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INNOVATION ACTIVITY IN POLISH INDUSTRY - POSSIBILITIES OF ENVIRONMENT-ORIENTED PRODUCT RATIONALIZATION THROUGHOUT LIFE CYCLE IN A METALLURGICAL ENTERPRISE

Bożena GAJDZIK

The Silesian University of Technology, Faculty of Materials Science and Metallurgy, Department Management and Informatics Science, Katowice, POLAND

ABSTRACT:
The aim of this article is to present the key elements of possibilities of environmental changes in metallurgical products during their life cycles. As case study was used the enterprise Ferrum - steelworks plants in Polish metallurgical sector. Moreover, on the basis of statistic data, the key innovation trends in Polish industry are presented here.
KEY WORDS: product life cycle, Life Cycle Assessment (LCA), product rationalization, product and process innovation

1. INTRODUCTION

Contemporary customers place new demands upon steel enterprises. Consumers expect not only high product quality assurance but also environment friendliness of the products - the reduction of their negative environmental impact. The balance between economical and ecological aspects as well as the reduction of negative environmental changes seems crucial here. Management in metallurgical enterprises is a deliberate, ordered set of actions ensuring the implementation of the sustainable development principles. One of its elements is the environment-oriented product rationalization throughout the products' life cycle and modernization of technology. Innovation activity in industry concerns elaborating and implementing of new or significantly improved products (goods and services)– product innovation and processes – process innovation. It comprises many different scientific, technological, organizational, financial and commercials steps. Enterprises have their own R&D offices or buy disembodied technology and know-how – patents, licences, trademarks etc. In Poland enterprises' expenditures on R&D activity and innovation grow systematically. The enterprises co-operate with the surrounding in order to gain new innovations. New technological solutions and new products help the enterprises to get advantage in the competition. Innovation – creating something new, unique, never before done.

2. PRODUCT LIFE CYCLE

The product life cycle is a period from the creation of a product to its withdrawal from the market. From a marketing perspective a product life cycle consists of four stages [1]:

- market introduction stage,
- growth stage (sales volume increases),
- mature stage (sales volume peaks – maximum sales),
- decline stage (sales volume decline).

Taking into account the eco-design requirements, the product life cycle should extend to include two additional stages of product design and recycling post-product waste. The Life Cycle Assessment (LCA) is an evaluation of its life from the design phase, through production, market introduction and, finally, loss of its utility value. The ISO 14040 standard presents general requirements regarding the analysis based on the LCA methodology.

LCA is defined as a statement of elements on input and output in production system and its potential environmental impact in the whole life cycle i.e. from the acquisition of raw materials through production, use or consumption to the eventual introduction of waste back into the

environment [2]. The purpose of the life cycle assessment in a metallurgical company is the establishment of actions whose target will be to manufacture a product that minimizes negative environmental impact. While carrying out a product life cycle assessment a company should:

- analyze and assess the product's environmental impact at specific stages of the cycle,
- undertake actions that reduce the product's negative impact on the environment,
- maximize environment friendliness of product design and technological processes [3].

3. ENVIRONMENT-ORIENTED PRODUCT RATIONALIZATION THROUGHOUT LIFE CYCLE

The process of environment-oriented rationalization of metallurgical products in their life cycle consists in the search of possibilities of reducing the products' negative environmental impact in all stages of its life (design, production, use, after use processing). The rationalization of metallurgical products is conducted through, among others:

- reduction of energy consumed during manufacturing processes by the introduction of new, less energy-consuming manufacturing technologies,
- reduction of the amount of raw materials used by the introduction of less material-consuming technologies (steel production consists of two main processes: converter-oxygen and electrical – in electrical arc furnaces. In the converter process pig iron with a 15-20% addition of scrap steel is supplied to the converter, whereas in the electrical process the steel is made mostly from scrap (80%),
- reduction of water consumption in manufacturing processes (closed water cycles),
- reduction of the amount of waste water generated,
- reduction of the amount of waste at every stage of the product's life cycle (waste management, reduction of hazardous waste),
- reduction of air pollution,
- modernization of the heating system (savings of heat, renewable energy sources),
- modernization of the transportation system,
- improvement of work organization.

Designing energy- and material-efficient products or products made of recycled materials (scrap steel), the application of waste reductions technologies (precise computer-controlled processes e.g. metal sheet cutting), development of non-waste technologies and clean production are most desirable. In the product manufacturing stage the preparation of manufacturing is crucial. It includes the choice of materials, manufacturing technologies, equipment and work organization methods. Energy- and material-efficiency of products, the amount of waste and pollution emissions are all dependent on the manufacturing technology. In metallurgical industry there have been investment projects focusing on environment production and product modification for many years. The statistics show that the share of new and modified products sales in overall sales has varied from 6.2% to 19.7% over the past few years (table 1). Enterprises which introduced new or significantly improved products and process during 2006-2008 represented 37.7% of total enterprises in Poland [5]. More information was presented in table 2.

Table 1. Share of technologically new and improved products sales in overall sales of industrial products in Poland [4, 5]

Specification	Products introduced into the market during [in %]					
	1998-2000	2000-2002	2002-2004	2003-2005	2004-2006	2006-2008
Manufacture of basic metals	6.7	6.2	11.7	7.5	6.2	8,3
Manufacture of metal products	15.8	19.7	18.7	12.8	7.3	11,2

Table 2. Product and process innovation enterprises in Polish industry (sections: manufacture of basic metals and manufacture of metal products [5]

Specification	Enterprises which introduced innovations during 2006-2008 [% of total enterprises]			
	grand total	new or significantly improved products		new or significantly improved processes
		total	of which new to the market	
Manufacture of basic metals	49,7%	32,2%	19,9%	40,9%
Manufacture of metal products	38,4%	28,0%	17,7%	30,5%

Intramural expenditures grow systematically in Polish industry. The scope of the analysis were the years 2000-2008. The values given in the local currency (Polish zloty) were converted to the currency of the EU (euro), the used exchange rate was the mean value of the last few years, which equalled 4 zloty = 1 euro. The first area of analysis was intramural expenditures on R&D activity and research equipment in Polish industry (fig. 1).

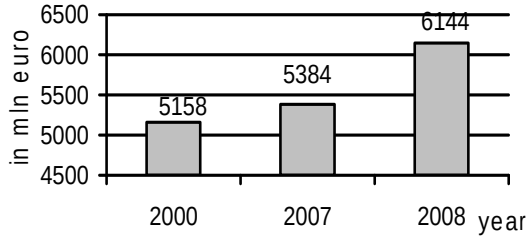

Fig.1. Intramural expenditures on R&D activity and research equipment in Polish industry (grand total) [5]

In the manufacture of basic metals sector euro 239 mln were spent on R&D activity and research equipment. In the manufacture of metal products euro 173 mln were spent on the innovation activity [5]. Moreover, expenditures on innovation activity for products and process innovations in Polish industry rose two times. In 2000 enterprises spent euro 48939 mln on the kinds of innovation but in 2008 expenditures grew to euro 97083 mln (fig. 2).

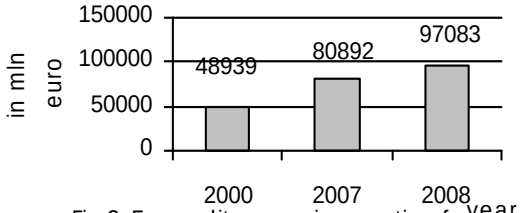

Fig.2. Expenditures on innovation for product and process in Polish industry (total) [5]

In the manufacture of basic metals sector euro 5069 mln were spent on new products and processes and in the manufacture of metal products sector euro 5130 mln were spent for the same purchase [5].

The structure of type of innovation was presented in table 3. The highest expenditures were on the acquisition of instruments and equipment. In per cent of total expenditures it set more than 60%. New technology as a resource is the significant source of advantage over the competition.

Table 3. The structure of expenditures on particular kinds of innovations in Polish industry sectors: manufacture of basic metals and manufacture of metal products [5]

Specification	Expenditures on particular types of innovations in 2008 [% of total expenditures]					
	on research and development activity	on the acquisition of external knowledge	capital		on staff training with innovation activity	on marketing for new product & significantly improved products
			on the acquisition of instruments and equipment	on buildings		
Manufacture of basic metals	4.2%	0.05%	69.26%	25.25%	0.18%	0.3%
Manufacture of metal products	3.04%	1.78%	62.71%	27.69%	0.43%	1.95%

In the manufacture of basic metals sector euro 3508 mln was spent on the purchase of new machines and technical devices in 2008, whereas in the manufacture of metal products sector euro 3216 mln was spent for the same purpose. Metallurgical companies that introduce innovations accounted for over 45% of all companies operating on the Polish market in the years 2006-2008 [5].

4. CASE STUDY – ENVIRONMENT-ORIENTED RATIONALIZATION OF PRODUCTS IN A METALLURGICAL COMPANY

A case study chosen to illustrate the rationalization issue is Ferrum SA. The enterprise specializes in the production of welded steel pipes. The applications of manufactured steel pipes are as follows: gas pipelines, water and sewage transportation, district heating networks, oil transportation and other media transportation(both above - and underground). The high quality of the pipes supplied is guaranteed by the Quality Assurance System according to requirements of ISO 9001 standard that is implemented in the whole enterprise and EMS accordance to ISO 14001. As the first enterprise in Poland, Huta Ferrum SA obtained the Cleaner Production Certificate (1996) [6]. The environmental reports of Ferrum SA served as a basis for an analysis of technological processes rationalization and the achieved ecological results. By making systematic investments the company achieved a long-term reduction of solid (fig. 3) and liquid (waste water) waste (fig. 4) generated.

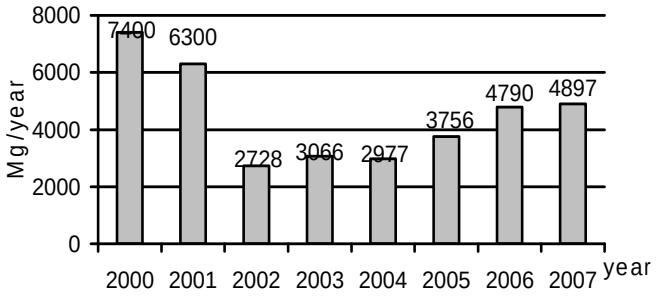

Fig. 3. Waste management in the enterprise Ferrum[7]

gas and waste streams treatment. The waste minimizing policy applied by the company is implemented through minimizing waste at the source and includes changes of raw materials, processes, products and technological investments [8,9]. It needs to be stresses that owing to technological investments and products modifications the amount of gas waste has also been reduced - table 5 shows 2006 and 2007 data.

From the total of generated waste approx. 98% undergoes recycling, whereas the remaining part is neutralized. Detailed information is presented in table 4. The company systematically reduces the amount of hazardous waste that accounts for about 1.89% of all waste. Waste is not stored on the site - the generated waste is recycled and utilized. This rational approach to waste management mainly consists in the improvement of product quality and streamlining the processes of waste (smelter)

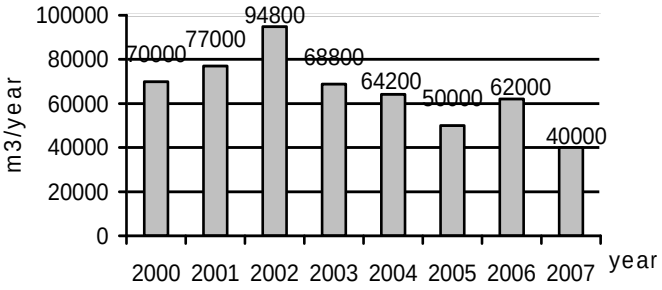

Fig. 4. Industrial waste water management in the enterprise Ferrum [7]

Table 4. Recycled waste at Ferrum SA [7]

Year	Amount of waste generated (tons/year)	Recycled waste	Percentage of recycled waste in overall waste in a given year
2000	7 400	6 900	93.24
2001	6 300	6 200	98.41
2002	2 728	2 705	99.15
2003	3 066	2 935	95.72
2004	2 977	2 959	96.03
2005	3 756	3 676	97.87
2006	4 790	4 622	96.49
2007	4 897	4 816	98.34

Table 5. Air pollution emissions of Ferrum SA [7]

Data on air pollution emissions		unit	2006	2007
total gas emissions including CO_2		[Mg/year]	8449	7447
total gas emissions excluding CO_2		[Mg/year]	41	22
total dust emissions		[Mg/year]	6	3
emission from fuel burning for heating purposes	total	[Mg/year]	8387	7349
	dust	[Mg/year]	6	3
	NO_x (as NO_2 equivalent)	[Mg/year]	15	13
	CO	[Mg/year]	11	4
	SO_2	[Mg/year]	13	4
	CO_2	[Mg/year]	8343	7325
	other	[Mg/year]	-	-
emission from technological processes	Total	[Mg/year]	68	101
	dust	[Mg/year]	0.25	0.245
	NO_x (as NO_2 equivalent)	[Mg/year]	0.07	0.118
	CO	[Mg/year]	0.02	0.025
	SO_2	[Mg/year]	-	-
	Freon and halocarbons	[kg/year]	-	-
	CO_2	M[g/year]	65	100
	CH_4	[Mg/year]	-	-
	other	[Mg/year]	3	0.6

Savings have also been recorded in energy consumption (electricity and heating) and water use. In 2000 the company's manufacturing processes consumed 13 367 MWh of electricity whereas in 2007 the number dropped to 13 113 MWh. As regards thermal energy consumed, in 2000 it was 118791 GJ, whereas now it is 65340 GJ. In case of water management, in 2000 its consumption was 73000 m^3 whereas now it is only 45000 m^3 (table 6).

Table 6. Energy and water consumption by Ferrum SA [7]

Year	Total electricity consumption (MWh/year)	Total thermal energy consumption (GJ/year)	Total water consumption (m^3/year)
2000	13 367	118 791	73 000
2001	11 486	98 235	80 000
2002	8 555	79 991	106 000
2003	9 723	70 397	74 000
2004	9 058	60 564	70 000
2005	10 107	70 400	53 000
2006	11 525	74 354	69 000
2007	13 113	65 340	45 000

5. CONCLUSION

Environment-oriented strategies of metallurgical companies focus on one hand on their product's modern quality - product made of recycled materials, energy- and material-efficient, etc., and on the other hand on the 'environment friendly' image of a company that systematically reduces the negative environmental impact of its manufacturing technology and products.

Innovation in enterprises are effective, although not necessarily simple way in securing competitive advantage and business growth for enterprises. Addressing competitiveness concerns of globally competing industry implies the need for manufacturing enterprises to implement new and innovative solutions. These innovations are associated with products, production processes, technology and other activities. Innovations in today's globally competing environment may vary widely across markets. In the paper some of them were characterised.

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