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MINING CHAINS IN HIGH EFFICIENCY LONGWALL SYSTEMS

1. Introduction

Coal mining is one of the few human technological activity which has a centuries-old tradition, experience and innovation in improving the operation processes. The increase of productivity alongside the safety issues have been the main topics during the changing of operational techniques for hundreds of years. Those problems have not lost their importance and are still at the forefront of mining process itself. Coal is still the most accessible fossil fuel of strategic importance for global energy. Its future share in global energy mix will be determined by the safety and productivity of mining processes together with the influence of its use for the environment. Meeting such demands requires innovative projects to ensure the competitiveness of companies supplying equipment for mining industry. It is important in that process to improve not only economic effectiveness but also the work safety.

Mining chains are of special importance in modern coal mining and its high efficiency winning and conveying systems. Their task is similar to camshaft belt in a combustion engine. They are responsible for the “management” of the whole system and decide on its efficiency parameters. Mining chain is the key factor ensuring the continuity of the operation process and coal transportation from the mining face. Its strength determines the efficiency of the whole mining complex. The complexity of its production process and maintaining the chain strength parameters require great technological knowledge in materials science and strength of materials. Innovation and improvement of chain production process are the measures of the progress in the design of high efficiency longwall systems.

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2. Capital Group FASING on the global mining chains producers' market

Capital Group FASING has 100-years history in the metal industry. Mining and technical chains as well as flight bars for AFC's and BSL's are its dominant production. The restructuring of Poland's mining sector was a great challenge for FASING. Higher efficiency mining complexes and longer longwall systems created the demand for chains with better parameters than before. That process started in the framework of restructuring Poland's coal mining industry in the early 90's of last century and introduced a new quality in company's management. Increasing competition on the market, especially by foreign entities, was a challenge to the necessary organizational transformations that would allow to meet market requirements. Change of ownership, the entrance to the Stock Exchange, investments in the modernization of machines and equipment helped to ensure the economic stability of the company and build a recognizable brand in the world. Those activities were accompanied by capital investments on foreign markets and the creation of new entities of similar production profile.

The creation on new Joint Venture with Chinese partner gave FASING the chance to enter the World's biggest coal market, both technically and commercially. Newly formed Shandong Liangda Fasing Round Link Chains Co., is now the important player on the Chinese market. It uses the newest technology obtained from FASING, its marketing knowledge, management abilities as well as the Chinese labor. With that company FASING discovered the possibility to enter the Chinese market with innovative products, technology and marketing skills, thus enabling the sales of products manufactured in Poland's factory as well.

The takeover of Germany based Becker — Prünte Kettenwerk GmbH made possible to connect and use of more than 100 years of FASING's experience to enhance technical innovation allowing mining companies to meet the expectations of high-performance, safe AFC's and BSL's drives.

Those capital investments strengthened FASING's position on the market enabling the global sales increase. It is good example of the company development by combining its investments, marketing and production activities. The decrease in Poland's coal production during recent years had direct influence on the domestic demand for mining machinery, mining chains including. The only way of securing the sale of products is to find other markets. Thus, the confrontation with other manufacturers is inevitable. The increasing presence of FASING on global mining market stabilizes the company's activity and allows to invest in new equipment and the promotion of new products for high efficiency mining complexes.

3. Mining chains in the transportation systems

Efficient mining machinery and conveying system transporting coal from mining face are the basis for the functioning of modern mining. The intensification of technological process

can take place only in safe technical environment. Mining chain is the most sensitive part of high efficient longwall system. Its role is to withstand the load caused by the high efficient mining complexes at the same time maintaining their failure-free operation. Chain's strength in the AFC's drive is a decisive factor of economic efficiency of mining process. Increasing concentration in the coal mining expressed primarily by the length of the mining faces creates a growing demand for higher capacity drives. The chain and its strength parameters are the basis for their smooth functioning.

The demand for the development of new manufacturing technologies, matching chain's parameters to mining conditions reflects the role of mining chain in the whole transportation system. These are important aspects of ensuring the economic and technical efficiency of mining systems. Thus, the challenge for mine chain manufacturers can be described as follow:

- the selection of raw material for the production,
- the quality of welding,
- the heat treatment.

Each of those processes requires technological know-how as well as experienced management and production teams. The utilization of steel with additives such as chromium, nickel, molybdenum, vanadium or tungsten was very significant for the process. The correct selection of the chemical composition of the alloy steel starts the production process. The specifications for the obtaining of optimal material with much narrower tolerances than those in steelwork's standards were created at FASING's own laboratories. These solutions, based on years of company's experience result in the product at the level of quality expected by the global mining. The role the mining chains play in the mining equipment with high capital outlay creates specific requirements to enable its failure-free continuous performance. The manufacturing process is technologically very complex. The introduction of flash instead of resistance welding, especially for alloy steels, resulted in high quality butt weld. The welding process itself was modernized. Modern welders ensure computerized monitoring of the process. The process is stopped when failure occurs. The implementation of induction heating during heat treatment process improves the monitoring, ensures high quality and repeatability of the process. The variable hardness along the link together with flexible legs and appropriately hard crowns can be achieved. As a result the high strength, wear resistant (especially at crowns) chain link is obtained.

FASING's experience gained during the long-lasting cooperation with Poland's mining industry is now well used in the production of high quality products. The changes, which started in 1988, had tremendous influence on mining sector, especially for the technical equipment used during mining processes. Those changes concerned the production of mining chains as well. Their technological parameters are decisive in the mining face advance and thus, in the whole mining process's economical efficiency area. The fundamental changes in the manufacturing of mining chains took place from the year 1988 through 2006. Those changes were driven by the demand from the mining sector seeking new equipment for the

changing mining technologies. The changing assortment of mining chains manufactured between 1988–2009 is shown on Figure 1.

The low efficient longwalls required chains mainly with the diameter of 18–26 mm and such an assortment dominated in FASING’s production in the 80’s. The technological and technical transformation affected FASING’s production as well. New range of mining chains was introduced, meaning the diameters of 30 and 34 mm. The very next step was the chain with the diameter of 38 mm. Such development called for organizational changes within the Company, and for investments in new equipment.

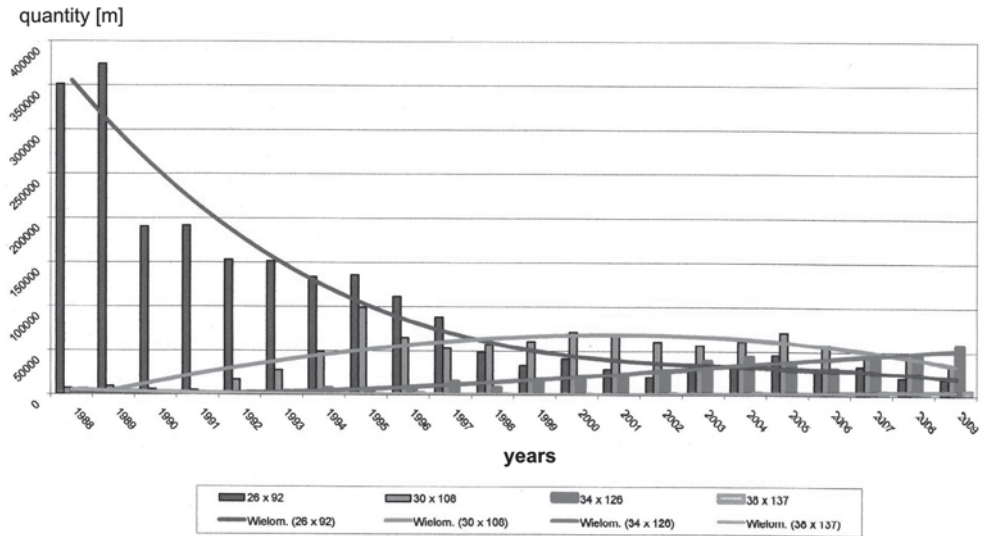


Fig. 1. FASING’s chain production 26–38 mm
(Source: Own study)

The quantity and assortment changes in FASING’s production were the consequence of qualitative changes which have taken place in Poland’s mining industry. The number of mining faces steadily decreased, beginning in 1990 (see Fig. 2).

The need to improve economic efficiency of Polish hard coal mining had an impact on the organization of the process of coal mining. Restructuring activity was mainly related to the mining technology. The progress made in that area allowed for the concentration of production by limiting the number of working longwall systems, lowering the costs, increasing efficiency and adjusting the Polish mining industry to operate in market economy. That qualitative change in the functioning of Polish mining industry also had an impact on the industrial environment.

Those activities set new requirements for mining chains. The demand for larger diameter, higher strength chains had risen.

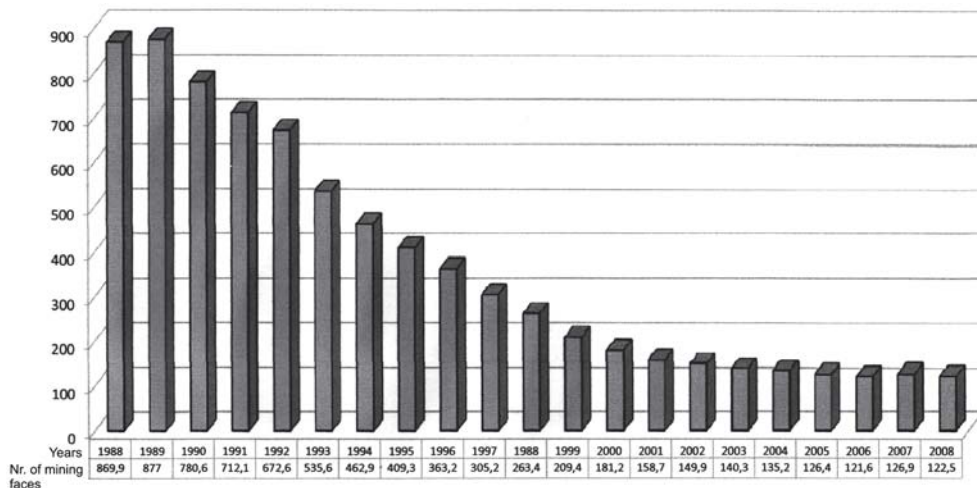


Fig. 2. Average number of mining faces in Poland's hard coal mining 1988–2008
(Source: Own study)

The said expectations required new technologies and equipment. Meeting those expectations meant the creation of conditions enabling technology for the production of chains of standards ensuring trouble-free high-performance longwall systems operation. For the new operating conditions the chain has become an integral part of the longwall equipment and no longer a necessary complement. Qualitatively, it is completely new situation. High-volume investments incurred by the coal producers to the concentration of mining are related primarily to the provision of meeting the parameters of efficiency. Failure-free operation of longwall systems is a guarantee of return on investment and the ability to achieve economic efficiency by coal mines. The role of mining chain in that process is exceptional. The chain not only assembles a mining and transporting system but it is the keystone of ensuring the achievement of its established tasks.

4. FASING's innovations In chain manufacturing technology

Intensification and concentration of coal extraction process create a need for continuous upgrading of chains to deliver the expected performance and reliability of chain conveyors serving the mining complexes.

Currently, round chains, flat chains, compact witch variable or equal pitch chains are used in chain conveyors. Differences in shape do not prejudice the strength parameters.

“Triple Low FASING Chain” designed and manufactured by FASING is clearly different from the previously used chains. The chain can replace $\phi 30 \times 108$ mm round link chain ensuring 2.5 times higher strength than the other one. The vertical link of the chain is forged

with wide profile for its universality and lower pan wear. It was designed to lower the grinding martensite phenomenon. The fast cooling is ensured by the relatively large contact area between the link and pan dissipating the heat resulted from friction. The shape and parameters of “triple low FASING chain” are presented on Figure 3. The chain with such shape and parameters ensure the fulfillment of economic, performance and safety criteria of longwall systems.

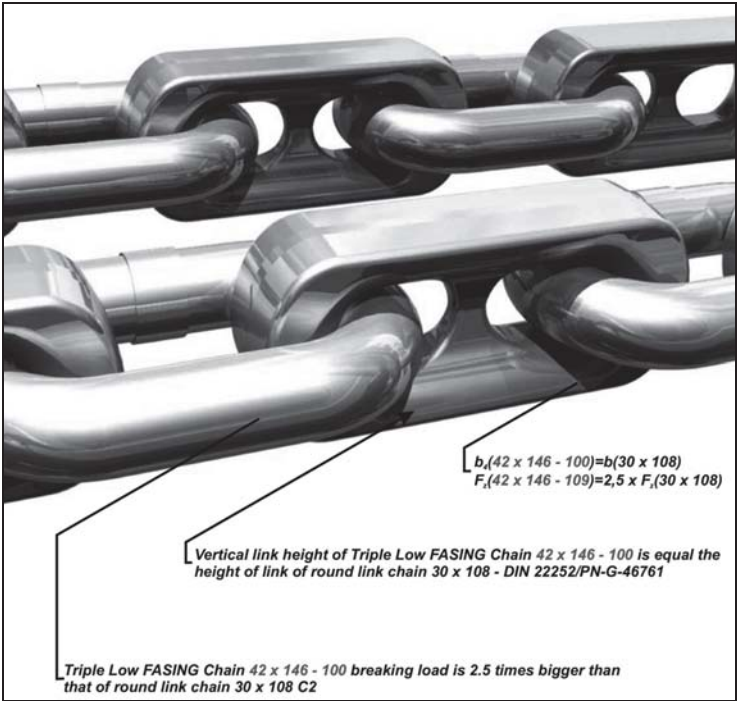


Fig. 3. Triple Low FASING Chain 42 × 146–100
(Source: Own study)

“Triple low FASING chain” offered by FASING is the product that provides transportation of ROM (run of mine) from high efficiency longwall systems. Its strength and versatility of use allows its application in conveyors at speeds exceeding 1.9 m/s and capacity of 3,000 to 5,000 t/h. The same pitch of vertical and horizontal link ensures its smooth operation. As a result of its high strength, the failure-free and reliable performance is ensured. The much longer life of the system also is reported which, in turn lowers production costs.

The full harmonization of the complex equipment in respect of its performance and safety of people employed in the service goes hand in hand with the modern mining expectations concerning high efficiency longwall systems. The key stone in that regard is mining chain. Its strength and failure-free performance translates into a multifaceted economic efficiency.

Rational use of time and getting the assumed efficiency can be achieved inter alia through the use of the chain which fulfills the technological and economic requirements. Different conditions for technological equipment employed at mining face very often require multivariate solutions in regard for feasible engineering equipment. Therefore, another feasible FASING's proposal: ϕ 42 mm flat mining chain with the pitch of 146 mm and vertical link of 109 mm in height. It is characterized with decreased link's height in order to enable the replacement of round link ϕ 34 mm chain, ϕ 38 mm flat and round link chain and ϕ 42 mm flat chain.

This chain is characterized by the "stud" situated in the middle of one of the link's flat leg. The role of the "stud" is to prevent any contact between adjacent horizontal links, as shown below (Fig. 4).

The robust 'stud' prevents its premature wear and the shape of its surface — rounded ends and smooth flat surfaces, prevent damage to the lateral surfaces of links. Its most important feature however is preventing of chain kinking thus eliminating the problem of chain straightening.

The vertical link is manufactured in die forging process, preceded by upsetting the material ensuring very high resistance to dynamic loads together with increased impact resistance.

5. Conclusion

Efficient, modern hard coal mining is first of all, the innovative technical equipment ensuring the safety and economic efficiency of mining process. An important part of critical significance for longwall systems is mining chain. The main task to be undertaken by the manufacturers of chains is to ensure their strength for the failure-free performance of the chain conveyors. The concentration of production together with the reduction of working longwall systems, increasing at the same time their productivity, call for the installation of high strength chains. FASING's proposals with regard to the innovative drives for mining complexes create rational utilization of AFC's and BSL's. These proposals have direct influence for the reduction of mining costs together with the efficient utilization of mining equipment. The systematic cost reduction is the right direction for modern mining. The technical equipment at the mining face is of fundamental importance, and mining chain plays a key role there.