SAFETY ASSURANCE AT THE DESIGN STAGE OF THE NEW PUMP ON THE BASIS OF EU DIRECTIVES

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Summary

The creation of the new construction solution of the device is a complicated process, in which the correct choice of the device conception has the main meaning. The chosen conception should fulfil the customer requirements as well as the obligatory law requirements on the market, on which the designed device will be admitted to the trade. These requirements began to apply in Poland, which are on the EU market, when Poland became the EU member. This article presents the effect of this requirements with particular attention on the effect of the safety principles on the new device creation process. This effect was shown on the example of the new construction solution of the pump. The concurrent design process was applied in this process, which allowed the time shortening of the project conduct. The creation of the solid models of the elements and components and the simulation research were conducted in the same time. It allowed the correction of the geometrical parameters as well as straight parameters of the created models. The conducted simulation research static, kinematical and dynamic pairs allow the approximation of the modeled phenomena with the particular meaning for the device reliability. This is important for the assurance of the device durability, the long time of operating as well as the fulfilment of the high safety requirements.

Keywords: safety, design, pump.

ZAPEWNIENIE BEZPIECZEŃSTWA NA ETAPIE PROJEKTOWANIA NOWEJ POMPY W OPARCIU O DYREKTYWY UE

Streszczenie

Tworzenie nowego rozwiązania konstrukcyjnego urządzenia jest złożonym procesem, w którym istotną rolę odgrywa prawidłowy wybór koncepcji urządzenia. Wybrana koncepcja powinna spełniać zarówno wymagania zamawiającego jak również wymagania prawne obowiązujące na rynku, na którym projektowane urządzenie ma być dopuszczone do obrotu handlowego.

W związku z wejściem Polski do Unii Europejskiej, w Polsce zaczęły obowiązywać wymagania istniejące na rynku UE. W artykule przedstawiono wpływ tych wymagań ze szczególnym uwzględnieniem zasad bezpieczeństwa na proces tworzenia nowego urządzenia na przykładzie projektowanego, nowego rozwiązania konstrukcyjnego pompy. W procesie tym zastosowano system projektowania współbieżnego co pozwoliło przede wszystkim na znaczne skrócenie czasu trwania projektu. Równorzędnie z tworzeniem modeli bryłowych części i zespołów prowadzone były badania symulacje co umożliwiło na bieżąco korygowanie parametrów geometrycznych jak również wytrzymałościowych tworzonych modeli. Przeprowadzone badania symulacyjne par statycznych, kinematycznych i dynamicznych pozwoliły na przybliżenie modelowanych zjawisk o szczególnym znaczeniu dla niezawodności urządzenia do zjawisk rzeczywistych. Jest to ważne ze względu na zapewnienie trwałości urządzenia, długiego czasu bezawaryjnej eksploatacji oraz spełnienia wysokich wymagań bezpieczeństwa.

Słowa kluczowe: bezpieczeństwo, projektowanie, pompa.

1. INTRODUCTION

Creating a new construction solution of a device is a complex process, in which the correct choice of the device concept plays a significant role. The chosen concept should meet both requirements of the party ordering the device as well as the legal requirements in force in the market where the designed device is to be admitted to trading and use. When Poland joined the European Union, the requirements existing in the EU market started becoming effective in Poland. The paper presents

the effect of these requirements on the process of creating a new device, with the example of the designed, new construction solution of the pump.

2. EU DIRECTIVES IN THE NEW PUMP CREATION PROCESS

The determination of directives, which the requirements have to be fulfilled, is the duty of a producer. The following directives are obliged in the pump creation:

- directive 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery;
- directive 94/9/EC of the European Parliament and the Council;
- of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres;
- directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility.

The main aim of 98/37/EC directive requirements is the minimization of the threats which result from the mechanical construction.

Taking into account the pump work in the potentially explosive atmospheres, one of most important requirements are in directive 94/9/EC. On the basis of the conducted threats analysis, the new pump was classified to the M1 category in the 1 group. The following main requirements have to fulfil by the devices from this group:

- necessity of the dustproof housing application;
- surface temperature should be lower than the temperature ignition of the explosive mixture;
- special measurement and control elements should be designed for the elimination of the forceful equalization of the pressure.

The determination of harmonized European norm (EN) is the next stage of the design process. The detailed technical requirements are in this norm. The harmonized norms can divide on three groups:

1. General norms (A) applied to the different groups of product (EN 292).
2. Sector norms (B) contain the detailed requirements for the chosen safety aspect (EN 982, EN 953).
3. Detailed norms (C) contain the detailed requirements for the group of products (EN 809).

3. CONSTRUCTION OF THE PUMP

The pump (Fig. 1) is dedicated for pumping oil and water emulsion with 3 to 5% of oil contents. The basic requirements required by the ordering party for this pump are:

- nominal pressure at the outlet: 40 MPa,
- flow capacity: 320 dm^3/min,
- motor power output: 250 kW.

The proposed solution is a new construction solution of a radial piston pump. Its main working elements are seven pistons spaced radially around the shaft axle. The pistons move in the pump body in plane and return motion forced by the properly shaped cam set on the shaft pin. Lift spaces are connected with the inlet and outlet (pumping) pipes from the outside of the immovable cylinder block. Valve timing is used as the element controlling the flow of the liquid.

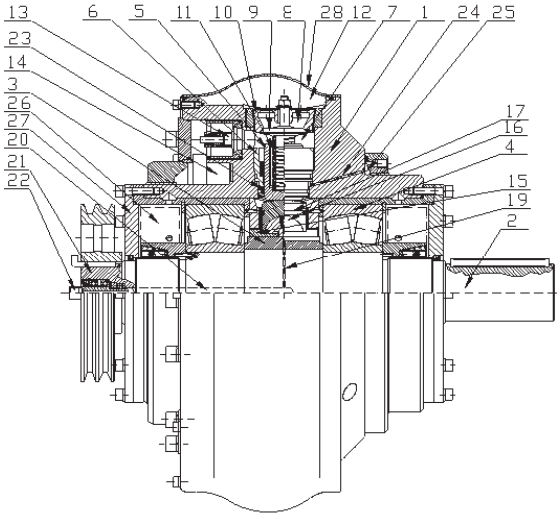

Fig. 1. Construction of the pump
1 – pump body, *2* – shaft, 3 – eccentric pin, 4 – rolling bearings, 5 – small piston, 6 – small cylinder, 7 – lift chamber, 8 – inflow valve, 9 – inflow valve head, 10 - inflow valve seat, 11 - inflow valve spring, 12 – inflow collecting pipe, 13 – pumping valve head, 14 – pumping collecting pipe, 15 – bearing foot, 16 – ball-shaped pin, 17 - lifter, 18 – non-return valve, 19 – radial duct, 20 – axial duct, 21 – peripheral drive pin, 22 – rotating oil line, 23 - additional sealing, 24 – oil duct, 25 – oil collecting pipe, 26 - counterweights, 27 - cover, 28 - inflow collecting pipe casing

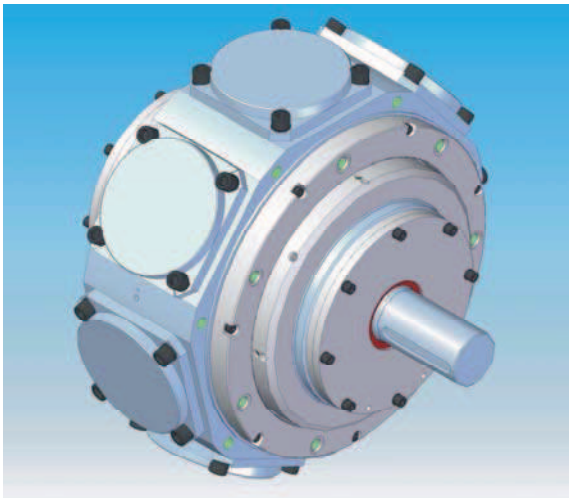

Fig. 2. View of the pump

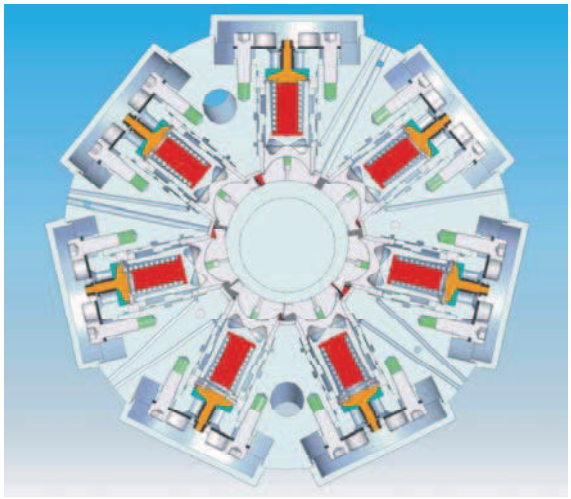

Fig. 3. Building of the pump

4. TECHNICAL HARMONISATION IN THE EUROPEAN UNION

Since 1985, the so-called "new approach" to technical harmonisation is used in EU. This approach is based on harmonisation of legislation in the scope of the basic technical requirements, significant to ensure safety, health, protection of the environment and public interest. The basic requirements are included in legal acts called directives.

The directives of the new approach have common structure, which includes the articles defining their scope of effectiveness, the conditions of marketing products and admitting them for use, the rules for free flow and presumption of compliance, the procedures for assessment of compliance and marking with the CE sign, the requirements for the notifying units. Appendixes are enclosed with the directives, which specify, among others, the basic requirements related to health and safety, the contents of the EC declaration of compliance, the rules of EC testing. The technical specification of products which meet the basic requirements of a specific directive, is to be found in the standards harmonised with the requirements of the appropriate directive. One has to note that products produced in accordance with harmonised standards are considered to meet the basic requirements of the appropriate directive.

In order to ensure coherent assessment of compliance of products with the basic requirements of the appropriate directives, in 1989, common policy as regards certification and tests was set forth, which was called the global approach. Breaking down the assessment of compliance into modules, including the design and production stages, is significant from the point of view of developing pump elements in this approach. In order to document compliance of the product with the appropriate directives, it must be provided with the CE sign. Only the products, which meet the basic requirements of the appropriate directives, may be freely admitted to trading in the internal EU market and released for use.

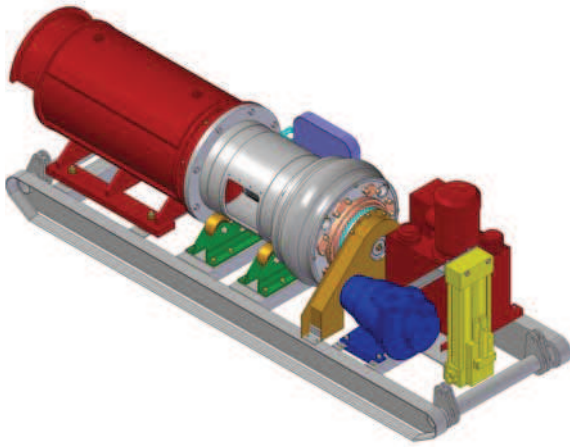

Fig. 4. View of the pump unit

5. EU DIRECTIVES COVERING THE DESIGNED PUMP

Defining the directives to cover the device is one of the duties of the producer. Only the devices, which meet the requirements of all the directives referring to them, may be introduced in commercial trading in the EU area.

The pump as a machine is first of all subject to the requirements in the 98/37/WE directive on harmonising regulations of member countries in reference to machines (the so-called machine directive). The main objective of this directive is to reduce threats resulting mostly from the mechanical structure of machines. The basic requirements set forth in Appendix I to this directive refer to threats.

Considering that the pump will work in a mine, that is in the possibly explosive atmosphere, it should also meet the basic requirements of the 94/9/WE directive on protection devices and systems dedicated for use in spaces with explosion hazard. Appendix I to this directive sets forth the classification of devices into groups and categories. On the basis of the conducted identification of threats, it has been determined that the pump is in category Ml in group I. The Ml category includes devices dedicated for work in mine underground areas and on the surface, where explosion of methane or coal dust is probable. This group includes machines fitted with additional anti-explosion protection measures. The equipment in this group should maintain very high degree of safety even in case of damages to one of the protection measures or in case when two independent damages occur in the machine)'. On the basis of the requirements for the Ml category (apart from the requirements for all the groups), additional requirements for the designed pump have been set forth:

– the necessity of using a dust-proof casing,
– surface temperature should be significantly lower than flash point of the surrounding explosive mixtures,
– the possibility of opening a part of the pump, which may cause ignition, may only occur when the power supply is off and under spark-safe conditions,
– the pump should have appropriate elements preventing accumulation of static electricity capable of causing hazardous discharges,
– random or leak currents should be prevented in the conductive parts of the pump, which are conducive to corrosion, overheating the surface and causing sparks.

A special measuring device should be designed for control and setting up, to prevent violent balancing of pressures in the hydraulic system. The above requirements along with the basic requirements of the 98/37/WE directive and the basic requirements of the 94/9/WE directive referring to all the groups of equipment constitutes the premises adopted for developing the construction solution concept of the pump.

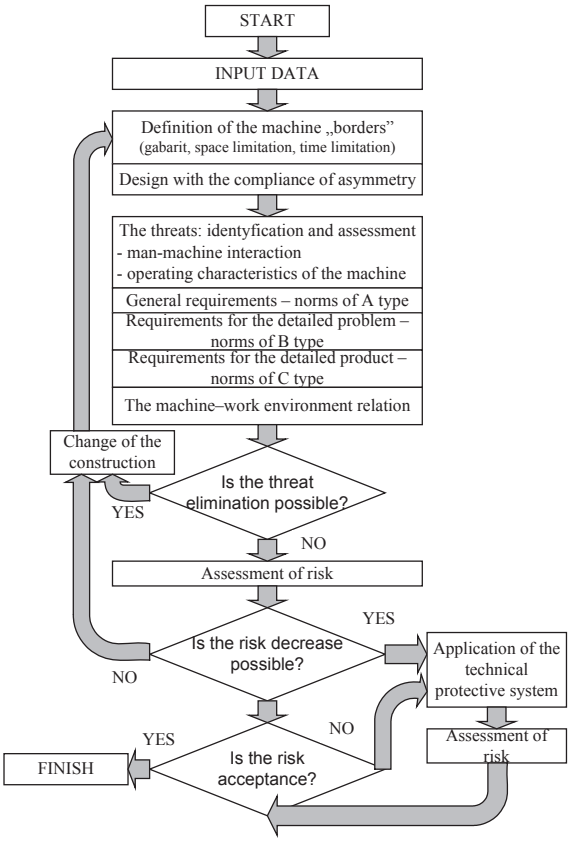

Fig. 5. Diagram of the design proces according with the basic requirements of EU directions

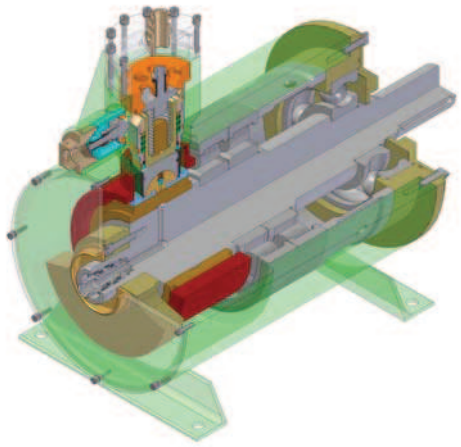

Fig. 6. Stand to the pump research

6. HARMONISED STANDARDS IN THE PROCESS OF DEVELOPING THE PUMP

The next stage after defining the directives related to the pump was to specify the detailed technical requirements which allow meeting the basic requirements of the directives. The detailed technical requirements are included in the harmonised standards. A harmonised standard does not need to include all the basic requirements of the directive. Therefore, the producer must use a supplementary technical specification.

Harmonised standards may be broken down into 3 groups:

1. General standards (A): used for many groups of products, e.g. EN 292 *General principles for design.*
2. Industry standards (B): these include detailed requirements in the selected scope, significant from the view point of safety, e.g. EN 952 *Guards.*
3. Detailed standards (C): addressing a specific group of products, e.g. EN 809 *Pumps and pump units for liquids. Common safety requirements.*

In order to meet the basic requirements of the machine directive in the scope of protection against mechanical hazards (Appendix I to the 98/37/WE directive, clause 1.3), the detailed technical requirements are used, which are included in the harmonised standards:

1) EN 809 Pumps and pump units for liquids. *Common safety requirements.*
2) EN 982 *Safety of machinery. Safety requirements for fluid power systems and their components. Hydraulics.*
3) EN 953 *Safety of machinery. Guards. General requirements for the design and construction of fixed and movable guards.*

On the basis of the above standards, technical requirements have been set forth, which allow meeting the basic requirements of the machinery directive only in the scope of protection against mechanical hazards:

- covered moving parts, such as clutch units, which may pose hazard, should be secured with guards (according to EN 953 Safety of machinery. Guards. General requirements for the design and construction of fixed and movable guards);
- rotating shafts with protruding elements, which can cause wounds, should be guarded;
- the clutch transferring drive force and its mounting should be capable of withstanding constant maximum load of the torque generated by the motor under all expected conditions of operation;
- the guard may be only removed with a dedicated tool, and the casing in the open position should be fixed to the pump;
- access should be provided for sealing the shaft in order to check its operation;
- open elements or elements accessible at a certain stage of assembly / repair should have blunt or machined edges and feathers removed;
- the elements of the hydraulic system should be easily accessible and safe in regulation and maintenance;
- all parts of the system should be so designed or secured in any other way that the pressure not exceeding the maximum working pressure of the system or any of its parts or the nominal pressure of each specified element could not cause damages to them;
- the pump should be fitted with sealing appropriate for the liquid used and for the threat from the possible leakage of this liquid;
- the producer should specify the allowed values of force and moments at the inlet and outlet pipes;
- percussive pressure and counterpressure should not pose hazard;
- leakage (internal or external) should not pose hazard;
- the paths for removing internal leakage should be located and installed so as to prevent air-locking of the system and should be selected for dimensions and location so as not to generate excess high counterpressure;
- high pressure vents should be located so as not to pose hazard for employees;
- temperature of liquid should not exceed the defined limiting values, at which it may be safely operated, or the defined range of operating temperature for particular elements of the system;
- the pump or pump unit should not lose stability during transport and assembly at tilts of up to 10°;
- the installed pump should be stable with the used clamping screws.

7. CONCLUSIONS

Based on the experience acquired during the process of creating a new solution for the pump, the following conclusions come to mind:

1. Selection of the solution concept for the device largely depends on the basic requirements included in the EU directives for the given device. The basic requirements of the directives had effect on the shape of the pump concept in the scope of:
   - selection of materials and peripheral elements,
   - control,
   - mechanical structure,
   - construction and principles of operation,
   - maintenance of operation,
2. As assessment of compliance in the global approach applies to both the production and designing stages, the designing process must be conducted based on the appropriate harmonised standards.

Identification of threats and their assessment constitute the basis for the process of reaching compliance with the basic requirements of the directives.

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[3] Nurnikowy agregat pompowy nowej generacji o parametrach technicznych nie gorszych od określonych przez Zamawiającego, Sprawozdanie wykonawcy z I etapu pracy naukowo-badawczej pod red. A. Jurkiewicz, Kraków 2003.