Procedia
Environmental Science,
Engineering and Management
http://www.procedia-esem.eu

Procedia Environmental Science, Engineering and Management **7** (2020) (1) 45-51

24th International Trade Fair of Material & Energy Recovery and Sustainable Development, ECOMONDO, 3th-6th November, 2020, Rimini, Italy

NEW INFORMATION TECHNOLOGY MODELS TO SUPPORT PROPER AND EFFECTIVE BUSINESS MANAGEMENT TO IMPROVE THE TRANSITION TO THE CIRCULAR ECONOMY*

Daniele Giuseppe Romanello[1], Francesco Caramagno[2], Antonio Zerbo[3], Vincenzo Guadagnuolo[4], Alberto Bertino[4]**

[1]Department Electrical Electronic and computer Engineering, University of Catania, University of Catania, Via Santa Sofia 64, 95123Catania (Italy)
[2]Department ofPhysics and Astronomy "E. Majorana", Via S. Sofia, 64, 95123 Catania (Italy)
[3]Department Economics and Business, University of Catania, Corso Italia 55, 95129, Catania, Italy
[4]Acciaierie di Sicilia spa, Strada Comunale Passo Cavaliere, 1A, 95121 Catania CT, Italy

Abstract

The aim of this paper is to propose technological innovations that support companies in complying with document and management obligations, including the use of management software to simplify emission, storage and control of data regarding legislative requirements, authorization and analytical monitoring of water and waste pollution. This is also the way to facilitate the competent authorities in the control and suppression of wrongdoing. To this end, a leading metallurgical company of the Sicilian territory, Acciaierie di Sicilia spa, has been investigated, which implements the circular economy in its production cycle, producing round for reinforced concrete starting from the scrap iron. The company uses software that can control business schedules and performance, implements business intelligence to explore data, creates interactive dashboards, and builds great reports; moreover, it carries out performance management to connect the information and knowledge obtained with Business Intelligence and plan the control cycles of the whole organization.

Keywords: business schedules, E-R model, digital transformation, steel sector, technological innovations

*Selection and peer-review under responsibility of the ECOMONDO
**Corresponding author: e-mail: caramatafra@gmail.com

1. Introduction

In last years, it is necessary to apply automation information technology and connectivity to achive the digitalization of steel production that goes far beyond conventional automation of industrial production. Initiatives have been started around the globe to foster digitalization, like IIoT (Industrial Internet of Things) in the US, Industrie 4.0 in Germany, or China 2025. Primetals Technologies is actively driving the digitalization shaping the future of steel production (Herzog et al., 2017).

To improve the efficiency of natural resources use and reuse, a digitalized network system was implemented in a steel industrial complex. The system consisted of four parts: online instrument and sensing devices, programmable logic controller, data communication network and control center based on expert knowledge (Wang et al., 2011).

Emerging of information processing with physical processes IT-systems directly embedded in the technical process; Integration of processes among themselves by information flows; Interaction of the technical process with its environment; Learning functions to adapt technical processes and IT-systems. Decision support regarding quality control Smart control of process chain (through-process automation); Smart evaluation of large amounts of data Re-scheduling of materials and Smart assistance systems, Smart (predictive) maintenance. Digitalisation is a necessary pre-condition for Industry 4.0, but Industry 4.0 is much more than digitalisation; Industry 4.0 is more a paradigm/philosophy than a technology and the main job is now to find the best applications for Industry 4.0 with the largest possible effort for steel industry.

The digitization of business processes is an opportunity arising from the social and economic context in which we currently operate: not only the rules are pushing towards this goal, but also the business and management needs of digital documents. The aim of this paper is to propose technological innovations that support companies in complying with document and management obligations, including the use of management software to simplify emission, storage and control of data regarding legislative requirements, authorization and analytical monitoring of water and waste pollution. This is also the way to facilitate the competent authorities in the control and suppression of wrongdoing. To this end, a leading metallurgical company of the Sicilian territory, Acciaierie di Sicilia spa, has been investigated, which implements the circular economy in its production cycle, producing round for reinforced concrete starting from the scrap iron.

The company uses software that can control business schedules and performance, implements business intelligence to explore data, creates interactive dashboards, and builds great reports; moreover, it carries out performance management to connect the information and knowledge obtained with Business Intelligence and plan the control cycles of the whole organization (Bonanno et al., 2018). Digital transformation, proposed by an Entity Relationship (E-R) model for conceptual and graphical data representation at a high level of abstraction, could combine self-service analytics capabilities with company data control and management, easily implement planning and budgeting solutions, perform timely profitability analysis and scorecards to effectively adjust business performance with strategic goals. Benefits would include automatic timing, reduced response time and corporate bureaucracy, comprehensive improvement in decision-making, less punitive and more stimulating management of corporate human resources.

2. Case study: *Acciaierie di Sicilia*

Acciaierie di Sicilia S.p.A company, part of the *Alfa Acciai group* since 1998, is the only steel mill in Sicily. Located in the industrial area of Catania, the company has a production capacity of about 500,000 tons / year of rebar for bars and rolls, obtained through the electrofusion of ferrous scrap from the region. This important production company employs a total of 200 people. Thanks to the dimensions reached, to the technology used and to its products, the company has placed itself in a prominent position in the European steel industry. It represents for the *Alfa Acciai Group* the natural reference for the market of southern Italy. Among the company's main objectives environmental sustainability and product quality are found which are actually used in the production of "eco-sustainable steel" B450C S, which ensures excellent performance in anti-seismic structures. The objective of eco-sustainability is also confirmed by the environmental certifications obtained (EN ISO 14021, ISO 14025, EPD, LCA). Furthermore, the Company, by using the scrap (waste) as raw material and transforming it into a finished product (round), represents an example of "Circular Economy" (Lavallèe and Plouffe, 2004).

As far as the steel production process is concerned, it is of the so-called "solid charge" type. It involves the fusion of ferrous scrap in the electric furnace with the addition of ferroalloys, fluxes and recarburizers. This process is divided into the following phases:

Preparation of the charge baskets. The packing of the charge baskets take place in the scrapped room, and then everything will be loaded in the oven.

Merger. Fusion of the ferrous scrap in the electric furnace.

Pre-refining. When the last basket is completely melted, liquid steel is collected using an automatic sampler and sent to the Steelwork Laboratory for chemical analysis. At the same time, thanks to continuous oxygen blowing, the steel is decarburized until reaching the desired carbon value for tapping.

Tapping. The melted and slagged steel is tapped into the ladle by a beak-shaped opening on one side of the oven. The tapping operation must be carried out quickly, paying attention that melting slag is not transferred, which due to its highly oxidising characteristic becomes the cause of problems during ladle processing.

Processing in ladle. When the tapping is finished, gas is continued to be blended to homogenize the chemical composition after the addition of the ferroalloys during the tapping. The ladles containing the steel, compliant by chemical composition and temperature, are sent to continuous casting for the production of billets.

Continuous casting. In continuous casting, the greatest importance is attributed to the ingot mould because, the solidification of the steel begins there with the formation of a layer of solid peripheral skin that must withstand the ferrostatic pressure of the liquid steel inside it. During this phase the scrap is transformed and solidified into billets, which are nothing more than parallelepipeds that have sections equal to 330 mm and are 11 m long. These represent a semi-finished product for the company that may be sold as they are, to external or foreign mills that then work them according to their needs, or they can become the raw material for the mill department.

Rolling process. Inside the mill section, the billets are heated again, inside a heating furnace that brings them to the optimal temperature to be then molded inside the rolling mill and transformed into the finished product. The finished product is the rebar for reinforcement (in bars or rolls) with sections ranging from 8 mm to 30 mm and which are identified by the hot stamped company brand during the lamination reproduced longitudinally at a distance of about 800 mm. This trademark, being deposited with the organisation issuing the qualifications, allows it to be distinguished at any time even after delivery to the customer. Finally, the finished product is stored inside the warehouses and subsequently sold.

Acciaierie di Sicilia S.p.A is fully aware that a responsible and sustainable economic strategy, addressed to the environmental problems deriving from its activities, is essential to achieve long-term competitive success. Industrial sustainability is intended as a balance between expectations for growth in business value, protection of the environment, protection of health and safety of workers and satisfaction and respect for its customers.

Steel compared to other competing materials in the life cycle has lower energy consumption, high recyclability, conservation of natural resources and extensive reuse of by-products.

It is a widely used material, as an important component for a wide range of applications and market products, such as in the automotive, construction and packaging industries. Only after a very careful LCA study of specific activities can the company obtains the EPD. Before identifying the reason/motivation for which a study is conducted, it is necessary to identify the system where it builds the study (with the appropriate limitations).

The analysis of the Life Cycle Inventory (LCI) provides the creation of an inventory of flows to and from nature for a product system. Inventory flows must incorporate inputs of water, energy, raw materials and emissions into the air, land and water. To develop the inventory, a flow model of the technical system is constructed using data on input and output, which can subsequently be processed and commented, which is going to be used to make assessments and useful indications at the decisional level (Westkämper et al., 2000).

The Sicilian firm believes in sustainability and demonstrates it through the implementation of an integrated management system according to ISO 9001 (2015) for quality, ISO 14001 (2015) for environment and ISO 45001 (2018) for safety. In addition, company disposes about an Integrated Environmental Authorization related to energy activities, production and processing of metals, this mandatory regulation (Legislative Decree 152, 2006) provides for the use of BAT, Best Available Techniques, widely owned by the company to improve efficiency levels of plants and reduce pollution. Moreover, firm is certified ISO 14021 (2016) concerning the content of recycled material and ISO 14025 (2006) with regard to the environmental product declaration and its impacts. Finally, company has the Susteel which is a voluntary certification of the sector and the ICQM ECO which measures environmental performance of the product. Acciaierie di Sicilia until now, in the industrial symbiosis view related to water -safety, it has implemented purifier, iron – removing and water – waste treatment plant (Guadagnino et al., 2018).

Concerning the air variable, it has installed scrubber systems and gas cleaning to monitor and reduce fine dust and CO_2, then it has also injection system of carbon active which allows to control emissions and, in particular, mercury’s ones. Additionally, the steelwork has the continuous monitoring of emissions to avoid environmental accidents and the dioxin sampler that has the same scope. Lastly, the firm wants to implement in the recent future carbon footprint, the water footprint and also the environmental performance indicators.

3. Materials and methods

Digital transformation is making everything faster, more personalised, and more efficient. In particular, seamless vertical and horizontal networking, optimisation algorithms, and data-driven models are becoming crucial in providing the increasing flexibility in production planning without the negative impact on productivity and operational stability. Nonetheless, technological know-how in metallurgy continues to be indispensable, and it is now more important than ever that such domain knowledge is integrated into dynamically-growing MES functionalities easily and intuitively. After all, the dynamic changes in market demands, triggered by IoT, require considerably shorter cycles of automation modernisation as we head towards Industry 4.0.

The growing amount of data and the increasing information exchange capability is resulting in closer co-operation between plant and automation suppliers, such as SMS group, and plant managers. The present paper shows successful digitalisation applications for greenfield – and even more challenging – brownfield projects with the SMS group's new manufacturing model applied in new challenges in steel production Many challenges must be successfully overcome during the production of steel. The flexible customisation of products must be achieved while ensuring a consistently high level of product quality. Production lead times must be minimised and high delivery punctuality levels must be maintained. At the same time, resources must be optimally utilised with reduced stock, and maximum yield must be attained to ensure profitability. In addition, the requirements of end customers with regard to special properties and "tailor made products" are increasing, while lot sizes are tending to become smaller and smaller (Munda and Matarazzo, 2020).

During the production process a large number of set-up values for the various process steps are created to optimise the product. In addition to these values there are a lot of measured values and signal information. When analysing this signal information, it is easy to become confused, especially when you consider that there might be 500 or more temperature values (measured, calculated, surface, and average) from the heat, through casting and rolling, right up to cooling. Knowing the origin of the signals and the way they are created is of vital importance during analysis and thus a crucial factor in long-term production optimisation (Runde and Bruns, 2019).

4. Results and discussion

To facilitate the design of the new management system, an ER (entity-relationship; in Italian: entity-association model or entity-relationship model) diagram is proposed in which all the logical connections between the various entities are indicated in order to translate the resulting information from analysis into a conceptual scheme. This diagram is extremely important in the first phase of the database design. It allows you to graphically represent the entities, which are described in detail within the rectangles, and how the latter are associated with each other. The entities used here represent classes of "objects" that have common properties but autonomous existence for the purposes of the application of interest and specifically are: Plant, Producer, Transporter, Recipient, Refuse, Recovery and Disposal. The number 1 and the letter N, which flank them, indicate with what cardinality the entities participate in relations, and specifically 1 indicates that there is only one element, while N that there is a multitude of elements. Instead, as regards the interconnections, that is, Production and Transport, described within the rhombuses, they indicate the possible options for the user's choice.

All this information, summarized in Fig. 1, will allow the IT company that will be responsible for the design of the management system to understand and consequently quickly design the architecture of the new system, thus allowing an important reduction in the time required for the entry into force of the system.

The E-R diagram proposed in Fig. 2 allows the conceptual representation of reality to be computerized at a high level of abstraction. In light of what has been said, it does not allow (by itself) to be able to create a consistent database, as it requires translation into a logical schema. Moving on to the analysis of the diagram, we find:

- Company: It guarantees that all useful information can be kept track of which allows to completely characterize each company.

- Detection: Allows the company to enter (by means of the insertion report) one or more surveys, which will be characterized by a series of attributes. Note how the cardinality of the relationship suggests that a certain survey is entered by a specific company.

- Entity: Through the relationship (vision) that binds the "Entity" entity to the "Detection" entity, it is possible to allow each entity to view the various surveys entered by the various companies. Following the analysis of the E-R diagram (Fig. 2), it is possible to move on to the following logic diagram:

• company (company id, name, partitabiva, street, city, telephone number, authorization code, access id, password)

• survey (survey id, company id, survey_type, application, official frequency, survey date, survey time)

• entity (entity id, name, login ID, password)

• vision (entity id, identification id).

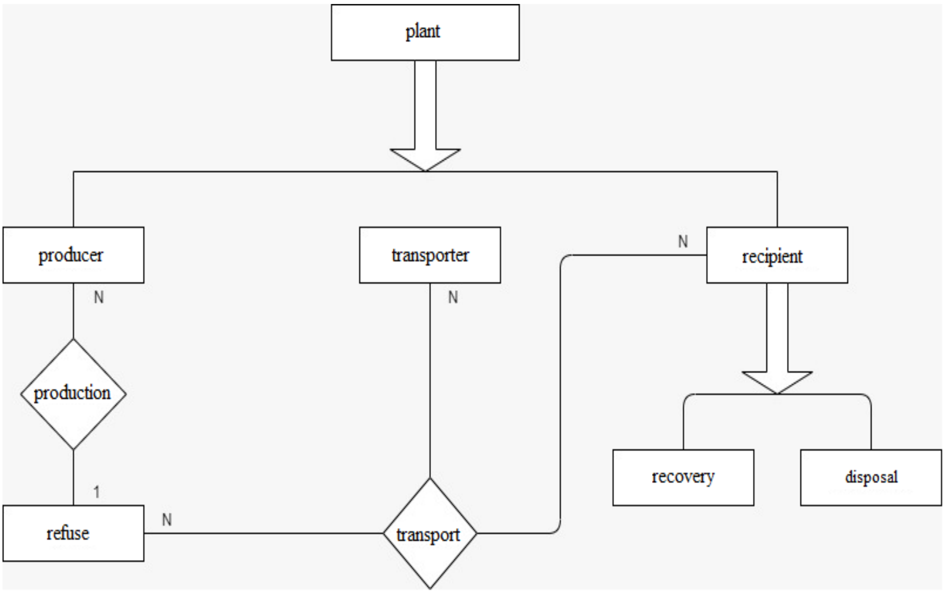

Fig. 1. E-R Diagram

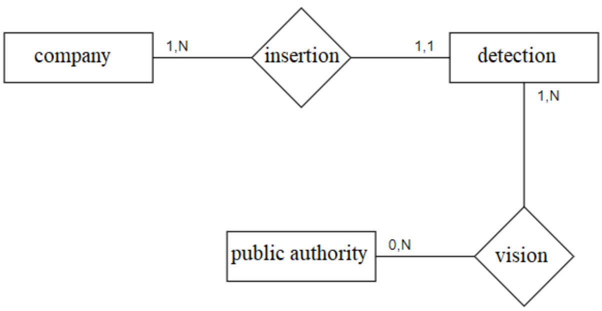

Fig. 2. Analysis of the E-R diagram

6. Conclusions

The innovation technology in steel process production could achive a lot of advantages, such as: single plant as Cyber Physical Production System (CPPS, vertical integration) 100% traceability of intermediate and final products; Intelligent product with knowledge of its own quality and production history (one aspect of end-to-end engineering); Intensive networking and communication of all plants (horizontal integration inside company); Intensive communication along the complete supply chain (horizontal integration outside company); Suitable handling and usage of all data; De-central instead of central solutions/self-organisation.

References

Bonanno S., Amato F., Silluzio C., Trimarchi E.G., Matarazzo A., Bentivegna G., (2018), Smart and circular economy applied to a sicilian company as a sewage treatment model, *Procedia Environmental Science, Engineering and Management*, **5**, 21-28.

Guadagnino P., Cantone L., Conte P., Pocina G., Matarazzo A., Bertino A., (2018), Techniques of reuse for slags and flakes from the steel industry: A circular economy perspective, *Procedia Environmental Science, Engineering And Management*, **5**, 93-100.

Herzog K., Winter G., Kurka G., (2017), The digitalization of steel production, *Berg Huettenmaenn Monatsh*, **162**, 504-513.

ISO 14025, (2006), Environmental labels and declarations - type III environmental declarations – Principles and procedures, Geneva, On line at: https://www.iso.org/standard/38131.html.

ISO 9001, (2015), Quality management systems - Requirements, Geneva, On line at: https://www.iso.org/standard/62085.html.

ISO 14001, (2015), Environmental management systems - Requirements with guidance for use, Geneva, On line at: https://www.iso.org/standard/60857.html.

ISO 14021, (2016), Environmental labels and declarations – self-declared environmental claims (type II environmental labelling), Geneva, On line at: https://www.iso.org/standard/66652.html.

ISO 45001, (2018), Occupation health and safety management systems - Requirements with guidance for use, Geneva, Online at: https://www.iso.org/standard/63787.html.

Lavallèe S., Plouffe S., (2004), The ecolabel and sustainable development, *The International Journal of Life Cycle Assessment*, **9**, 349-354.

Munda G., Matarazzo A., (2020), On the impossibility of using “the correct” cost-benefit aggregation rule, *Journal of Economic Studies*, **47**, 1119-1136.

Runde W., Bruns M., (2019), Hi-tech steel production planning, *Steel Times International*, **43**, 41-42.

Westkämper E., Alting L., Arndt G., (2000), Life cycle management and assessment: approaches and visions towards sustainable manufacturing, *CIRP Annals*, **49**, 501-526.

Wang J., Li S., Xiong G., Cang D., (2011), Application of digital technologies about water network in steel industry, *Resources, Conservation and Recycling*, **55**, 755-759.