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# ECO-INNOVATION IN MANUFACTURING PLANTS ILLUSTRATED WITH AN EXAMPLE OF STEEL PRODUCTS DEVELOPMENT

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The article focuses on an important, from the economic point of view, topic of manufacturing plants' innovation. It presents the effects of re-design and development of products of selected steelworks. The importance of environment friendly changes in the development of manufacturing products is also stressed in the article. The eco-innovation in connection with metallurgical products means technical, organizational and marketing changes. All innovations are orientated on eliminating or/and reducing the product's negative environmental impact.

*Key words:* eco-innovation, environment friendly design, product development

**Ekološko inoviranje u proizvodnim poduzećima ilustrirano na primjeru razvoja proizvoda od čelika.** Članak se usredotočuje na, s ekonomskog stajališta, važnu temu inoviranja proizvodnih pogona. U članku je predstavljen učinak re-dizajna i razvoja proizvoda u odabranoj čeličani. Važnost prihvatljivih promjena u okolišu za vrijeme razvoja proizvoda je također naglašen u članku. Eko-inoviranje metalurških proizvoda znači tehničke, organizacijske i marketinške promjene. Sva inoviranja su orijentirana na uklanjanje i / ili na smanjenje negativnog utjecaja proizvoda na okoliš.

*Ključne riječi:* eko-inovacije, okoliš dizajn, razvoj proizvoda

## INTRODUCTION

In the global economy environment, industrial products need to be re-designed in order to meet the requirements of the global market. Changes regarding products are implemented on two levels, with one focusing on their competitiveness and the other on environment protection. There is an interaction between both levels as competitive products are mostly those products that have been re-designed to become environment friendly. The European Union *Green Paper on Integrated Product Policy* describes the importance of environment friendly design in the following way: „the integrated product policy should first of all focus on the design of environmentally friendly products" [1]. Industrial products are a direct or indirect cause of environment pollution and as such should be re-designed. Over the recent years there have been a number of changes to industrial products. In some cases completely new, environment friendly products were created as a result of a process called eco-innovation. Most frequently, however, the development of products consisted in the introduction of changes without a change to the main structure of a product but considerable improvement of its environmental impact (product modification).

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## ECO-INNOVATION

Prior to the explanation of the term eco-innovation, the word innovation should be defined. It derives from the Latin word of *innovare* which means „make new".

Innovations in production plants are based on scientific and technical progress. One may say that innovations in industrial plants are all product design and development processes aimed at the application and implementation of improved solutions in science, technology, work organization and management methods [2].

The term of eco-innovation in connection with products means technical and process changes (organizational, marketing, etc.) in the structure of a product in relation to all the stages of its existence aiming at eliminating or/and reducing the product's negative environmental impact. Eco-innovations imply progress i.e. they consist in the development of new or significantly better products.

## ENVIRONMENT FRIENDLY DESIGN AND PRODUCT DEVELOPMENT

Environment friendly design is aimed at the introduction of changes in the structure (main structure) of a product in order to:

- increase the amount of recycled materials,
- decrease product weight and the amount of generated waste (if possible, create non-waste products),

– increase the efficiency of power and raw materials consumed during production (saving resources and materials at the start of the manufacturing process, improvement of the product's material and power consumption index),
– reduce manufacturing costs (environmental and economical effects as the basic principle of environment friendly re-design of products - cleaner production principles),
– improve product functionality (clean use principles), reliability, durability and easy disassembly,
– solve problems related to utilization and recycling, (easy recycling and re-use),
– increase market appeal of the product and meet international quality standards [1].

Life Cycle Assessment (LCA) addresses the environmental aspects and impacts of a product system and it is used to product development. Life Cycle Assessment is one of several environmental management techniques for evaluation of impacts that a product or process has on the environment over the entire period of its life – from the extraction of the raw materials from which it is made, through the manufacturing, packaging and marketing processes, and the use, re-use and maintenance of the product, and on to its eventual recycling or disposal as waste at the end of its useful life [3].

Life Cycle Assessment (LCA) study in steel industry is widely developing in the world. This method has been undertaken in ULCOS (Ultra Low $CO_2$ Steelmaking) as the most holistic approach of assessing environmental impact and selecting new technologies. The aim of the ULCOS program is to develop breakthrough technology that will reduce the Carbon dioxide ($CO_2$) emissions of today's best routes by at least 50 %. ULCOS is a major program, which plans to find innovative and breakthrough solutions to decrease the $CO_2$ emissions of the steel industry. In the ULCOS program innovative ironmaking processes are under development [4].

## EXAMPLES OF ENVIRONMENT FRIENDLY IMPROVEMENTS TO PRODUCTS

As a case study the following steel plants operating on the Polish steel markets were used: ArcelorMittal Poland SA, Ferrum SA, Huta Batory Sp. z o.o. From among the aforementioned companies ArcelorMittal Poland SA is the biggest steel producer. The company has a Product Development Office that in 2008 carried out the following tasks:

1. Preparation of documentation and start-up of new products manufacturing: HE 400 I-section, HE360 I-section, UPE160, 180,200 U-sections with parallel alloys; documentation on roll pass design for rolls producing PU7 sheet pile, HE320 and 340 I-section made from slabs, I-sections for the Russian market in compliance with the CTO АСЧМ 20-93 standard; documentation on roll pass design and implementation of changes to the production of the G46 sheet pile making evaporation from PU sheet pile possible, changes in the production of I-sections making it possible to limit the number of stands; the production of HE320,360 I-sections from MCOS-3 feedstock, documentation on IPE600 I-section and P65 bar.

2. Introduction of new grades of steel : C9d/3, C82D/2 for the production of wire rods and related products; S355G11 – construction steel for buildings and quay structures, S355Ml – construction steel with guaranteed impact resistance (at -50°C); construction steel - sections compliant with GOST standard, S355K2/FRITENAR 355- construction steel with guaranteed impact resistance of 40J (at -20°C).

3. Rolling tests of new grades of steel and their main usage: fine-grained thermo mechanically rolled structural steel, steel for welded gas containers, structural steel with enhanced corrosion resistance, steel with a high yield point for cold stamping, for the production of electro filters, multi-phase steel for the construction industry, steel tubes for the transmission of liquid fuels and the shipbuilding industry, other steel used for tube making [5]. It needs to be stressed that in 2006 ArcelorMittal Poland SA introduced 14 new grades of steel, whereas in 2007 their number reached 17.

The implemented product modifications contributed to the achievement of the following ecological and economical results: reduction of G480V steel consumption (V25, V29, V32,V36 sections) - reduction of steel consumption in lining structure owing to the increase of the mechanical property $R_{emin}$ z 340 MPa na 480 MPa); manufacturing savings (150x150 x 16 ÷ 20 mm equal-sided angle - eliminating the need to develop a new production technology and the purchase of new roll assemblies in order to start-up the production of 150x150 angles with a thickness from 16 mm to 20 mm, extending the rolling campaign by over 1000t from one pass draw), entering new markets (10Б1, 12Б1, 12Б2, 14Б1, 14Б2, 16Б1, 16Б2, 18Б1, 18Б2 parallel-piped I-sections in compliance with GOST 26020-83 standard – entering the Russian market), increase of profit due to the replacement of an old product with a new one with a higher mark-up, strengthening of the products brand and the corporate image [6]. The steel company receives national and foreign awards for innovation, e.g. the introduction of a new type of steel i.e. G480V for the production as sections used in mining linings received a distinction at the corporate competition entitled 'Performance Excellence Award 2007'. The biggest number of awards went to Zak³ad Wielkopiecowy (Blast Furnace Plant). The invention project entitled '*Urządzenie do usuwania skrzepów kanału odciągowego pokrywy pieca kadziowego*" – received the award and certificate of the World Intellectual Property Organization for the best solution submitted for the 6$^{th}$ International Ecological

Competition ECO 2005. In 2006 ArcelorMittal was among the ten most innovative companies and received the Innovation Leader 2006 title. At the national level, the company was awarded the Grand Prix title at the EKO-2007 competition for 10 innovative projects [6,7]. Moreover, the Cracow-based branch of ArcelorMittal Poland received an award for innovation at the $10^{th}$ Little Poland Quality competition.

Another company whose innovative activities have been analysed is Ferrum SA. The company specializes in the production of pipes for the transmission of utilities in Poland. The applications of manufactured steel pipes are as follow:

- gas pipelines,
- water and sewage transportation,
- district heating networks,
- oil transportation,
- other media transportation (both above and underground).

Environmental investments i.e. the modernization of the thermal cutting process in the production of welded structures and the investment of high frequency pipe welding line brought about environmental and economical results illustrated in Tables 1 and 2 [8,9].

The company Ferrum SA produces:

- high frequency induction welded steel pipes,
- spirally welded steel pipes,
- longitudinally welded steel pipes,
- extruded tree-layer PE coating,
- internal protective cement lining for steel pipes and fittings.

Table 1 **Environmental and economical effects of the modernization of welded structures thermal cutting process in Ferrum [8]**

| **Environmental effects** |
|---|
| – reduction of the amount of waste – scrap meal by 250 tons/year, |
| – reduction of technical gases consumption in thermal cutting: oxigen by 18 000$m^3$/year and acetylen by 1000 kg/year, |
| – reduction of calcium carbide consumption by 1000 kg/year, |
| – reduction of toxicity category III waste production – carbide residue by 3 tons/year, |
| – elimination of the source of impulse noise, |
| – savings in raw materials and energy as well as in fuels at the sheet producers and power suppliers owing to the reduced demand for charge |
| **Economical effects** |
| – savings in materials and labour (PLN 797 300 per year), |
| – profit from the production of casings for shipyards: |
| – 1996 – PLN 146 000; |
| – 1997 – PLN 157 300; |
| – 1998 – PLN 166 300. |
| – total economical effect in 1996 was – PLN 943 300 |

Welding Department in 2002 was separated from the enterprise, now it is the firm in ZKS Ferrum SA.

Ferrum products (pipes) can be used as the following construction elements:

- pipelines casing,
- shipbuilding industry,
- mining industry,
- welded structures,
- masts,
- chimney ducts,
- elbows and others fittings.

Table 2 **Environmental and economical effects of the investment of high frequency pipe welding line in Ferrum SA [9]**

| **Environmental effects** |
|---|
| – reduction of air-emissions ($CO_2$, NO, $SO_2$, dust), |
| – elimination of solid waste - welding slags and dust (toxicity category 4) – before investment: 330 Mg/year, after modernizationp – complete elimination of this kind of waste, oil scale from pipe expander (toxicity category 2) – before investment: 10 Mg/year, after investment completion – complete elimination of this kind of waste |
| – reduction of electric power consumption by 181 608 kWh/year i.e. 6,538 * $10^8$ kJ/year, |
| – reduction of hard coal consumption by 55,688 Mg/year and brown coal consumption by 107,502 Mg/year |
| **Economical effects** |
| – savings of materials, |
| – savings of labour, |
| – reduction of manufacturing costs, |
| – introducing products to new markets |

While analysing product innovations implemented in Huta Batory (Batory Steelworks), which specialises in the production of seamless tubes, it was noted that there had been investments in the modernization of the boiler tubes ultrasound testing work station, the range of products on offer had been extended to comply with the European Union and the United States markets, the mechanical properties and impact resistance of the products had been enhanced (high and repeated impact resistance at the temperature of -40° C) and uniform texture of products (cross-section) was achieved. The company also produced a test batch of pipes for the transmission of crude oil and gas at low temperatures (in response to the demand of the Russian market). In 2007 the production of high resistance tube stock to be used for coal carriages construction started. Construction, boiler and line tubes as well as drill pipes are manufactured with the application of the best available technique (BAT). The company obtained the API – American Petroleum Institute licence for line tubes and drill pipes (2003). The main applications of X60 (and higher) tube stock, according to the API-5L licence, are high pressure pipes (low thickness of the wall) and submarine pipes (thick-walled). Huta Batory (Batory Steelworks) in cooperation with the Institute for Ferrous Metallurgy in Gliwicecarries out research and development studies aiming at the preparation of a range of steel grades for

the power and chemical industries with an increased nitrogen content and the development of manufacturing technology for products from this particular type of steel. The Batory Steelworks has cooperated with the Institute for several years. In 2001 it resulted in the introduction of a steel grade (P92) used for the construction of super-critical parameter boilers (addition of tungsten and boron). The Batory Steelworks has developed its own, company standard, ZN-HB-002/2003, which defines the production and acceptance of tubes made of this steel grade [10].

## CONCLUSION

The steel companies mentioned in the article have environment management systems (according to ISO 14001 standard) and quality assurance systems (ISO 9001) in place. The introduction of changes to the manufacturing process depends on the adopted environmental policy and demands of the market. In each of the examples of product innovations described above both ecological and environmental effects were achieved. New products ensured the company's sales in new market segments and enabled them to increase their share in the market. Eco-design and international standards are conducive to the development of entrepreneurship and diversification of products range. Eco-design spurs innovation and helps to intensify the search of innovation in the area of environment protection, comes up to the customers' expectations and improves the image of steel companies and their products.

The companies in metallurgical sector in Poland use the strategies of the sustainable development, so they have to realize the specific triad: economy-environment – society. All new and modernized products have got high quality and protect our environment. In the all analysed enterprises are management systems according to requirements of ISO 9001 standard and ISO 14001 standard and activities connected with social responsibility business. By improvement and development of production, companies in Polish market can reach the requirements of international standards.

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**Note**: Translated at Niuans Translation Agency – Gliwice, Poland.