANY ET. AL., 2009). The whole development is done on computers, and there is no need for plane drawings for the production (CNC machines, 3D printing processes), (FICZERE, BORBÁS, 2016). The question arises: is there any need for using the conventional plane drawing rule systems? If yes, which parts of them are modern, and which parts are not worth applying anymore? A further advantage of 3D models against the 2D plane drawings is that they can be used for marketing purposes as well as interferences cheques, fit investigations, motion simulation (animation) and functional analysis can be made by them. Furthermore, it can also be used for surveying the loadability (numerical analysis), optimizing the geometry and material and for examination of the assembly possibility (IVANCO, KMET, FEDORKO, 2016, ULEWICZ R., JELONEK D., MAZUR M. 2016, KRYNKE M. 2015, ULEWICZ R. 2013, NOWAKOWSKA-GRUNT J., MAZUR M.).

First the main requirements of the drawing documentations will be investigated, after (it), the problems of plane drawings generated by CAD systems will be introduced. Finally, suggestions for modifying the drawing rules to the case of freehand drawings and CAD drawings will be given.

## 2. General Requirements About Drawing Documentations

The main rules about planning are clarity, simplicity and safety which means the followings in the area of technical drawings

- obvious documentations (drawing, parts list, technical description)
- simple understandability (readability)
- availability of all information (without redundancy)
- possibility of simple and quick representation in any circumstances

The components and structures must be creatable safely by the drawing, while the framed construction must be operable.

In the course of modelling the generated plane drawings can be part drafts or assembly drafts. The requirements of these two drawing documentation are partly the same and different.

The main requirement about part drafts is obviously the manufacturability. It means verifiability and the giving the necessary views, sections, symmetries, dimensions, surface roughness, form and orientation tolerances.

The requirements about assembly drafts are the followings:

- clear definition of the relationships of joining components
- functions of related surfaces should be obviously traceable
- assembled status, position should be overview, question of decidability of assembly
- boundary conditions (positions, dimensions, stresses should be verifiable

By creating plane drawing the above given considerations must be observed as far as possible.

## 3. Differences Between Plane Drawings And Generated Drafts

If the component or mechanism has a 3D model, the simplest way of creating plane drawings is generating projections with the help of an embedded algorithm of the applied software. It happens usually with respect to the rules of drawings. With an exception to the rule if the component has such details or features which have rules of symbolic simplified representation are applied to in 2D drawings:

- thread,
- ribbing splinedshaft and hub,
- gears.

In case of threads, the representation is also simplified in three dimensions (Fig. 6), in order to spare with graphic memory and computational time, and the plane representation will also be simplified (MOLNAR, ET. AL., 2016, SYGUT P., KLIMECKA-TATAR D., BORKOWSKI S.). In such cases colours are used to represent the features (for example the length of thread), but the solid geometry does not follow it.

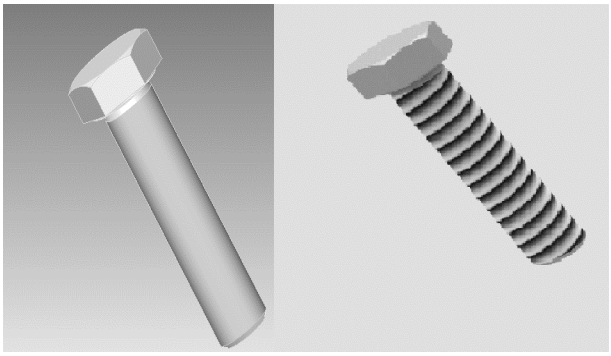

*Fig. 6. Solid representation of a screw with simplified representation of the thread (colour and rendering)*

*Source: own study*

Splines are not simplified in projections by software (Fig. 7).

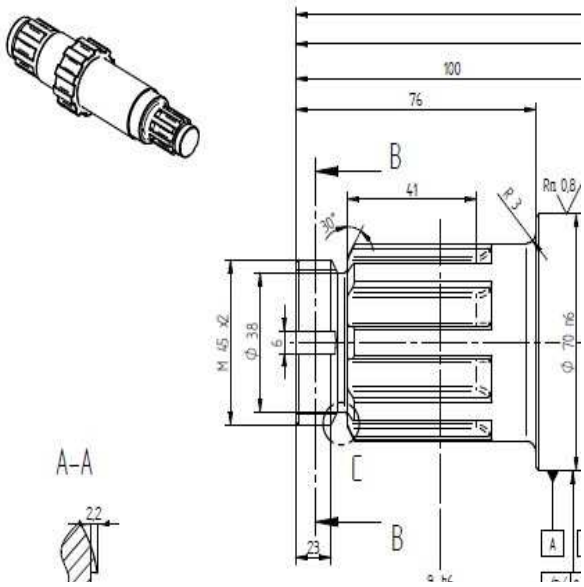


*Fig. 7. Projected representation of spline shaft without simplification*

*Source: own study*

At representing gearing also may not be simplified (Fig. 8), software aim to visualize the real shape and the generated representation is not only incorrect but makes reading the drawing more difficult, especially in case of joining gears.

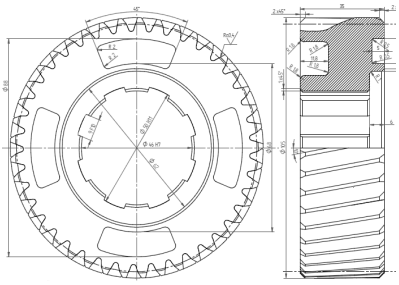

*Fig. 8.: Drawing of a gear without simplification of splines and gear features*

*Source: own study*

*Fig. 9. Representation of gear with simplification*

*Source: own study*

Another problem is the usage of different sections. Generating revolved sections which is a simple type of section, cannot be generated automatically. In case of broken-out-section the border line of the break-out also does not meet the current standard of engineering drawing (Fig. 10).

The reason of it is that modifying the default line types is quite difficult (it is possible only in groups at the same time).

This problem has been solved in the latest versions of software, so the border-line of broken outs appears automatically in the correct form. Marking of tangential connections does also not meet the standards because rounding should be marked with only one tangent line, not two.

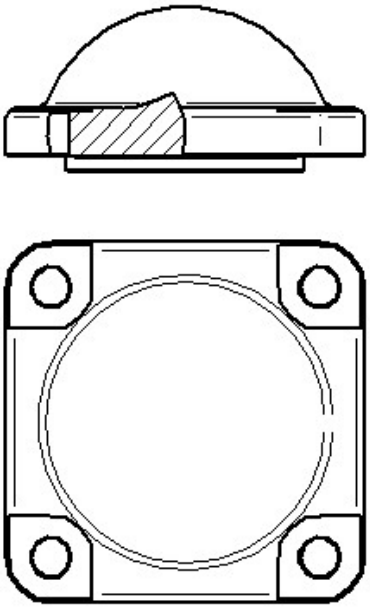

*Fig. 10. Problem of border line of broken-out-section*
*Source: own study*

Rules of sections in the symmetry plane are also disregarded, software applies only full- or broken-out-sections.

It is clear that the necessary details can be represented fully, but in many cases it is much more difficult and needs more paper than a freehand drawing.

In general software does not apply the rule, that certain parts must not be sectioned lengthwise – mostly tight elements – to avoid mass effect such elements are for example shafts, pins, ribs, spokes (Fig. 11).

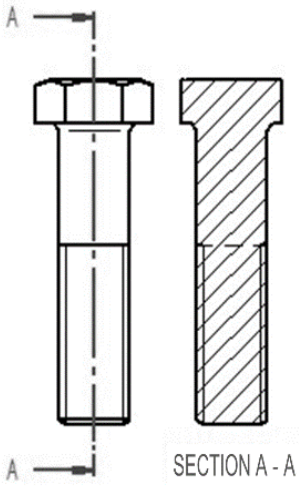


*Fig. 11. Problem of section of tight, cylindrical part*
*Source: own study*

In case of rod-like or shaft-like-elements (hardware parts), such as pins, screws, shafts this feature can be defined which is taken into account by the CAD software.

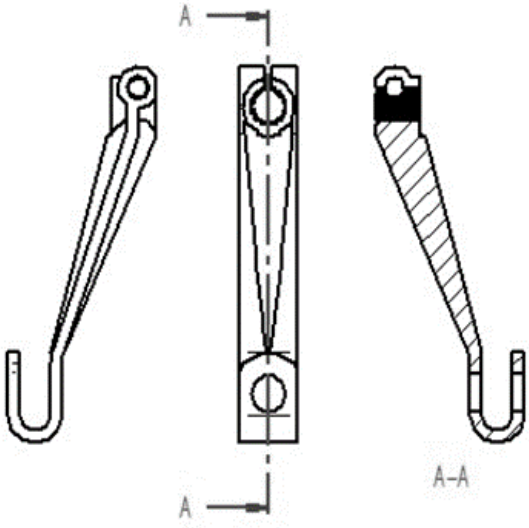


*Fig. 12. Problem of sectioned representation of spline elements*

*Source: own study*

Another problem is the section of gears. In case of straight or oblique tooth, the solid model is always sectioned by the cutting plane and the simplified representation is not applied. It is a frequent situation that in case of odd number of teeth on the one side the tooth surface can be seen but on the other side there is a sectioned tooth. In

case of oblique teething it is more difficult to understand the drawing (Fig. 8).

In case of oblique projections it is difficult represent the symmetry lines and bolt hole circles. Mostly in software it is not adapted therefore symmetry lines follow the horizontal and vertical directions of the paper (Fig. 13).

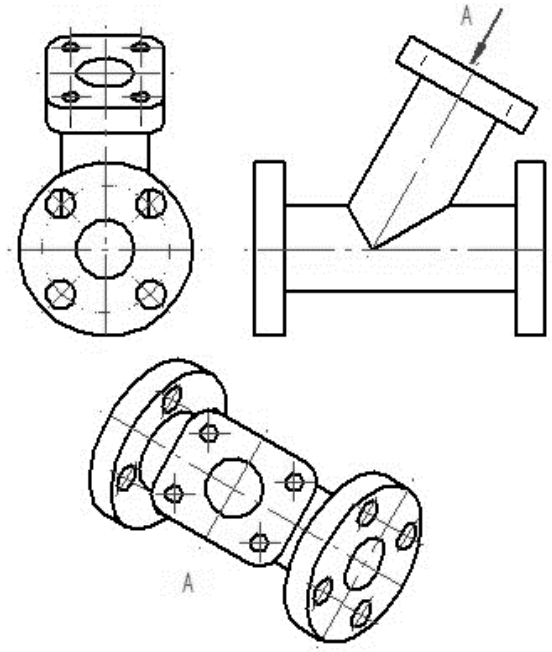


*Fig. 13. Problem of representation of symmetry-lines and bolt hole circle*

*Source: own study.*

If students study hand and software drawing simultaneously, they are inclined to accept to be correct without criticism, which they have seen on the screen.

## 4. Harmonizing Of Hand And Software Drawing Habits, Suggested Modifications

In order to make the transition from the drawn 2D documentation to the generated 3D documentation does not pose any break neither for the designer, nor the user, if a bit late, but it would be appropriate to make recommendations to convert the machine drafting standards, as well as the developers of CAD systems.

Below – from our own experience – the following possibilities are emerging:

### 4.1. Application of colours

It is possible to use different colours for lines beside the thickness. It works at 2D software long ago. It was not very successful, because it is very different from the engineering way of thinking, and from the usual code system.

Instead of hatching of surfaces, or distinction of parts it could be possible to fill the surfaces with different colours inside the contours.

### 4.2. Application of simplificatopns

In case of threaded parts, splines and teething the simplified and realistic representation should be both accepted. At the figures of SKF threaded parts are represented in this way for decades (Fig. 14).

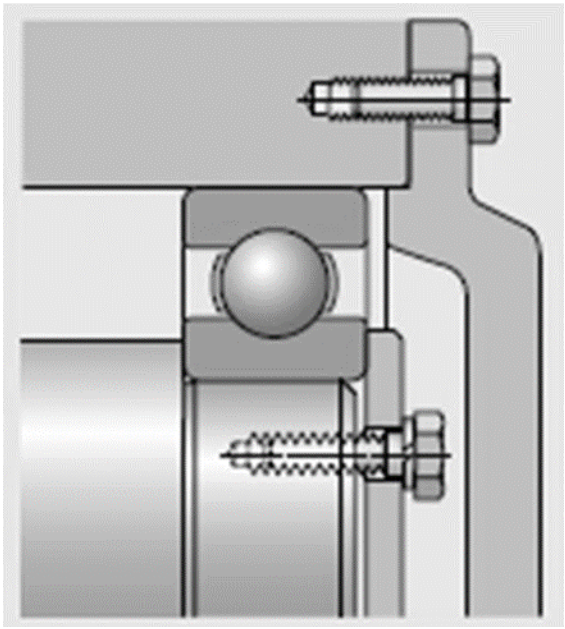

*Fig. 14. Thread and threaded hole representation realistic (SKF)*

*Source: own study*

Following this train of thought investigate the differences between the ways of representation of the clutch in the figure below.

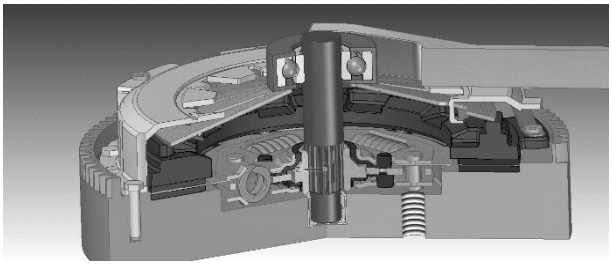

*Fig. 15. Sectioned solid representation of clutch*
*Source: own study*

The figure is relatively well-arranged, but attention should be paid to the fact that axis type elements should not be sectioned. The next figure depicts the sectioned view of the same clutch made by the same cutting plane. It is important to notice that the software in not able to represent the splined shaft in a symbolic way, it also needs a great amount of post correction.

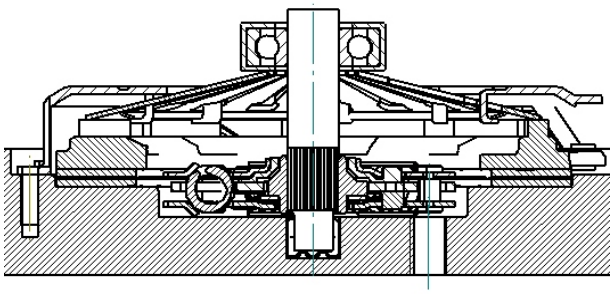

*Fig. 16. Section view of assembled clutch*
*Source: own study*

Then examine the result of making solid section view using different colours instead of standard specifications / rules.

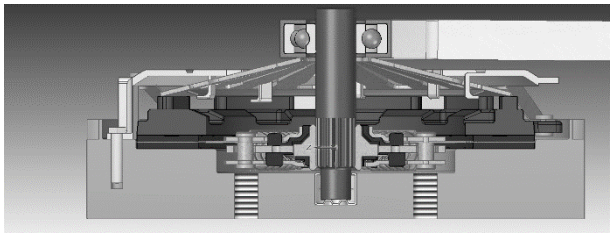

*Fig. 17. Section of a clutch in solid environment*
*Source: own study*

It is also important to mention that in solid environment the software is not able to generate revolved section, also more sections are needed to represent each connections exactly.

It is visible that in case of symmetric element (for example bearings) it is specifically disturbing if that is not in the right position.

It is important to notice, although attention was paid to it, that the cutting plane should not cross the teeth of flywheel-ring gear, so that the teeth could be seen in view, not in section, but the teething is still difficult to interpret for computers.

### 4.3. Use of axonometric figures

With the use of solid CAD software views and sections are just generated, which can be prepared quite quickly.

It would be practical to prescribe to represent the solid view of the element as well on the draft, it could help in interpreting the drawing especially in case of complex, intricate elements.

### 4.4. Suggested modifications for CAD software developers

On the generated drafts from the realistic 3D visualization the representation should be simplified as far as possible (threads, gear teeth, etc.)

Some software (for example Solid Edge) already has the opportunity to use simplified representation, but these do not always meet the standard code of technical drawings.

The border lines of sections and broken-out sections should be defined and formatted simpler.

It is suggested to apply this rule in case of auxiliary sectioning, ribs and gears, so that the gear teething or rib could be seen in view, independently of the position of the plane section.

## 5. Summary

This paper attempted to reveal the main problems. It is suggested to harmonize the code system of the two different ways of creating drawings within the limits of common sense and using the modern technical opportunities.

It is important to remark that the regulations and recommendations of standards can be different in many cases. Software must meet not only European

but also American and Japanese standards. It can be solved with different predefined profiles.

It should be always kept in mind that the purpose of drawings is communication. They establish the connection between people working in the planning, manufacturing, and operation phase of the product. That is why it should be strained after the most simple, clear and fast opportunities of representation.

CAD systems are not always and not everywhere available. What is more, in most cases, for example, in case of a malfunction of an element to receive its technical details its parameters and its installation environment only a monochrome pencil can be available.

Therefore, it is important to consider whether non-symbolic representation of threads, material patterns is applicable in all cases, or the conventional regulations such as hatching in different directions should be followed.

By the appearance of solid modelling systems the code system of technical drawings could be more permissive. In some cases more solutions could be permitted, but only with observing and conserving the original symbolic representation.

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***PRODUCTION ENGINEERING ARCHIVES***

2016, Vol. 12, No. 3, pp 30-33
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: 10.09.2016 Accepted: 17.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4rd quarter 2013**

# Influence of long-term heating on the fatigue properties of low-alloyed cast steel STN 42 2707

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**Abstract**. In this paper the authors publish own experimental results of examination of low-alloyed cast steel STN 42 2707 fatigue properties (near- threshold regime of fatigue crack propagation for rates from da/dN =5.6x10$^{-9}$m.cycle$^{-1}$to da/dN =10$^{-12}$ m.cycle$^{-1}$ and $K_{ath}$ at da/dN =10$^{-12}$ m.cycle$^{-1}$) initial state and after long-term heating (T = 400 °C, t = 4000 hours ≈ 167 days) obtained at high-frequency loading (f ≈ 20 kHz, T = 20 ± 5 °C, R = -1). The long-term heating of material caused decrease of $K_{ath}$ and increase of fatigue crack growth rate in the near-threshold regime; then worse of low-alloyed cast steel STN 42 2707 fatigue properties.

**Key words**– cast steel STN 42 2707, long-term heating, fatigue properties, $K_{ath}$, da/dN = f($K_a$)

## 1. Introduction

Fatigue is a predominating fracture mode of components and constructions. Therefore, its prevention is a fundamental design criterion (BOKŮVKA O. et al. 2002, ULEWICZ R., MAZUR M. 2013). Lifetime of components or constructions (number of cycles N) contains number of cycles necessary for fatigue crack nucleation $N_i$ and number of cycles for crack propagation $N_s$. Components or constructions in terms of their resistance to fatigue failure can be evaluated by two methods; that is according to total lifetime (number of cycles N, where $N = N_i + N_s$) or according to fatigue crack propagation with respect to laws of fracture mechanics (according to number of cycles necessary for crack propagation $N_s$) (TRŠKO L. et al. 2013, SKOČOVSKÝ P. et al. 2015).Evaluation of components and constructions resistance according to fatigue crack propagation describes well the real state, because the most of operation fractures is caused by fatigue crack growth from defects of different character. Amplitude of stress intensity factor $K_a$ is the determining characteristic for describing fatigue crack propagation. In this case for evaluation of material fatigue properties is used experimentally obtained fatigue crack growth curve that is dependenton the rate of fatigue crack growth da/dN on the amplitude of stress intensity factor $K_a$ and where the $K_{ath}$ is basic threshold

value of amplitude of stress intensity factor $K_a$.In this curve there can be observed the near-threshold regime ($da/dN < 10^{-9}$ m.cycle$^{-1}$, mid-growth rate regime ($da/dN = 10^{-9}$ m.cycle$^{-1} \div 10^{-6}$ m.cycle$^{-1}$) and high-growth rate regime ($da/dN > 10^{-6}$ m.cycle$^{-1}$). The behaviour in the near-threshold regime is very influenced by structure, environment, value of $\sigma_m$, mechanical properties incl. toughness temperature and value of asymmetry coefficient R (KUNZ L. 2003, RITCHIE R. O. 1981, BOKŮVKA O. et al. 2015).

Cast steels are very important group of construction materials. With regard to the chemical composition and structure,in principle, there are no differences from wrought steel. However, in cast steelcasting defects (buckles, shrinkages, cavities, blowholes and so on) resultingfrom casting procedure are observed (LETKO I. et al. 2002, SKOČOVSKÝ P. et al. 2000). These defects are preferred places for the fatigue crack growth (LETKO I. et al. 2002, KLESNIL M., LUKÁŠ P. 1975, HURTALOVÁ L. et al. 2013).

In this paper the authors publish own experimental resultsof examination of low-alloyed cast steel STN 42 2707 fatigue properties (near-threshold regime incl. $K_{ath}$), initial state and after long-term heating, obtained at high-frequency loading (f = 20 kHz, T = 20 ± 5 °C, R = -1).

## 2. Experimental part

The experimental work, quantitative chemical analysis, optical light microscopy, tensile tests and fatigue tests were carried out on two different states (initial and after long-term heating) of low-alloyed cast steel STN 42 2707. Chemical analysis was performed by the emission spectrometry on an ICP (JY 385) emission spectrometer using a fast recording system Image. A light metallographic microscope AXIO Imager A1m was used for metallography analysis. Tensile tests were carried out on a ZWICK Z050 testing machine at ambient temperature of T = 20 ± 5 °C, with the loading range in interval F = 0 ÷ 20 kN and the strain rate $\varepsilon_m = 10^{-3}$ s$^{-1}$. Round cross-section specimens were used; the shape and dimensions of the test specimens met the requirements of EN 10002-1 standard (5 specimens were used). Fatigue tests were carried out at high-frequency sinusoidal cyclic tension-compression loading (f = 20 kHz, T = 20 ± 5 °C, R = -1, cooled by distilled water with anticorrosive inhibitor) and with the use of high-frequency loading equipment KAUP-ZU Žilina (BOKŮVKA O. et al. 2015, PUŠKÁR A. et al. 1987, TRŠKO L. et al. 2016).

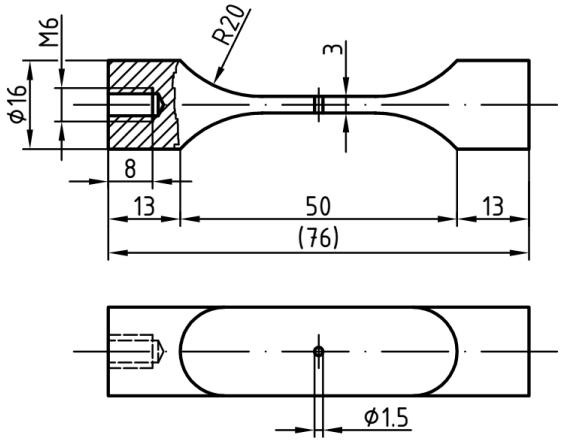


*Fig.1. The shape and dimensions of the fatigue crack growth test specimen*

*Source: own study*

The shape and dimensions of specimens used in the fatigue crack growth tests are given in Fig. 1. The applied amplitude of stress intensity factor $K_a$ was determined using the following equation:

$$K_a = \sigma_a.\left(w.tang\left(\frac{\pi.a}{w}\right)\right)^{1/2} \quad \text{MPa.m}^{1/2} \quad (1)$$

in which $\sigma_a$ is stress amplitude (MPa), a is the half crack length (m) and W is the specimen width (m), (BOKŮVKA O. et al. 2015, PUŠKÁR A. et al. 1987, TRŠKO L. et al. 2016). The fatigue crack growth rate $da/dN = f(K_a)$ in the area from $da/dN = 5.6x10^{-9}$ m.cycle$^{-1}$ to $da/dN = 10^{-12}$ m.cycle$^{-1}$ and the value of $K_{ath}$ was determined at $da/dN = 10^{-12}$ m.cycle$^{-1}$; four specimens of initial state of low-alloyed cast iron and the four specimens after long-term heating (T = 400 °C, t = 4000 hours (≈ 167 days) in the furnace with protective atmosphere) were used.

## 3. Results and discussions

The results of quantitative chemical analysis (chemical composition), tensile tests (yield point $R_p0,2$ tensile strength $R_m$, elongation $A_5$, reduction of area Z, toughness $KCV^{+23}$), optical light microscopy (microstructure) and high-frequency fatigue tests ($da/dN =$

f($K_a$), $K_{ath}$)) are shown in Table 1, Table 2, Table 3 and on the Fig. 2 and Fig. 3.

*Table 1. Chemical composition (in weight %), low-alloyed cast steel STN 42 2707*

| Cast steel STN 42 2707 | C max. | Si | Mn | P max. | S max. | Cr max. | Ni max. | Mo max. | Co max. | Al max. |
|---|---|---|---|---|---|---|---|---|---|---|
| standard | 0.12 | 0.2 0.5 | 1.0 1.6 | 0.025 | 0.020 | 0.3 | 0.4 | 0.15 | 0.30 | - |
| verified | 0.1 | 0.31 | 1.45 | 0.019 | 0.016 | 0.09 | 0.08 | - | 0.12 | 0.08 |

Source: own study

*Table 2. Mechanical properties of low-alloyed cast steel STN 42 2707*

| Cast steel STN 42 2707 | $R_{p0.2}$ (MPa) | $R_m$ (MPa) | $A_5$ (%) | Z (%) | $KCV^{+23}$ ($J.cm^{-2}$) |
|---|---|---|---|---|---|
| | 285 | 464 | 39.1 | 71.8 | 158.8 |

*Source: own study*

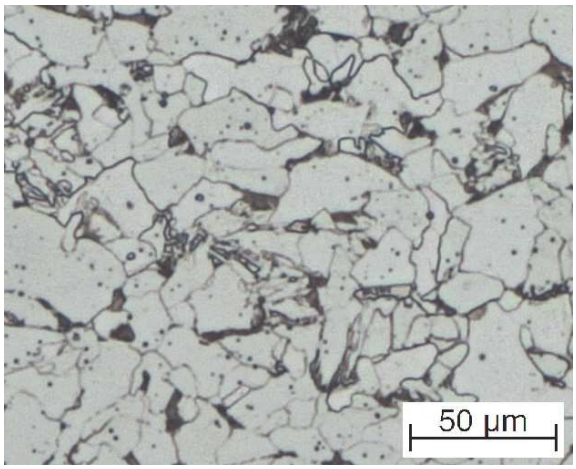


*Fig. 2 Microstructure of low-alloyed cast steel STN 42 2707, etch. 3 % Nital*

*Source: own study*

*Table 3. Basic threshold values of amplitude of stress intensity factor $K_{ath}$,, low-alloyed cast steel STN 42 2707, initial state (A) and after long-term heating (B), high frequency fatigue loading (f = 20 kHz, T = 20 ±5 °C, R = -1)*

| Number of specimen | $A_1$ | $A_2$ | $A_3$ | $A_4$ |
|---|---|---|---|---|
| $K_{ath}$ ($MPa.m^{1/2}$) | 5.23 | 5.03 | 5.16 | 5.15 |
| Average value of $K_{ath\ 1\div4}$ = 5.14 $MPa.m^{1/2}$ | | | | |
| Number of specimen | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
| $K_{ath}$ ($MPa.m^{1/2}$) | 54.58 | 4.57 | 4.53 | 4.18 |
| Average value of $K_{ath\ 1\div4}$ = 4.46 $MPa.m^{1/2}$ | | | | |

*Source: own study*

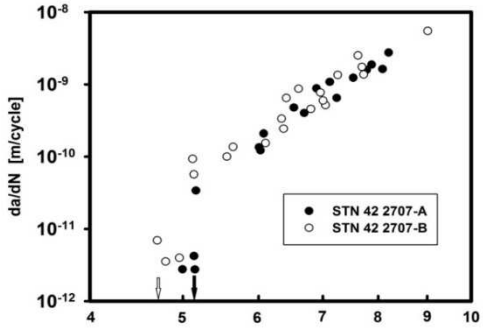


*Fig. 3. Dependence of fatigue crack growth rate da/dN on the amplitude of stress intensity factor $K_a$, da/dN = f($K_a$), low-alloyed cast steel STN 42 2707,high frequency fatigue loading (f = 20 kHz, T = 20 ±5 °C, R = -1)*

*Source: own study*

The chemical composition and mechanical properties of tested material, Table 1, 2 correspond with STN 42 2707 standard. The microstructure (Fig. 2) was created by ferrite and perlite and is characteristic for cast steel.

The obtained results about fatigue resistance of low-alloyed cast steel STN 42 2707 are shown in Table 3 and on the Fig. 3. The basic amplitudes of stress intensity factor $K_{ath}$ were $K_{ath}$ = 5.14 $MPa.m^{1/2}$ (initial state A) and $K_{ath}$ = 4.46 $MPa.m^{1/2}$ (state after long-term heating, B); decrease (B) against (A) state is cca 13.2 %. We can calculate the critical size of crack $a_c$ (permissible size of defect) with using equation (2), where

$$a_c = \frac{1}{\pi} \cdot \left(\frac{K_{ath}}{\sigma_s}\right)^2 \text{m} \qquad (2)$$

$K_{ath}$ is basic threshold value of amplitude of stress intensity factor ($MPa.m^{1/2}$) and $\sigma_s$ the safe stress (MPa); $\sigma_s$= 80 MPa and is valid in the power industry for water pumps design. The critical size of defect is $a_c$ = 1.31 mm (for initial state, A) and $a_c$ = 0.98 mm (for state after long-term heating, B); decrease of this value for heat threated state against value for initial state is cca 25.2 %. These factscorrespond with works (BOKŮVKA O. et al. 2002, BOKŮVKA O. et al. 2015). The value of $K_{ath}$ for initial state (Table 3) was $K_{ath}$ = 5.14 $MPa.m^{1/2}$. The authors (RŮŽIČKOVÁ M. et al. 1999) in their study based on their own results (19 th wrought steels with Rm from $R_m$ = 360 MPa to $R_m$ = 1820 MPa) suggested equation for $K_{ath}$ calculation (3),

$$K_{ath} = -0.0052\,Rm + 8.5906 \quad \text{MPa.m}^{1/2} \qquad (3)$$

where $R_m$ is tensilestrength [MPa]. This equation is valid in the region from $R_m \approx$ 360 MPa to $R_m \approx$ 1040

MPa, after $R_m \approx 1040$ MPa the $K_{ath}$ is constant, $K_{ath}$ = 3.21 MPa.m$^{1/2}$. With using equation (3) the value of $K_{ath}$ = 6.17 MPa.m$^{1/2}$. The experimentally determined value of $K_{ath}$ in the case of low-alloyed cast steel STN 42 2707 is lower.

The obtained results mentioned above confirm the conclusions about a considerable influence of different factors(e. g. structure, temperature, mechanical properties incl. toughness) on the fatigue resistance of structural materials in the near-threshold regime (TRŠKO L. et al. 2013, RITCHIE R. O. 1981,BOKŮVKA O. et al. 2015).

The results (Fig. 3) after da/dN = $10^{-10}$m.cycle$^{-1}$ are for the both state (initial and state after long-term heating), is practically the same. It corresponds with works (KUNZ L. 2003, RITCHIE R. O. 1981,BOKŮVKA O. et. al. 2015, TRŠKO L. et al. 2016) which stated small influence of structure, temperature, mechanical properties incl. toughness, $\sigma_m$, and enviroment on the dependence of rate of fatigue crack growth da/dN vs. amplitude of stress intensity factor $K_a$ in the mid-growth rate regime.

With regard to the results,it can be assumed that ageing is the reason of fatigue resistance decrease. This effect is observed very often in the mild steels. The aging is the reason for changes of material strength and deformation properties. The tensile strength, yield point, hardness increase but, on the other hand, the elongation and toughness decrease. The size of plastic zone on the crack tip decrease. With regard to this fact, the retardation effect against fatigue crack growth decrease and therefore decrease the value of $K_{ath}$ (PÍŠEK F. et al. 1975).

## 4. Conclusions

With reference to the experimental results carried out at high-frequency loading (f = 20 kHz, T = 20 ± 5 °C, R = -1) the following can be summed up:

- in the low-alloyed cast steel STN 42 2707 was recorded negative influence of long-term heating (T = 400 °C, t = 167 days) on her fatigue resistance in the near-threshold regime;
- the basic threshold value amplitude of stress intensity factor $K_{ath}$due to long-term heating decrease cca 13.2 % (initial state $K_{ath}$ = 5.14 MPa.m$^{1}$; state after long-term heating, $K_{ath}$ = 4.46 MPa.m$^{1/2}$);
- the critical defect size decreasecca 25.2 % (initial state, $a_c$ = 1.31 mm ; state after long-term heating, $a_c$ = 0.98 mm);
- in the mid-growth regime of da/dN = f($K_a$) curve was not recorded differences in fatigue behavior;
- these facts must be taken in consideration with reference to reliability and safety when designing the structural elements.

## Acknowledgements

The research was supported by Scientific Grand Agency of Ministry of Education, Science and Sport of Slovak Republic and Slovak Academy of Sciences, grant VEGA No. 1/0123/15, by the project APVV-14-0096 and project “Research Centre of the University of Žilina”, ITMS 26220220183.

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***PRODUCTION ENGINEERING ARCHIVES***

2016, Vol. 12, No. 3, pp 34-37
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: 10.09.2016 Accepted: 20.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4rd quarter 2013**

# Tendencies in the development of modern sacral architecture on the example of the Archdiocese of Czestochowa

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**Abstract.** Trends in development of 1945-2015 sacral architecture in Poland are presented in the paper. The issue is analysed on the example of Czestochowa Archdiocese churches. The analyses are based on the authors' own researches conducted between 2010-2015. Churches drafts, information about estimate year outlays and data from parish records were collected from each parish and considered. The author especially focuses on the buildings from the 70s,80s and 90s, which are not suited to the current needs of parishes. Visible trend to build very large sacral objects in the 70s/80s, due to uncertainty of getting further building permissions is described. Multifunctional buildings, containing catechetical classrooms erected as a result of restrictive government regulations on the construction of churches in the 80s and 90s are presented.
The author emphasizes that in the XXI century, smaller and better adapted to the needs of the local community church buildings are created. These facilities are in addition more energy efficient and built with materials of better quality.

**Key words** – sacral architecture, church buildings, Archdiocese of Czestochowa

## 1.Introduction

The development of sacral architecture, especially Roman Catholic churches, in post-war Poland correlates strongly with the changing political situation. Between the end of World War II and the fall of communism, a period of stagnation had been visible. The improvement has appeared after 1989. Nowadays no obstructions in designing and building churches are imposed. ~~S~~acral objects are considered as any other investments. After 2000, the dynamics of sacral objects erection has decreased considerably, due to the suffice of them. 3635 new churches were built in Poland during described 70 years. (BIQDATA.WYBORCZA.PL)

In XXI century, decreasing number of parishes in Europe has been noted. However, in Poland, during two decades 1990-2010, the number of parishioners per 1 parish decreased from 3682 to 3162, the total number of parishes increased by 1737 (17.6%). This phenomenon is described as unique among European countries (THE CATHOLIC CHURCH IN POLAND. 2014).

There is a lack of research on the development of sacral post-war architecture in literature. Those churches requires detailed cataloguing~~,~~ to show a remarkable influence of political situation on the investments. Creating a monograph about post-war sacral architecture in Poland should be provided interdisciplinary, with architects, historians and constructors participation.
The paper illustrates situation among Czestochowa Archdiocese, but further investigations among other Dioceses should be provided to compare and contrast the impact of political situation on the architecture within the country.

## 2. Methodology of research

The analyses are based on the authors own researches conducted among 2010-2015 in the Archdiocese of Czestochowa. Churches drafts, information about estimate year outlays and data from parish records were collected from each parish and considered. Interviews with parsons were conducted due to obtain information about number of faithful and usefulness of each part of construction. The total area of sacral buildings, the area of church used strictly for religious rituals, the number of active faithful and the area per one faithful were analyzed.

## 3. Results and discussion

There were 7555 church buildings throughout the whole country in 1945. During the first 25 years after the war, 333 sacral objects appeared (Fig. 1).

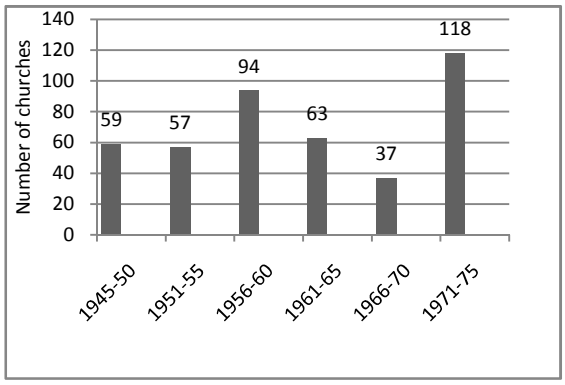


*Fig. 1. Number of new churches erected during first three decades after the World War II in Poland.*
*Source: author's own research*

Insufficient number of new erections can be explained by the tough policies directed against the church by the communistic state government. Requirements in creating a new sacral object had been stringent deliberately to obstruct the erections. In years 1956-1960, thanks to the changes in the political situation, transitory improvement has been noted. After that short period, the restrictions were reintroduced (SIWEK S. 1986; BIELECKI K. KARCZ J. 1979).

In the years 1970-1980 the number of churches under construction increased. Most churches created in the 80s were multifunctional objects. Those days the easiest way to obtain the permit was to project a chapel with area of less than 250 $m^2$. A catechetical objects with usable area less than 600 $m^2$ were also accepted much easier than earlier.

However for larger churches it was still difficult to get permission. There are many sacred buildings with usable area over 1000 $m^2$ and even more whose area exceeds 1500 $m^2$, erected in the 80s. Most of them were built between 1984 -1992. In 1988 - 173 churches with an area of over 1500 $m^2$ and 66 buildings larger than 1000 $m^2$ were erected. This phenomenon can be explained by the stiff history of restrictions.

When building permission was given after years of failure to receive it, the Archbishop often decided to build an inadequately huge object. The prospects of receiving further permissions were uncertain. (BIQDATA.WYBORCZA.PL; ARCHITEKTURA7DNIA.PL)

The Archdiocese of Czestochowa is divided into four pastoral districts: Czestochowski, Radomszczanski, Wielunski and Zawiercianski. In the Czestochowski region of the Archdiocese of Czestochowa, 85 new church buildings have been erected since 1945 (Fig.2)

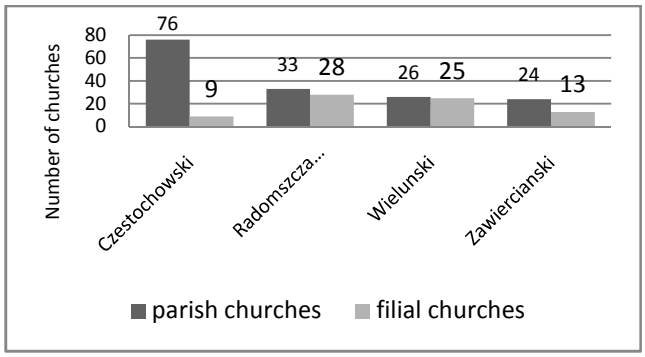


*Fig. 2. Number of new churches erected in years 1945-2015 in Archdiocese of Czestochowa*
*Source: author's own research*

Filial churches are objects situated within the parish but which are not the main church building.

In the Wielunski region there are 51 new church buildings in total. The Radomszczanski region comprises 61 church buildings erected after World War II. The Zawiercianski pastoral region has had the least number of churches built since 1945 – 37. Generally exist 234 church buildings which were erected between 1945 and 2015.

There is a significant number of churches that are currently too large for the needs of contemporary parishes in Poland. As large, author means:

- one-story objects with a surface area over 1000 $m^2$ or
- two-story objects with a surface area of ground floor over 900 $m^2$.

The Archdiocese of Czestochowa has 8 buildings which fall into this category (Tab.1). Five of them are two-story.

*Table 1. Data for large churches of Archdiocese of Czestochowa*

| No. | Name of the church | Location | The surface area of the ground floor | Number of levels | Number of parish inhabitants/ active faithful | Years of construction |
|---|---|---|---|---|---|---|
| 1. | Church of St. Adalbert | Czestochowa | 940 $m^2$ | 2 | 10000/4000 | 1978 - 1985 |
| 2. | Church of Our Lady Victorious | Czestochwa | 1060 $m^2$ | 2 | 8000/3200 | 1975 - 1985 |
| 3. | Church of St. Stanislaus | Czestochowa | 1370 $m^2$ | 2 | 6000/2400 | 1983 - 2000 |
| 4. | Church of St. Albert Chmielowski | Czestochowa | 1020 $m^2$ | 2 | 1800/720 | 1981 - 2001 |
| 5. | Church of Sacred Heart of Jesus | Czestochowa | 1100 $m^2$ | 2 | 7962/3185 | 1978 - 1990 |
| 6. | Church of blessed Ursula Ledóchowska | Czestochowa | 1300 $m^2$ | 1 | 7500/3000 | 1987 - 1999 |
| 7. | Church of Virgin Mary Mother of the Church | Radomsko | 1000 $m^2$ | 1 | 1800/720 | 1981 - 1991 |
| 8. | Church of Virgin Mary Queen of Poland | Zawiercie | 1000 $m^2$ | 1 | 9000/3600 | 1974 - 2000 |

*Source: autor's research*

Needs of a contemporary parish can be estimated by the number of active congregation. In Poland, the percentage of people participating in a holy mass is recorded at 40%. Therefore the number of churchgoers is much smaller than the number of all parish inhabitants (THE CATHOLIC CHURCH IN POLAND. 2014).

In the Archdiocese of Czestochowa in the years 1990-2010 the number of parishes increased from 282 to 311 (THE CATHOLIC CHURCH IN POLAND. 2014). Most sacral objects are fitted to the congregation, erected using modern materials, with adequate insulation and durability. Suitable energy efficiency of new-erected sacral buildings is being observed (REPELEWICZ A. 2014). Investors decide to apply layered walls, which, according to the author's study, practically did not occurred formerly. There are modern energy-saving windows and heating systems with high efficiency too. The system of quality control during the construction of religious facilities improved significantly.The quality control structures have been reformed by Church authorities (ULEWICZ R. 2013).

There are more environmental educated engineers in our society at present, so the suitable energy efficiency of the sacral buildings in projecting phase may be emphasised (ČEKANOVÁ K., PAULIKOWÁ A. LESTYÁNSZKA ŠKURKOVÁ K. 2015).

Examples of newly erected objects may be the following: Church of St. John Sarkander in Czestochowa (Fig. 3) is used by the community of 1320 parish inhabitants. It was built in 2002-2007. The total area of the building is 330 $m^2$. The church has a relatively small cubic capacity. It was built with modern construction materials having good thermal insulation. It also has an interesting outside form.

*Fig. 3. Church of John Sarkander in Czestochowa*
*Source: author's own photography*

Holy Redeemer Church in Blachownia. is used by the community of 1400 parish inhabitants. It was built in 1995-2000. The total area of the building is 224 $m^2$. The church has an extraordinary low cubic capacity in comparison with other religious buildings (REPELEWICZ A. 2015).

Obviously, there are also some examples of currently constructed large buildings in the Archdiocese of Czestochowa. Sanctuary of the Blood of Christ and the Sanctuary of Divine Mercy in Czestochowa are such an examples. These are not the parish churches, but the objects of worship for a greater number of followers. In communism, relatively the easiest way to get permission for building was to design it as catechetical objects with usable area less than600 $m^2$. At that time, a lot of such objects were built in Poland. In the design phase lots of catechetical classrooms and auxiliary rooms with

a small chapel for mass were shown on drawings and presented for approval at state planning offices. Having obtained permission the object was erected differently from the designed. Often parts of the walls were removed, enlarging the chapel and reducing the number of catechetical halls. Sometimes the external dimensions of the entire facility were enlarged too. These actions has had an unexpected results. The external form of the church is often random. As a result of contemporary changes in people's mentality, there is a need for a church to be located near in the proximity of one's house. Travelling to a distant parish, which was formerly an accepted norm, has become a waste of time. Therefore, new sacral buildings are still erected. However, the newly designed churches significantly differ from those raised in the twentieth century. They are much more suited to the current needs of parishes. What is more, contemporary parishes are not created as a multifunctional facilities, since the transfer of religious education to schools has been done. Now religious education in Poland takes place in schools, and catechetical classrooms located among sacral buildings are not used for their original purposes. Some of them are generally not used at all. A positive example is Church of Visitation Virgin Mary in Czestochowa. A catholic high school and a middle school are located in the catechetical part of the church. When the area of parishes has been reduced and divided into different parts, huge sacral buildings are not fitted to the number of parishioners. The costs of their maintenance (heating, lighting, ongoing maintenance) and repairs significantly exceeds the capabilities. This is a serious problem for the administrators of these facilities and their parishioners. Finding a way out of this situation is a major challenge for both the church authorities and local communities. It is necessary to look for opportunities to use these huge spaces for other purposes, which would not be contrary to the fundamental role of a parish church.

These problems may intensify with aging and deteriorating of the buildings. A further reduction in the number of parishioners as a result of demographic changes and the secularization of society cannot be excluded.

## 4. Summary

A real shortage of church buildings after communistic times caused a huge increase in church investment in the 80s and 90s. Society needs were answered by construction of churches which was dictated sometimes by ideological considerations. There are a significant number of churches that are very large and they are currently too large for the needs of contemporary parishes. Also catechetical objects with usable area less than600 $m^2$ are left ver from the communist era. Catechetical parts of these objects are currently unused or used for other purposes.

On the basis of observations of changes in projects and the realization of examined churches over time, it can be noticed that today's objects are smaller, and adjusted to the number of parishioners. A tendency to apply modern building materials and to energy efficient designs is also noticeable.

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*ARCHIWUM INŻYNIERII PRODUKCJI*
***PRODUCTION ENGINEERING ARCHIVES***

2016, Vol. 12, No. 3, pp 38-41
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received:15.09.2016 Accepted: 24.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4th quarter 2013**

# Analysis of causes and effects errors in calculation of rolling slewing bearings capacity

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**Abstract:** In the paper the basic design features and essential assumption of calculation models as well as the factors influencing quality improvement and improvement of calculation process of bearing capacity of rolling slewing bearings are discussed. The aim of conducted research is the identification and elimination of sources of errors in determining the characteristics of slewing bearing capacity. The result of the research aims atdeterminingthe risk of making mistakes and specifying tips for designers of slewing bearings. It is shown that there is a necessity fora numerical method to be applied and that real conditions of bearing work must necessarily be taken into account e.g. carrying structure deformations as the first ones.

**Key words** – FMEA method,slewing bearing, carrying capacity, quality

## 1. Introduction

Human desire to receive the best product has led to emergence of tools and methods of quality management that needs to monitor and act to strive for perfection of a product. The concept of quality is not limited to a product or service, it is a broader concept and can be applied everywhere (ULEWICZ R. 2013).

Alongsidewith the development of quality management, emerged many methods which have an impact on quality while sing data collected with the help of quality tools. Methods of quality management are more oriented on the analysis of collected data, however,tools have a more basic character and serve the collection of data concerning a given product. Animportant thing is the ability to see information contained in the methods and use of it to improve other processes or products (ULEWICZ R., JELONEK D., MAZUR M. 2016).

The article presents the factors that aim to improve the quality and process of slewing bearing load capacity calculation. The objective of conducted research is identification and elimination of sources of errors in determining characteristics of slewing bearing capacity. The result of the research is determination of risks of making mistakes and providing advice for designers of slewing bearings.

## 2. Factors influencing the capacity and durability of the slewing bearings

Slewing bearing is a subgroup of rolling element bearing commonly used in large industrial machineries such as turntable, steel mill cranes, offshore cranes, rotatable trolley, excavators, stackers, swing shovels, and ladle cars. A slewing bearing is basically a bearing with a gear wheel integrated in the inner or outer ring, which is subjected to a complex set of heavy loads. They typically support high axial *Q*, high tilting moment *M* and high radial load *H* (Fig. 1).

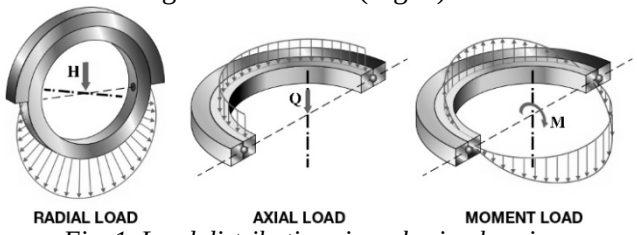


*Fig. 1. Load distributions in a slewing bearing.*

*Source: http://www.silverthin.com/.*

Slewing bearings are often critical production part. An unplanned downtime when a bearing breaks down can be very expensive due to the loss of production. Moreover, as replacement of large slewing bearing can take several months to arrive due to long manufacturing and delivery time; plants often carry spare bearing to guard against these unforeseen circumstances adding an extra cost. In order to prevent unplanned downtime, a condition monitoring and prognosis method is needed (KRYNKE M. 2015, ŚPIEWAK S. 2016).

There are many different types of slewing bearings depending on the number of rows and in the type of rolling elements. Thus, there are bearings with one, two and three rows, and the rolling elements can be balls or cylindrical rollers (SMOLNICKI T. 2013).

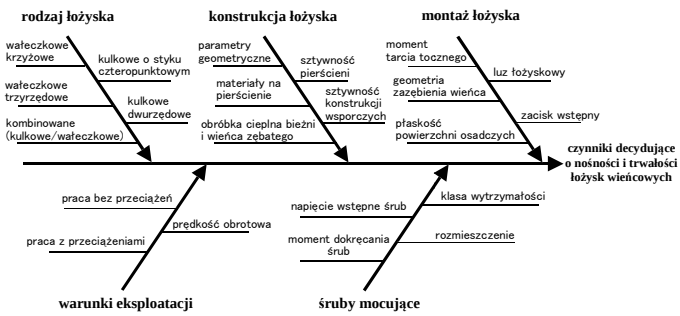


*Fig. 2. Factors influencing the capacity and durability of the slewing bearings.*

*Source: own study*

Slewing bearings designed and manufactured for a specific application requiring knowledge of the design of the device on which the bearing will work, the approximate dimensions of the bearings, the diameters of the bearing rings mounting screws locations, as well as all the types and magnitude of loads that are transmitted through the bearing (Fig. 2).

## 3. Calculation of slewing bearings carrying capacity

The load capacity of slewing bearings is determined by different calculation methods. Simple model calculations allow to determine the characteristics of the bearing under the condition of a number of simplifications. The consequence of the applied simplifications is an inaccurate assessment of actual bearing capacity (KANIA L. KRYNKE M. 2013). Load capacity of slewing bearing is dependent on a number of factors, such as (KRYNKE M., BORKOWSKI S. 2014):

- the flexibility of the bearing rings,
- the flexibility of fastening bolts on the bearing rings in the structure of the working machines,
- the sizes of the contact areas of rolling elements with raceways,
- nominal angle of action of the forces transmitted through the rolling elements, and its change under load bearings,
- the coefficient of adhesion of beads to the raceways,
- fill factor parts rolling around the circumference of the raceways of the bearing,
- clearance of the bearing,
- the flexibility of the supporting structures.

Static load rating of slewing bearings presented in graphs, called characteristics. Generally it is the curve described by the function $M(Q, H)$, where $M$ denotes the maximum value of the tilting moment, $Q$, the maximum axial force, and $H$ is the radial component of the load (Fig. 3). Component $H$ is often accepted as a constant value, which is determined by the functions $M(Q)$.

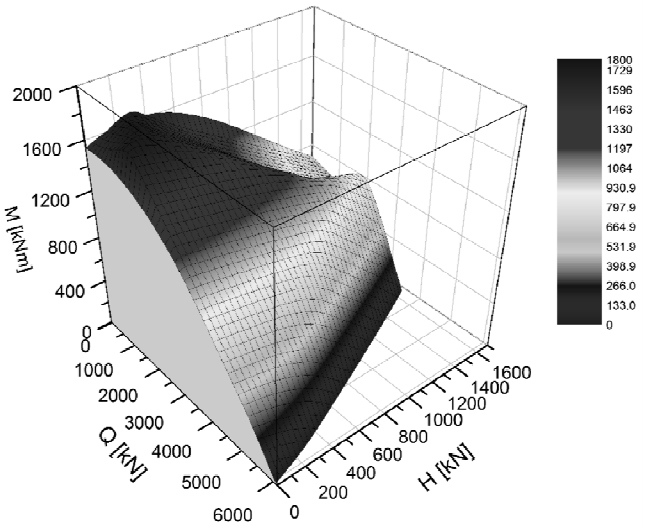


*Fig. 3. 3D graph the static load of slewing bearing M = f(Q,H).*

*Source: own study.*

## 4. Quantitative assessment of the causes of errors in determining the bearing capacity

To determine the risk associated with the determination of the bearing capacity of rolling bearings, which are as a result of the simplifications adopted in models of computation, the FMEA method was used. This method analyzes the causes and consequences of errors. The purpose of this analysis-search for possible causes and effects of errors in the design stage and eliminate them before it becomes a finished product. It has also wide application at the stage of operation where there are already failures caused by errors in the implementation of products, that is, in the production process. This method is mainly used in project and research activities and production (JAGUSIAK-KOCIK M. KNOP K. 2016).

In studies the risk was determined by identifying the criteria for selection of coefficients, i.e.: R – the risk of error, Z – the error value and W – the difficulty of accounting errors in the calculations. A number of priority risk was defined by using dependencies:

$$RPN = R \times Z \times W \quad (1)$$

In the FMEA analysis, it is assumed that the causes of the error estimation of the bearing capacity, where the number of priority $1 < RPN < 100$, does not require the introduction of protection measures. But if the priority number $RPN \geq 100$, you should take precautions for reasons arising out of errors in determining the bearing capacity. Tab. 1 shows the individual factors and risks that are there, if not their relative in the calculations of the bearing capacity of rolling slewing bearings.

The greatest risks related to incorrect evaluation of the slewing bearing capacity include ignoring susceptibility of bearing supporting structures for machine and bearing clearance.

*Table 1. Analysis of the causes and consequences of errors in the calculation of the bearing capacity of the slewing bearings.*

| Potential error | The effects of errors | The cause of the error | Tools/ research methods | The current state | | | | Recommended action |
|---|---|---|---|---|---|---|---|---|
| | | | | R | Z | W | RPN | |
| Ignoring the flexibility of bearing rings | Revaluation static load capacity | The assumptions made in the model computing | Classical computation models bearings | 5 | 4 | 7 | 140 | Construction of numerical models using FEM |
| Ignoring the bolts of the bearing ring | Revaluation static load capacity | Simplification of the model computing with respect mounting bolts | Classical computation models of bearings, without the possibility of input of the bolts | 6 | 3 | 6 | 108 | In numerical calculations the finite element method to model the bolts with beam elements with pretension |
| Ignoring changes in the nominal contact angle of balls | The risk of damaging the edges of the raceway bearing, the underestimation of the static load capacity | Calculations of ball bearings on models of computation relating to roller bearings, in which there is the change of angle of contact | Classical and numerical model for the calculation of bearings | 7 | 4 | 6 | 168 | In computational models, the balls should be replaced element special which allows, in particular, in accordance with the change in the angle of operation of the parts of rolling due to |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | portable loads |
| Ignoring the bearing clearance | Revaluation static load capacity, Incorrect meshing geometry of gear ring and pinion | Simplification of computational models without the possibility of introducing bearing clearance | Calculation of replacement characteristics of the rolling elements | 7 | 5 | 3 | 105 | Clearance introduced into the computational model by moving the replacement material characteristic for rolling elements |
| Ignoring the initial clamp | The underestimation of the moment of rolling friction during rotation of the bearing | Simplification of computational models without the possibility of introducing preliminary clamp | Calculation of replacement characteristics of the rolling elements | 8 | 2 | 3 | 48 | preliminary clamp through the substitution bias characteristics of the materials for parts of rolling |
| Ignoring the flexibility of systems of reference and of bearing used for machine | Revaluation static load capacity | Lack of knowledge of the geometry of supporting structures at the stage of calculation of the bearing capacity | Classical computation models bearings | 9 | 6 | 9 | 486 | It is necessary to know the structure of bearing installation and execute a computational model taking into account the entire structure of the machine relative to the site of rotation |
| Ignoring the deviation from flatness of the surface retaining | Revaluation static load capacity | The assumptions of the model calculation | Classical computation models bearings | 6 | 4 | 7 | 168 | The deviation from flatness must be considered in the geometry of the model calculation, concerning the seats of the bearing |

*Source: own study.*

## 5. Summary

The study analyzes the methods quality of calculating the slewing bearing static load capacity. In relation to the classical methods used currently are considered the main factors that formed the basis of a simplification of the classical methods of calculating the bearing capacity, namely:

- the flexibility of the bearing rings,
- the flexibility of the bolts securing the ring to the structures it is installed,
- deformation and change of contact geometry in the contact zone of rolling elements contact with the raceways of the bearing,
- flexibility and deformation of the supporting structure of the working machine caused by the load.

In the light of the obtained results, when determining the bearing capacity of slewing bearings, located on load-bearing structures, do not have a corresponding stiffness, it is necessary to consider that flexibility is not only rings, bearings and bolts, as well as exposure to the entire load-bearing system of the working machine.

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*ARCHIWUM INŻYNIERII PRODUKCJI*
***PRODUCTION ENGINEERING ARCHIVES***
2016, Vol. 12, No. 3, pp 42-45
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received:15.09.2016 Accepted: 26.09.2016 Online: 30.09.2016

Available online on: http://www.qpij.pl **Exist since 4th quarter 2013**

# Engineering production education in e-learning example in Poland

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**Abstract**: It can be observed that the modern world which is subjected to a variety of changes, in particular socio-economic and civilizational ones, known commonly as the so called information revolution creates the need for intense search for new, more effective educational models. All the changes are linked to the formation of network society, information society and knowledge-based economy, which are termed differently in science. The paper discusses research conducted among 698 students of Czestochowa University of Technology and Wroclaw University of Technology in Poland. The aim of the following work is to indicate main problem areas and provide solutions to them.
**Key words** – e-learning, Moodle platform, education.

## 1. Introduction

In current discourses on sustainable development, one can discern two main intellectual cultures: an analytic one focusing on measuring problems and prioritizing measures, (Life Cycle Analysis (LCA), Mass Flow Analysis (MFA), etc.) and a policy/management one, focusing on long term change, change of incentives, and stakeholder management (Transitions/niches, Environmental economy, Cleaner production). Educating a new type of engineer requires a paradigm shift in engineering. The future requires an engineer who combines the usual scientific strengths of engineering with strength in managing change and innovation in order to deliver systems level innovation. Innovation is still promoted as if the world is still almost a barren place to be filled with ingenious products and systems.

The development of the Internet and its applications determined an increase of the role of computer-based instruments in the learning process. This is the reason why educational institutions have an increasing need to use virtual learning environments (VLE), namely an electronic learning platform that accompanies the traditional teaching-learning-assessment process (OPROIU G.C. 2014).

Within only a few years, the use of e-learning has increased rapidly in Poland. Although the advantages and disadvantages of e-learning were discussed in a variety of previous studies, it is crucial to understand why some students are dissatisfied with their e-learning practice (MULDER K. F. 2016.).

E-Learning has become an important educational instrument in the new Higher Educational Environment in the digital age which creates student-centered learning and educational skills and offers new more flexible and interesting learning methods.

Education connected with performing tasks using Moodle and other related resources and Internet Tools reveals new unknown areas and opportunities to students. It makes young people realize what the educational usefulness of the network is and how many abilities associated with the efficient use of the Internet (other than entertainment or social) they still have to possess.

E-learning, until recently known as the future of education, is becoming the present reality. It brings a number of new opportunities (WU J.H., 2008).

## 2. New education form in Polish universities

As a result of the popularization of the Internet, educational technologies have widely developed and, as the educational process is further improving, the Internet users fully benefit from the process, which is adequate to their expectations.Educational and formal training programs are ever more adapted to students' needs, and the instruments used can be accompanied by a wide variety of education related services, by an extended flexibility of the learning directions, a higher complexity of the trainers' role or by an improvement of teamwork. adults' participation in permanent education requires a series of activities to be performed as computer reproduced or simulated representations, supported by various animation methods and techniques, sounds, colours, and graphics (BEDRULE – GRIGORUTAM. V., RUSU M. L. 2014).

E-learning is one of knowledge transferring methods and it is increasingly used in Poland in economic education at university level. Enrichment of teaching process offered at the level of academic courses just by creating learning opportunities through the Internet is a noticeable trend also in Polish academic practice.

Distance learning can be defined as a form of education in which interactions between the learner and the teacher do not require the presence of both participants of the education process at the same time in the same place. The development of modern information and communication technologies has contributed to the increasingly common support of teaching by means of computers and the Internet (e-learning).

E-learning is not only connected with studying itself, but also with the competence control (ARDID, 2015).

There are following advantages of e-learning education (PAECHTER, 2010; LIAW, 2007; OTTER, 2013):

- Content standardization.
- Precise control of the learning process and its effects.
- Access to online materials in a given courseat anytime from anyplace.
- Reduced tuition costs (important especially in the case of training a large number of people, e.g. for companies).
- Increased availability of educational services (lack of spatial barriers, which is important e.g. for people with disabilities).
- Making learning process more attractive through the use of multimedia.
- The possibility to learn at one's own pace and at the preferredtime.
- Minimizing students' fear and timidity.
- Implementation of traits such as being systematic and self-reliant among learners.
- Removal of restrictions related to the time and place of study.
- In the case of e-tests: objectivity of evaluation.
- Immediacy of assessment (the grade can be issued immediately after the test).

There also disadvantages of e-learning:

- Lack of the personal contact with the teacher.
- Lack of the direct contact with other learners – the feeling of isolation.
- A high level of self-discipline or self-direct is required.
- The difficulty in an appropriate and individualized motivation of learners.
- The diversity of results depending on learners' computer competence.
- The need to have hardware with suitable parameters.
- Greater amount of time on the tutor's side (preparation of the materials, correspondence with students).
- Vulnerability to technical problems.
- No rules concerning diploma recognition.
- None or very limited opportunities to acquire and improve practical skills, which is crucial within the fields such as medicine or performing arts.
- In the case of e-tests: key evaluation (the final result is assessed, not the line of reasoning).
- Problems with the remote verification of the identity of the students taking e-tests.

## 2. Research and their analysis

A study concerning students' satisfaction with e-learning was conducted at the Czestochowa University of Technology. It began in 2013 and refers to a quarterly period. The survey was conducted among 209 university students. As far as the second research is concerned, it was conducted on the Faculty of Chemistry at the Wroclaw University of Technology, and the answers were provided anonymously by 489 surveyed students. Its aim was to determine the degree of of students' satisfaction with the education form which is

offered by Moodle platform; as well as to improve e-learning activities, and to identify which form of activities cause the most problems for the students.

Moodle platform is used as a learning resource, as teaching-learning-assessment means alongside traditional teaching, learning and assessment methods and means.

Respondents had to answer the following questions:

1. How many times did you participate in the e-leraning lessons at the Faculty of Management Czestochowa University of Technology?
   Once.
   More than twice.
   Three times and more.
2. Did you take part in the training on how to use Moodle platform before starting the course?
   Yes.
   No.
3. Did you get help from teachers in charge of the classes when you encounteredproblems with passing the modules?
   Yes.
   No.
4. What is your opinion on the future of e-learning at the University?
   Nothing will changed.
   Approximately 25% of the classes will be conducted in that form.
   Half of the classes will be conducted in that form.
   More than 75% of the classes will be conducted in that form.

The gender has been included in the survey because female students are more satisfied with tutors' contribution to the education of students than male students (GONZÁLEZ-GÓMEZ, 2012; LU, 2010). 72% of respondents were satisfied with e-learning mode while 28% of them were dissatisfied.

Issues connected with the new approach to the education, that is e-learning, showed the following advantages and disadvantages of this form of education:

- flexibility of work,
- independence of learning any time,
- raising awareness owing to added materials, films and papers,
- self-management time,
- self-discipline.

Disadvantages of e-learning as result of research are following:

- technical problems with Moodle platform,
- the absence of a student on the training introductory generates subsequent problems in the service platform by him, for example: no password to access the subject, no knowledge about the fact that following lessons are in e-learning form,
- lack face to face contact with ateacher,
- aversion to reading material,
- problems with self-discipline,
- problems with self-management time.

## 3. Summary

E-learning, until recently known as the future of education, is becoming the present reality. It has brought a number of new opportunities.

Based on the researcher conducted, it was stated that e-learning is an innovation in Polish education but, as many authors claim, e-learning can be as effective as conventional in-class face-to-face teaching and learning methods if the techniques are appropriate for teaching goals with a well-organized student–teacher interaction(OZTEKIN A., DELEN D., TURKYILMAA A., &ZAIM S., 2013).

The development of the Internet and its applications has determined an increase of the role of computer-based instruments in the learning process. The use of Internet for teaching and learning is becoming a natural extension of a classroom. The modernization of education suggests that students donot only have to acquire skills and habits to work with the growing amount of information and more sophisticated information streams, but also have to possess an ability to obtain new knowledge, to build independently an overall cognitive process in the surrounding IT environment (SHOPOVA T. 2014, HOOPER AND RIEBER, 1999, CASTANEDA AND SOTO, 2010).

Several countries can benefit fromthe support of e-learning to enhance their education and their research and to go towards learning.

It was also stated that for foreign students who decide to enrol to the Czestochowa University of Technology within the Erasmus programme, Moodle is a solution that can be considered their future tool for education.

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# ABSTRACTS:

**K.Brózda, J.Selejdak**

In the design and construction of building and engineering structures, it is of utmost importance to provide their reliability and safety. The use of FRP (Fiber Reinforced Polymers) bars as reinforcement of structural concrete elements could help reducing the typical defects of reinforced concrete and increase its strength parameters. In the paper the selected FRP bar characteristic properties are presented and advantages derived therefrom are specified. Furthermore, the most commonly used in construction types of FRP bars, depending on the raw material used during the production process are listed. In addition, the possibility of recycling of elements reinforced with FRP bars is presented and compared with traditional reinforced concrete (reinforced with steel bars). The production method of FRP bars (pultrusion) is shown. Moreover, the advantages and disadvantages of using this method are discussed.

**M. Dobosz**

The authors of this article analyse and propose improvement of safety and health at work in the transship-ment terminal of a logistics company. The character of the place means that workers are exposed to constant overload of their musculoskeletal system, which is defined in the process of transporting the cargo of con-siderable weight. After analysing changes in the conditions of safety and health at work on selected posi-tions were proposed. Qualitative research using the observation method, as well as the quantitative approach after changes in working conditions show the change of attitudes of employees to their work and higher per-formance. After a year of the proposed changes, a decision was made to introduce them also into external companies and for employees working in the cargo transshipment terminal.

**V. Lazić, D. Arsić, R.Nikolić, M.Mutavžić, B.Hadzima**

The objective of the research, presented in this paper, was to demonstrate the superiority of the hard facing as the revitalization tech-nology of various damaged machine parts. The analysis of the two different revitalization methods of the damaged machine parts is presented – the re-placement of the damaged part by the new – spare part and reparation by hard facing. The comparison is done on the example of hard facing and replacing of damaged loader's teeth. The paper presents a method for calculating costs of the two revitalization technologies based on their prof-itability and their comparison. That method could be applied for similar calculations for any machine part, with smallest or no adjustments. The paper presents a verification of advantage of applying the hard facing as the machine parts reparatory technology with respect to the other revi-talization technology. The savings realized by application of hard facing reparation of the loader's teeth reach 73.5 % for one set of teeth and 82.40 per annum of the costs for purchasing the new spare parts. The analysis was conducted under an assumption that organization of the maintenance function is at the exceptionally high level so that the purchasing of the new part/repairing of the damaged one is always done in time. This idealized approach was adopted since in that way one obtains the least economic effects of the reparatory technology application with respect to replacing the part with the spare one. In any other case the economic effects would be significantly higher, namely even more positive in favor of the hard facing revitalization technology.

**L.Parv**

The value of use is a specific notion but of a great generality that makes the product to be regarded as a complex system that trans-forms itself in time, thus undergoing evolution. Therefore, the product is important not in itself, but for the sake of the requirements it satisfies and for the functions it provides. In the analysis of value there are connections of a technical nature that implicitly lead to connections of an economic na-ture. Thus, the method of the ”analysis of value” will actually examine the cost of product functions, the aim of the method being the balance of functions costs on the basis of their importance for the product. Identifying the functions represents one of the important stages of the analysis of value. The difficulty in fixing the functions derives from the fact that there are not any rules clear enough for this activity, but only principles.

**D. Klimecka -Tatar, K. Radomska, G. Pawłowska**

Preparatory procedures for the material have a significant influence on the surface stereometry of the material. This study investigated the effect of the electropolishing process on the surface quality of metallic prosthetic constructions based on Co-Cr-Mo alloys. It has been found that the process of electropolishing prevents to excessive development of the surface of a material and consequently im-proves surface quality.

**M. Győri1, P. Ficzere, L. Lovas**

The traditional 2D drawing (hand drawing) in engineering has a commonly known communication code. These communication codes (type of line, width of line or other marks) makes the engineering communication easier, faster and safer. In the last couple of decades

new computer aided design and manufacturing methods have been developed. The communication has been changed. This article aims to investigate the gap between software development and rules of communication. Although software support has developed the communication codes and basics have not been significantly changed. 2D drawing code is not yet fully included in modern 3D CAD software. Automatic 2D drawing generation from 3D computer models results problems, for example in sections, cuts and break-outs. This paper shows the most common problems and makes recommendation through harmonisation of the communication codes.

**O.Bokůvka, M.Jambor, F.Nový, L. Trško, J. Lago**

In this paper the authors publish own experimental results of examination of low-alloyed cast steel STN 42 2707 fatigue properties (near- threshold regime of fatigue crack propagation for rates from da/dN =5.6x10-9 m.cycle-1 to da/dN =10-12 m.cycle-1 and Kath at da/dN =10-12 m.cycle-1) initial state and after long-term heating (T = 400 °C, t = 4000 hours ≈ 167 days) obtained at high-frequency loading (f ≈ 20 kHz, T = 20 ± 5 °C, R = -1). The long-term heating of material caused decrease of Kath and increase of fatigue crack growth rate in the near-threshold regime; then worse of low-alloyed cast steel STN 42 2707 fatigue properties.

**Aleksandra Repelewicz**

Trends in development of 1945-2015 sacral architecture in Poland are presented in the paper. The issue is analysed on the example of Czestochowa Archdiocese churches. The analyses are based on the authors' own researches conducted between 2010-2015. Churches drafts, information about estimate year outlays and data from parish records were collected from each parish and considered. The author especially focuses on the buildings from the 70s,80s and 90s, which are not suited to the current needs of parishes. Visible trend to build very large sacral objects in the 70s/80s, due to uncertainty of getting further building permissions is described. Multi-functional buildings, containing catechetical classrooms erected as a result of restrictive government regulations on the construction of churches in the 80s and 90s are presented. The author emphasizes that in the XXI century, smaller and better adapted to the needs of the local community church buildings are created. These facilities are in addition more energy efficient and built with materials of better quality.

**M. Krynke, K. Mielczarek**

In the paper the basic design features and essential assumption of calculation models as well as the factors influencing quality improvement and improvement of calculation process of bearing capacity of rolling slewing bearings are discussed. The aim of conducted research is the identification and elimination of sources of errors in determining the characteristics of slewing bearing capacity. The result of the research aims atdeterminingthe risk of making mistakes and specifying tips for designers of slewing bearings. It is shown that there is a necessity fora numerical method to be applied and that real conditions of bearing work must necessarily be taken into account e.g. carrying structure deformations as the first ones.

**J. Rosak-Szyrocka, M. Blašková**

It can be observed that the modern world which is subjected to a variety of changes, in particular socio-economic and civilizational ones, known commonly as the so called information revolution creates the need for intense search for new, more effective educational models. All the changes are linked to the formation of network society, information society and knowledge-based economy, which are termed differently in science. The paper discusses research conducted among 698 students of Czestochowa University of Technology and Wroclaw University of Technology in Poland. The aim of the following work is to indicate main problem areas and provide solutions to them.

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2016, Vol. 12, No. 3, pp 1-3
ISSN 2353-5156 (print version)
ISSN 2353-7779 (online version)

Article history: Received: dd.mm.rrrr Accepted: dd.mm.rrrr Online: dd.mm.rrrr

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