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CIRCULAR ECONOMY AND TECHNOLOGICAL INNOVATION IN STEEL INDUSTRY*

Sergio Salvatore Fichera[1], Sergio Arfò[1], Yi Li Huang[1], Agata Matarazzo[1], Alberto Bertino[2]**

[1]Department of Economics and Business, University of Catania, Corso Italia 55, 95129, Catania, Italy
[2]Acciaierie di Sicilia S.p.A., Strada Comunale Passo Cavaliere, 1, 95121 Catania, Italy

Abstract

Thanks to its "circularity", steel is the most recycled material on Earth. Therefore, the steel industry is in a perfect position to cough the opportunities deriving from the use of a circular economy-based development model. The exploitation of this kind of technology can contribute to more and more requested decouple between economic growth and waste production. In this regard, is important to focus our attention on the documentation issue associated with both normative and control aspects. Hence, this paper aim is to propose technological innovations to support businesses in the fulfilment of the documental obligations. The intention of this study is not only to simplify the process of emission, storage and control of the data but also to assist the authorities in the fight against the deeply settled illegality in the steel industry. Consequently, the innovations here proposed will have the purpose to propel the industry towards the enhancement of the managerial performances in the environmental field.

Keywords: circular economy, metallurgy, technological innovations, software, steel

1. Introduction

Until the second half of the twentieth century, the model used was the linear model, based on the typical "take-make-use-dispose" scheme. The linear model consists of the use of the raw material until its exhaustion, and then proceed to the elimination of what has become

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**Corresponding author: e-mail: arfosergio@gmail.com

waste (Giorgi et al., 2017). The idea of a circular circuit of materials was first presented in 1966 by the economist Kenneth E. Boulding, in his article "The Economics of the Coming Spaceship Earth" (Boulding, 1996). Other hints on the subject can be found in some theoretical texts of the Seventies (Matarazzo et al., 2020). The circular economy is also based on studies of industrial ecology, a field of research that has been gaining strength since 1989 thanks to the article by Nicholas E. Gallopoulos and Robert A. Frosch (Frosh and Gallopoulos, 1989).

These studies deal with those organizations of the industrial system that aim to create closed-loop processes in which the waste of one production process becomes a resource for another. The theme in question was taken up at the Rio conference in 2012, whose program was focused on the concept of Green Economy, a term coined in 1989 by Pearce in the book "Blueprint for a Green Economy" (Pearce et al., 1989). The circular economy is among the goals of the Green Economy and is defined as a subcategory of the same. The European Economic Area (EEA) states that if the latter refers to a very broad view of environmental issues, the circular economy is the main focus of interest in resource efficiency and the reduction of waste production (www.fondazionesvilupposostenibile.org). The circular economy, rather than evolution and refinement of the Green Economy, does not fully consider the idea that products are subject to planned obsolescence, assuming instead the recovery and reuse, given the final goal of zero waste. The objective of this model is also to achieve zero emissions using innovations in all sectors of the economy (Giuffrida et al., 2019; Toni, 2015). To enable Europe to exercise a leadership role on the world stage, in 2019 the European Commission's initiative for a Green Deal was introduced. It represents a roadmap to make the EU economy sustainable, with the main objective of making Europe the first climate-neutral continent by 2050. It is expected that the ecological transition will be supported by the Investment Plan presented by the European Commission on January 14, 2020. The management of special waste is a very important issue for the community and is foreseen within the New Green Deal (Arfo et al., 2019).

Here we will focus on what is waste management in a theoretically very important sector, the steel industry. In the perspective of a green economy, this sector must take the final step to move away from obsolete management techniques and accept a digitalized system that allows the reduction of the complexity of the phases, an increase in transparency and simplification of controls.

Specifically, in this paper, we will introduce the case study and the technological innovations that have followed over time and the techniques currently used for the transport of dangerous goods in line with the binding reference standards. Besides, we will identify the documentary requirements and the attempt to digitize the system through the Waste Tracking Control System. Finally, a new management system is proposed to eliminate paper management and simplify the phases considered complex with an analysis of all the benefits that the environment would have from the application of this new system leachate treatment. In this regard, the company "Acciaierie di Sicilia", the leader in the steel production sector (ww.acciaieriedisicilia.it) has been analyzed.

There is a need to analyze all the improvements that would derive from a computer system for the management of forms and waste traceability. To this end, the Waste Traceability Control System (SISTRI 87) was analyzed, which was officially abolished on December 14, 2018, and never came into force (Prestigiacomo, 2011). Starting from all the negative aspects that have characterized it, we tried to identify guidelines to develop new software that can deal with the lack of coordination and transparency in these phases of the activity.

2. Case study: Acciaierie di Sicilia"

In the metallurgical sector, and more specifically in steel production, the transition from a linear to a circular development model has required the involvement of several actors

(Alessandroni, 2006). The company here investigated is "Acciaierie di Sicilia" which is part of the "Alfa Acciai" group. "Alfa Acciai" started its activity in the mid-fifties in Brescia (www.alfaacciaia.it), dedicating itself and specializing in steel production and rolling (Federacciai, 2020; Suriano et al., 2016). Acciaierie di Sicilia S.p.A. produces class C steel for reinforced concrete. Class C is the definition with which the Eurocodes of design define high ductility steels for use in seismic zones. The company also holds numerous product certifications that allow it to be considered an international leader in its sector (Ingrao et al., 2019).

The production process begins when the "secondary raw material" enters the company and ends when the output is ready to be delivered to the customer (Federacciai, 2018). In detail, 6 phases can be identified:

1. Raw material-second input controls
2. Loading Matter in Electric Oven
3. Oven Activation and Fusion Control
4. Liquid Steel Reviver from Ladle
5. Continuous Steel Casting
6. Rolling train activation

To reduce the environmental impacts, the "industrial symbiosis" have been identified, i.e. the possibility of exchanging resources between two or more industries of different sectors, meaning with resources not only materials (products or waste) but also energy waste, services or other, through solutions that can be advantageous for both subjects and at the same time useful for the protection of the environment and natural resources (Fichera et al., 2018). Among the synergies created, there are numerous techniques for the recovery of process waste, such as:

- steel slag from electric furnace or converter, which can be used in the construction sector to make constructions such as road surfaces, bituminous conglomerates or cement;
- steel slag from the electric furnace can be used as a subgrade and road embankment;
- refining slag could be used instead of lime (Floresta et al., 2018);
- rolling slag, which can be used in the chemical industry or cement production;
- flue gas dust, which can be reintroduced into the metallurgical production cycle as zinc and lead recovery (Magro et al., 2018; Suriano et al., 2016);
- steelmaking process gases (coke oven gas, blast furnace gas, steelmaking gas), which may be able to support power plants for the production of heat and electricity;
- thermal waste of various kinds deriving from steelmaking processes, which can be used both as a service for other external or internal users and district heating projects serving the territory;
- fluff, which can be used as fuel, incorporated for the creation of concrete or asphalt and used for the creation of desonorizing layers (Cocconi, 2015).

3. Materials and methods

Road transport of waste and, in particular, of hazardous special waste, represents a phase of management that is particularly attentive to the risk factors it entails. For hazardous waste, in fact, strict safety standards must be observed both in fixed storage facilities and in dealing with road trips (Sassone, 2019).

Articles 193 of Legislative Decree 152/2006 (Decree 152, 2006) in implementation of articles 15 and 30 of Legislative Decree no. 225 of 5 February 1997 (so-called Ronchi Decree) (Decree 22, 1997) subject to the compulsory drafting of an identification form accompanying the transported waste (FIR, waste identification form) and to specific registration in the national register of companies that carry out waste management activities, the specific

activities of transport on behalf of third parties of non-hazardous waste and the activities of transport of special hazardous waste (Berntsen, 2004; Matarazzo et al., 2017).

Transport is one of the most environmentally harmful phases of the entire waste cycle chain, as the transit area, even if not affected by the deposit or storage, still suffers the effect, over time and in an uninterrupted manner, of negative passage of waste and consequently the sedimentation of polluting elements. In this sense, the Legislator has introduced the "proximity principle", with the aim of ensuring the least possible movement of waste from the place of production to that of destination. On this point, art. 182 paragraph III of Legislative Decree 152/2006 provides - albeit with some exceptions - the prohibition to dispose of non-hazardous urban waste in regions other than those where it was produced. A softer discipline is instead dedicated to the activity of waste recovery. Art. 181 paragraph V of Legislative Decree 152/2006, in fact, provides for the exclusion from the higher prohibition for the fractions of urban waste subject to recycling or recovery, for which free circulation is always permitted on the national territory.

The waste transport activity is accompanied by numerous documentary obligations carried out mostly by means of paper documents integrated with each other through the cross-references of the subjects involved in the management process (Magnelli, 2016; Matarazzo et al., 2017). These are three documents:

1. Identification form (F.I.R.), adopted with D.M. 145/1998 (Decree 145, 1998), is the mandatory document that accompanies the shipment of the waste produced, from the moment of delivery to the transporter, until delivery to the recipient for disposal or recovery.

2. From the loading and unloading register, it is an accounting register containing information on the qualitative / quantitative characteristics of the waste which constitutes proof of its traceability regarding its production and sending for recovery or disposal. All the movements of loading and unloading of waste are recorded inside (Milazzo et al., 2017).

3. Single model of environmental declaration (M.U.D.), is one of the declarations to be made on the subject of waste which aims to check how much and what waste is produced and how it is disposed of or sent for recovery (Matarazzo et al., 2017). Unlike the other two documents dealt with previously, it is never mentioned in the Environmental Code and finds express discipline in the Law of 25 January 1994, no. 70 (Law 70, 1994).

The obligations to keep and fill in these paper documents should have been partially replaced by the obligation to enter the respective data in the new waste traceability control system (Guadagnino et al., 2018).

The SISTRI (Waste traceability control system) was created on the initiative of the Ministry of the Environment and the Protection of the Territory and the Sea to allow the computerization of the traceability of special waste at national level, urban waste in the Campania Region and definitively replace the traditional paper-based control regime (Albertazzi, 2010).

A further reason why this system was created is the fight against illegality in the sector of special waste. It was on 14 December 2009 that the Ministry of the Environment signed the agreement for the design and management of SISTRI with the company Selex Service Management (Finmeccanica group) (Gozza, 2009; Manzione, 2011). The SISTRI was based on electronic devices such as: a USB key, which traveled with the waste during transport, containing software that enabled the digital signature and all the specific data relating to the waste itself; with a "Black box" with a GPS reception module to detect the position of the vehicle used for transport in order to accurately track its movements, a safety module, an interface module with the USB device, a battery and a local memory to allow data storage (Ramacci, 2012).

The issues that aroused the greatest concerns in the application field were: first of all, the registration phase, which should have been simple, instead gave rise to interpretation

difficulties that led the ministry to even adopt a corrective decree, published close to the first deadline for registration, with further inconvenience for the companies concerned (Albertazzi, 2010). Even the apparently trivial phase of distribution of IT equipment presented critical profileѕ, taking into account the huge number of companies involved at the start of the system. Additional issues arose when exiting the standard waste management process. The cases were the most varied but the traceability system was too "static" to be able to adapt to the multitude of the latter.

Another factor takes over: waste regulation was becoming extremely diversified, detailed and often not immediately understood. It followed that particular problems had been and continued to be tackled on the territory in a pragmatic way, but diversified according to the different needs of the operators and on the basis of the indications of the competent authorities. Compared to these realities, which we could define as "flexible", SISTRI was born as a "rigid" system that did not allow for derogations or exceptions, even if they were respectful of the legislation. All these problems led to numerous postponements for the effective entry into force of the SISTRI system, initially scheduled for July 2010, until with article 6 of the Decree-Law of 14 December 2018, no. 135 the official suppression was decreed (Decree 135, 2018).

4. Results and discussion

Waste management is one of the most important and delicate phases in companies in the steel sector. For this reason, this phase must be monitored and constantly updated in order to avoid possible non-compliance and damage to the environment with the aim of ensuring maximum safety for employees and citizens (Sechi and Panizzi, 2017).

To cope with the complexity of this phase, a management system was invented, the SISTRI (waste traceability control system) which was wanted by the Italian Ministry of the Environment to monitor hazardous waste through its traceability. With article 6 of the Decree 135 (2018) it was decreed its suppression, since it never entered definitively into function, among other things. The never achieved objectives of this system were: to streamline and simplify the bureaucracy and the numerous phases linked to the management of waste and to try to stop the related illegal activities (Siragna, 2012).

Starting from the huge gaps that led to the "failure" of this system, this paper aims to develop a new management system that fills the gaps and allows you to make the final leap towards simple waste management, able to cope with sudden changes in the market, which responds quickly to daily needs, which allows a huge reduction in the paper consumed for forms, which simplifies the control activity and which is totally transparent from every point of view. This management system must differ from the previous one for simplicity in the registration phase of companies, which must be immediate, safe and very intuitive compared to the same phase that in SISTRI apparently should have been simple, but which instead gave rise to interpretative difficulties that they induced the ministry to even adopt a corrective decree, published close to the first deadline for registration, with further inconvenience for the companies concerned. It must respond with extreme immediacy to all unforeseen daily events that go beyond the standard process but which often occur, both for problems caused by the issuing company or the recipient company and for problems for the carrier.

It must allow a streamlining of the phases so as to make the operations carried out by the employees more fluid and simple but also to make the controls by the competent authorities more immediate, which can thus be carried out instantly thanks to access to the database containing all the information relating to each company, each transporter and all the history of loading and unloading operations carried out by the company every day. These important changes could ensure that the system is quickly digested by all companies operating on the

national territory, making waste management no longer a problem but an extremely "innovative and dynamic" phase that is easy to understand even for citizens, who remain in any case, an interested party, with the aim of cutting out obsolete paper management and taking the definitive step towards the green economy. The subjects obliged to adhere to this new management system should be on a national scale all the companies producing hazardous waste regardless of their size and all the recipient companies used for disposal or recovery. This is because, contrary to what is stated in the SISTRI, there is no certainty about the quantity and danger of waste that a company can produce even if it is small or medium-sized. The tools needed for the implementation of the new system are:

• A large database that contains all the information of the companies and transporters and that is able to make the data immediately available both for the actors of the operations and for the control bodies;

• An encryption system to protect data from any cyber-attacks;

• A simple and streamlined interface with which the operators of the various phases can interface;

• A tablet for each transporter with which it is possible to take charge of the waste to be delivered and allow, through the geo-localization, to trace the path followed by the same.

With these few tools it is possible to carry out a "complete" waste management that does not excessively affect the state coffers and that considerably reduces the use and consequent maintenance of equipment that is not really useful to the cause but above all that allows to reduce paper consumption print that generates an important environmental impact on the ecosystem. Registration is the phase that most caused problems in the previous SISTRI management system due to the considerable difficulties in interpretation. For the new system this phase must be the strong point. Each company that produces or receives hazardous waste operating in the Italian territory will have up to 6 months from the implementation of the system to be able to register or would face a fine and temporary interruption of production. Registration will be totally free but mandatory to avoid the delay of companies to lengthen the times and be able to make the system fully functional in a few months.

Each company that signs up must enter a lot of information such as: Business name; Company data; Region in which it operates; Owner or partners of the company; Number of employees; Turnover class; Certifications held by the company. This information is necessary in order to place the company in one of three categories: partnerships, joint-stock companies with a limited number of employees and large joint-stock companies. When the company registers, it can select whether it is only a manufacturer, a transporter, a recipient or more than one in the event that the company carries out more "operations". If the company that is registering is a waste recipient, it must select one of two possible options: disposal plant or recovery plant. In both cases, it must indicate the quantity of material it is authorized to manage, the EER authorizations and the CER authorizations it has (Baldo and Polesi, 2006).

Registration must be done through an online procedure without the need to go to the Ministry of the Environment headquarters, with the most modern computer security systems applied in order to avoid problems already at this stage. After having entered all the necessary information without which the system does not proceed to the subsequent phases, a unique code that identifies the company and a password with six-monthly renewal is sent via PEC (certified e-mail) to increase the security of company data and avoid industrial espionage. From the moment the company receives the credentials, it will have to start using the management system, even if it will be granted a month of transition where it will also be possible to continue using the paper system in order to avoid possible interruptions and problems related to technical times learning of the operators. Furthermore, with the inclusion of all the certifications available to the company, a notification system will be provided via certified e-mail that reminds the company of the deadlines of the same. In the event that the

company does not proceed with the renewal, despite the notification, within the scheduled time, the system for the company will be blocked and a report will be made directly to the competent authorities.

All transporters will also be obliged to register in the system and they must enter: Company name; Company data; Authorized EERs; Waste categories authorized to manage; Driving licenses general of employees.

All this information is necessary in order to create a list of all transporters available to the waste producer thanks to which it is possible to select the transporter starting from the CER code (European Waste Code) avoiding the possibility that the transports are carried out unauthorized subjects. With a management system of this type, therefore, one could have total control over all deadlines and also direct reporting to the competent authorities in order to avoid irregular activities being carried out, but at the same time having the opportunity to unlock the system quickly (a once the data has been updated) so as to avoid "dead times" in order to be able to respond quickly to changes.

5. Conclusions

The application of this new management system would bring numerous advantages to the entire steel industry. It would give the possibility of permanently detaching oneself from the now obsolete paper system, which is still used today, allowing a significant reduction in printed paper, thus managing to minimize the negative impacts on the environment. There would be a streamlining of procedures that would make operations more fluid and intuitive with the ability to quickly and quickly manage all unexpected events that may occur. Specifically, the advantages would be: Simple and immediate registration; Speed up of operations; Immediate response to system malfunctions; Reduction of possible errors; Notification of deadlines; Effective management of contingencies; Increase of corporate data security; Increased control in transport; Simplification of the activity of the supervisory authorities; Creation of a complete picture of the relationships between companies; Reduction of downtime by about 60% compared to the current situation; Reduction of environmental impacts; Transparency of operations; 20% decrease in consumption of toner cartridges and related waste; reduction of 90% of the paper needed for bureaucratic documents.

This important technological innovation could support smart working deriving from the Covid emergency that occurred in 2020. On the other hand, the consumption of electricity for the servers used and the consumption of PC memory increase. In the event that the management system does not work or due to problems with the central system or problems of the individual company, it is possible to use paper cards to download so as to never block company operations, which could otherwise cause waste and increased costs. These cards would be subject to a fee so as to discourage the use of paper by companies wishing to carry out illegal acts. In addition, there would be a number of paper cards that could be used beyond which a report would be made to the competent authorities and an obligation to send a proof for the company. Another advantage would be the possibility of streamlining all the operations related to endorsement which today generate numerous problems both for the company and in terms of resource consumption. To carry out this operation, in fact, the company is forced to send an employee to the chamber of commerce, generating a cost and a waste of time. On the other hand, as regards the consumption of resources, in this phase there is the consumption of large quantities of paper, the consumption of electricity, the consumption of toners of highly polluting printers with also the possibility of making invalidating errors for the correct execution of the operations and business. There would be greater security of company data because a saving in the data database would take place through weekly backups. Each company would have a dedicated folder containing all the loading-unloading movements. After 5 years,

the movements should be cancelled by the company without the possibility of the cancellation being made before the scheduled time. Furthermore, the operations would be totally transparent because they can be viewed simultaneously by all the "actors": producer-transporter-recipient and also by the competent authorities. Doing so would drastically reduce the chances of carrying out irregular activities.

All these advantages listed above would lead to a general convenience from the application of the system which should lead the "protagonists" of these operations to accept and quickly digest the change because it is positive. With this step towards digitalization, a fundamental step would be placed for a fluid waste management where there are no more illegal activities that have always characterized Italy and have not allowed the definitive leap towards the true Green Economy.

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