



8th Manufacturing Engineering Society International Conference

Good Practices and Trends in Reverse Logistics in the plastic products manufacturing industry

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Abstract

The management of solid waste and its impact on the environment has been a subject of study and revision in different aspects, from mathematical modeling to control, with the aim of proposing different alternatives that contribute to diminishing the adverse effects in the environment. In this regard, reverse logistics has become a key trend to balance economic development with environmental protection, as this approach allows the maximization of value and the sustainable use of products at the end of their life cycle. This approach has been applied in different sectors such as textiles, pharmaceuticals, food, among others, but still with great potential for study in the plastic industry given the impact of plastic products on the environment and the increasing pressures of consumers, government and environmental groups that propose new forms of operation and innovation in companies in the sector.

The goal of this work is the identification of good practices and trends in the plastic products manufacturing industry, with respect to the recovery of plastic products through reverse logistics, both at the revision level of literature, as well as, from the use of an evaluation instrument among entrepreneurs of the sector, in order to provide a framework for diagnosis and continuous improvement in the development of good practices in reverse logistics for the industry.

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Peer-review under responsibility of the scientific committee of the 8th Manufacturing Engineering Society International Conference

Keywords: Reverse logistics; good practices evaluation; social responsibility; plastic industry; Multicriteria Decision Making, MCMD, Analytical Hierarchy Process, AHP

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1. Introduction

Plastics are materials of high versatility in the industry, with applications in different sectors of the economy and growth prospects in the production of 4% per year until the year 2030 [1]. However, the plastic industry is facing several problems, such as the effects of climate change, the growing demands of customers towards the design of eco-efficient products and the use of plastic waste, due to the low degradability of this material, since it takes between 100 to 1000 years, depending on the type of plastic, generating negative environmental impacts on the environment. Worldwide, less than 10% of plastics are recycled, compared to 90% of metals, according to PlasticsEurope [2]. In this regard, the waste recycling landscape maintains inequalities worldwide, for example, while in countries such as the Netherlands and Germany the level of efficiency in recycling reaches 98%, in Colombia waste recycling rates do not exceed 20% so that the remaining 80% of waste ends up in sanitary landfills, open garbage dumps, rivers and public roads, generating pollution and negative impacts on the environment [3]. Among the causes that affect this problem are the absence of processes of recycling processes and deficiencies in the control and stimulus of the government to promote the use of clean technologies, good practices and integrated management systems focused in the corporate sustainability [4, 5], where reverse logistics is shown as an approach that helps companies optimize the use of resources and continuously monitor the negative impacts of their activities on the planet [3].

This work based on the concept of reverse logistics, for the identification and diagnosis of good practices and trends in waste management in the plastics industry, which allows the generation of added value and the contribution to sustainable development. The paper presents first, a literature review on reverse logistics. Then, the methodology framework is detailed. Subsequently, the results and analyses are shown, with the identification of good practices and trends, the diagnosis of behaviors in the use of good practices in reverse logistics and the design of improvement strategies. Finally, conclusions and future works were presented. This research project was developed with the objective of the application of good practices and trends in reverse logistics in the plastic industry ‘companies through the 3-phase methodology approach.

2. Reverse Logistics: A brief literature review

The management and use of solid waste have been studied and analyzed at an academic and business level, from the last three decades of the 20th century to the present. The first studies date from the end of the 70s with the development of distribution channels for recycling [6]. Nevertheless, it was not until the decade of the 90s that the inverse logistics approach was defined as a planned, implemented and controlled process that manages resources and information flows focused on the recovery of the value of waste and the reduction of environmental impacts [7].

At the level of state of the art, some studies have been developed to design optimization models, application of multicriteria decision methods in reverse logistics [8], and identify good practices and trends in the application of reverse logistics [9] in sectors such as glass [10], automotive, electronics and consumer electronics [11] and recycling of plastic waste [12]. However, from our point of view, the scientific literature about the use of integrated approaches for the identification and diagnosis of good practices and trends in waste management in the plastics industry is mostly limited. Therefore, this work has a contribution to increasing the scientific literature related to trends and business practices applied in the plastic industry and offers an innovative methodology for the diagnosis and continuous improvement [19,20,22] in the development of useful methods in reverse logistics in the plastic industry, generating value for companies and the environment.

3. Methodology

The investigative method used is described as follows. The project is framed within the analytical, descriptive and prospective study; because data and information of the present were collected and analyzed, with the aim of proposing improvements strategies based on reverse logistics. The design of the survey for evaluation taking into account the AHP technique with the contribution of experts that validate the factors and sub-factors based on the literature review in correspondence with the ISO 14001. This survey was applied in a sample of 35 companies of plastic industry in Colombia.

The proposed approach aims to evaluate the performance in adoption of good practices and trends in plastic industry based on reverse logistics through the integrated framework between the literature review and the use of an evaluation instrument designed and validated by experts based on Analytic Hierarchy Process technique (AHP). Regarding methodology, a 3-phases has been proposed to develop this research (refer to Fig. 1):

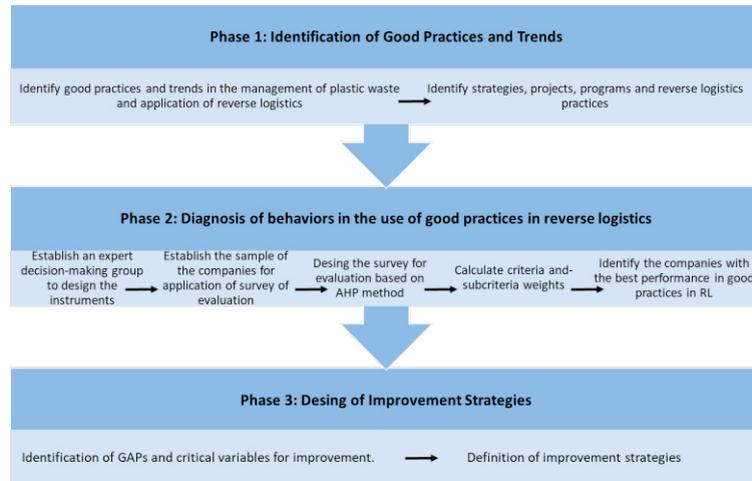


Fig. 1. Methodological approach for evaluating performance in adoption of good practices and trends in plastic industry based on reverse logistics

- Phase 1 (Identification of Good Practices and Trends): In this stage, we conducted a search in databases such as Scopus, of published articles related to the analysis of trends, good practices in the management of plastic waste and application of reverse logistics. Likewise, a documentary review of websites of plastic companies was carried out to identify strategies, projects, programs and reverse logistics practices. Different methodologies, such as, statistical diagrams were used;
- Phase 2 (Diagnosis of behaviors in the use of good practices in reverse logistics): In this stage, an instrument of the evaluation was designed and applied in companies in the plastic sector, taking into account the good practices and trends identified in phase one, the standard ISO 14001, and the use of multicriteria decision techniques. The objective is to identify the companies in Colombia with the best performance standards regarding the implementation of good practices for the management of their plastic waste;
- Phase 3: (Design of improvement strategies): In this phase, we identified the critical variables [13,14, 21] in the implementation of good practices in reverse logistics for the plastic industry. For the identification of the critical variables, we calculated the GAPS, or percentage differences between maximum score and score obtained as a result of the evaluation in reverse logistics, using Eq. 1.

$$GAP (\%) = \frac{Score\ obtained - Score\ max}{Score\ max} \times 100 \quad (1)$$

Finally, we defined improvement strategies to promote the generation of sustainable value in the sector.

4. Results

4.1. Identification of good practices and trends in reverse logistics

In this phase, we conducted a search in database Scopus®, of scientific publications using the keywords "reverse logistics" OR "green logistics" AND "plastics", from 1992 to the present, for identify trends and good practices in the management of plastic waste and the application of reverse logistics. The search allowed to identify 78 articles that complied with the keywords. Also notes that scientific publications have increased since the year 2010, although still the development of Investigations on the inverse logistic or green logistics is still limited and little studied in the plastic sector in stage 1, about 78 articles related to the keywords "reverse logistics" OR "green logistics" AND plastics

were found, which were analyzed to determine their usefulness against the objectives of the study, that is, to identify trends and good practices in the handling of plastic waste.

On the other hand, in Fig. 2a, it is observed that 65.8% of the publications on the subject come from scientific articles and 19.7% are conference papers, the remaining 14.5% correspond to other publications such as book chapters, articles of revision, among others. As for the documents found by area of knowledge, 22.8% are in the field of Engineering, and 18.1% correspond to the Business and Administration area (refer to Fig. 2b).

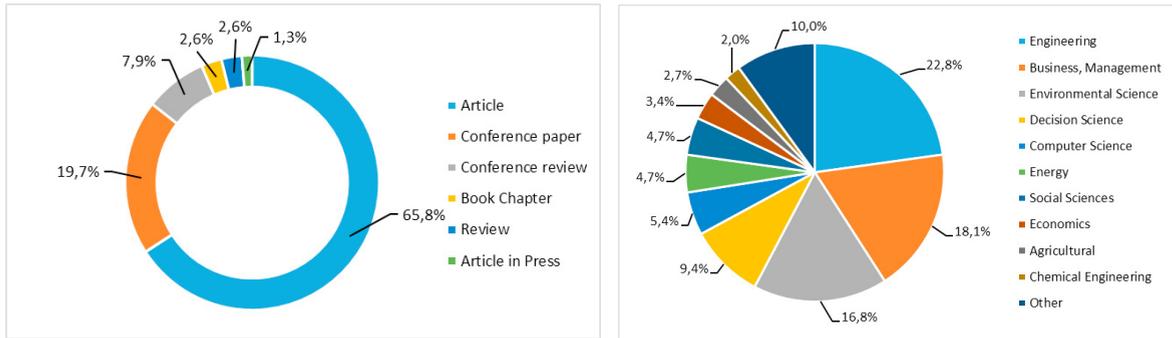


Fig. 2. (a) Documents by type; (b) documents by subject area (Scopus database)

Based on this search and review of websites of plastic companies, we identified good practices and projects related to the inverse logistics approach. These approaches including analysis and risk prioritization, the use of multicriteria techniques for the provision of resources, the use of programming models by objectives for the planning of sustainable inverse logistics operations, the application of recycling, reuse and reprocessing processes and the development of alliances with groups of interest. Concerning good practices identified and the drivers in reverse logistics [9,12] are closely related to the elements adopted in an environmental management system under the ISO 14001 standard, as shown in table 1. All the above helped to elaborate on the diagnostic instrument validated by experts using the Analysis Hierarchy Process (AHP) technique.

Table 1. Relationship between the elements that make up the high-level structure of the ISO 14001 (2015) standard with drivers and good practices in the implementation of reverse logistics.

Elements of the High Level Management Structure ISO 14001: 2015	Drivers in the implementation of Reverse Logistics	Authors
1. The context of the Organization: Identification of Stakeholders	Size of the company, strategic alliances, Extended responsibility of the producer, customers, environmental concerns, environmental needs, social needs, economic needs, social drivers, competition, political and economic conditions	Janes et al. (2010), Kapetanopoulou y Tagaras (2011), Lau y Wang (2009), Kannan et al. (2012b), Jindal y Sangwan (2013), De Brito y Dekker (2002), Rahman y Subramanian (2012), Chiou et al. (2012), Mittal y Sangwan (2014)
2. Institutional Leadership: Environmental leadership, Environmental Policy, Responsibility, and authority.	Awareness of senior management, corporate citizenship, internal controllers	Janes et al. (2010), De Brito y Dekker (2002), Ravi et al. (2005), Mittal y Sangwan (2014)
3. Planning: Risks and opportunities, aspects and environmental impacts, environmental objectives and goals, legal requirements, plans in environmental management.	Environment and ecological issues, legislation, compliance with obligations to protect the environment, Strategic approach to avoid returns, codes of conduct	Fleischmann et al. (1997), Rubio (2003), Ravi et al. (2005), Lau y Wang (2009), Rahman y Subramanian (2012), Kapetanopoulou y Tagaras (2011), Jindal y Sangwan (2013), Janes et al. (2010), Kannan et al. (2012)
4. Support: Competence, awareness, resource management, communication, documented information.	Economic factors, resources and integration and coordination, strategic costs, recycling costs, facilities, information, economic drivers	Tyagi et al. (2012), Rahman y Subramanian (2012), Chiou et al. (2012), Fleischmann et al. (1997), De Brito y Dekker (2002), Ravi et al. (2005), Jindal y Sangwan (2013)
5. Operation: Operational control, contingency programs,	Disposition, Retrieve return value	Janes et al. (2010), Dowlatshahi, S. (2000).
6. Performance Evaluation: Monitoring, measurement, analysis and evaluation, internal audits, review by management,	Performance visibility, recycled volumes	Janes et al. (2010), Chiou et al. (2012)
7. Improvement: Non-conformities, corrective actions, and improvement.	Improvement in customer service, Customer satisfaction	Lau y Wang (2009), Autry et al. (2001).

4.2. Diagnosis of behaviors in the use of good practices in reverse logistics

In this step, it began with the selection of companies belonging to the plastic industry. This allowed, in the first place, the choice of some representatives of these companies as experts for the validation process of the factors and sub-factors taking into account the good practices and trends identified in phase one, the standard ISO 14001, and the use of multicriteria decision techniques (AHP method) through the design of a survey.

In this regard, the survey was applied to a sample of 35 companies of the plastic industry in Colombia using Eq. 1 for the calculation of the sample size when the population is finite, that is when the total population is known.

$$n = \frac{Z^2 * p * q * N}{(e^2 * (N - 1)) + Z^2 * p * q} \quad (1)$$

Where the parameters of the equation are the following:

- N = Total population = 39 companies
- Z_{α} = Statistical value normal distribution, for a confidence level of 95% = 1.96
- p = probability of success = 0.5
- q = probability of non-success = 1 - p (in this case 1-0.5 = 0.5)
- e = study estimate error = 0.05

On the other hand, a decision-making group was selected to validate the factors and sub-factors through the application of AHP technique [8,16], for the diagnosis in good practices and trends in the implementation of reverse logistics in the companies of the plastic industry given they expertise in these topics. Regarding the selection of decision-making group, three types of experts were found to be meaningful for the decision-making process: Leaders of production or environmental departments of the selected companies (three experts were chosen, one expert representing small companies, and one expert from medium-sized companies and one representative from large companies). The second type of expert is a consultant in environmental management and reverse logistics. Finally, the third type of expert is one representative of the academic sector linked to environmental management, sustainability, and the application of multicriteria decision methods.

The multi-criteria hierarchy was then verified and discussed during multiple sessions with the expert decision-making team to establish if it was accurate and understandable. The final decision model with which the diagnostic instrument was designed and applied is presented in Fig. 3.

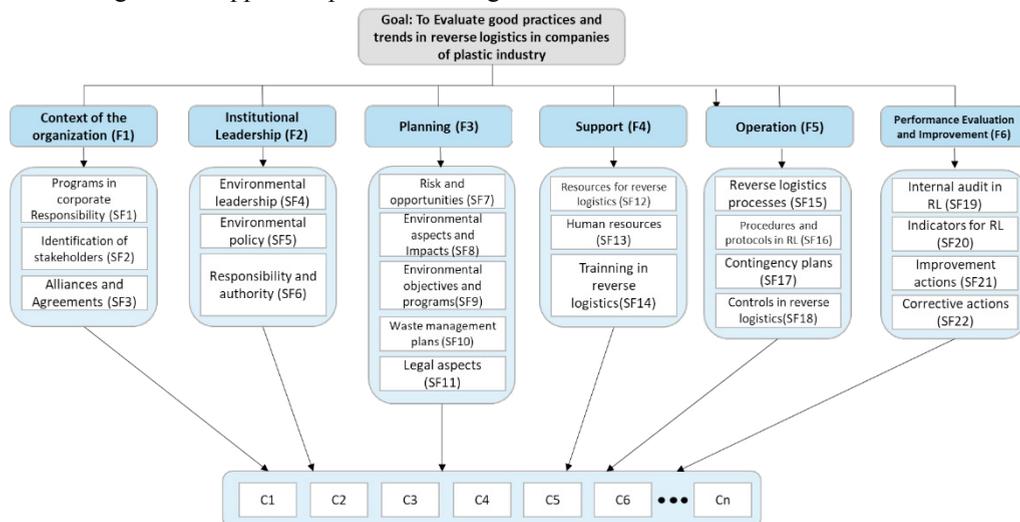


Fig. 3. Multi-criteria decision-making model to evaluate the application of good practices and trends in reverse logistics in companies of plastic industry

Subsequently, the experts first validated the factors and sub-factors described in Fig. 3 by paired comparisons taking into account the importance of one factor / sub-factor concerning the other, as shown in Fig. 4 and taking into

account the scale of the reduced AHP scale is considered by the decision makers when making comparisons (Refer to table 2).

According to your experience with respect to "Support" sub-factor, how important is each sub-factor on the left concerning the sub-criterion on the right when evaluating the good practices and trends in application of the reverse logistics in companies of plastic industry?

		1	2	3	4	5		
Resources for reverse logistics	is	<input type="radio"/>	Important than	Human resources				
Resources for reverse logistics	is	<input type="radio"/>	Important than	Training in reverse logistics				
Human resources	is	<input type="radio"/>	Important than	Training in reverse logistics				

① Much less ③ Equally ⑤ Much more

② Less ④ More

Fig. 4. Data-collection instrument implemented for AHP judgments

Table 2. Reduced AHP scale

Reduced AHP scale	Definition
1	Equally important
3	More important
5	Much more important
1/3	Less important
1/5	Much less important

From the Validation of the factors and sub-factors using the AHP technique, the global weights (GW) and the calculations of the consistency indexes in the judgments were obtained for the evaluation factors, with which the diagnosis of the good practices in the application of reverse logistics, which are observed in Table 3. The results obtained evidence that the "leadership" factor (GW = 33.4%) is the most relevant at the time of evaluating good practices in the implementation of the Reverse logistics, followed by the "planning" factor (GW = 17.8%), the context factor (GW = 16.3%) and the "improvement" factor (GW = 13%), which can determine the success of the plastic companies in the implementation of good practices, programs and trends in reverse logistics seen as a cycle of continuous improvement.

Table 3. GW and consistency values of factors for diagnosis in good practices and trends in reverse logistics (AHP method)

Cluster	GW	Consistency ratio (CR)
Cluster		0.09
Context of the organization (F1)	0.163	0.09
Institutional leadership (F2)	0.334	0.10
Planning (F3)	0.178	0.07
Support (F4)	0.052	0.09
Operation (F5)	0.061	0.01
Performance evaluation and improvement (F6)	0.213	0.05

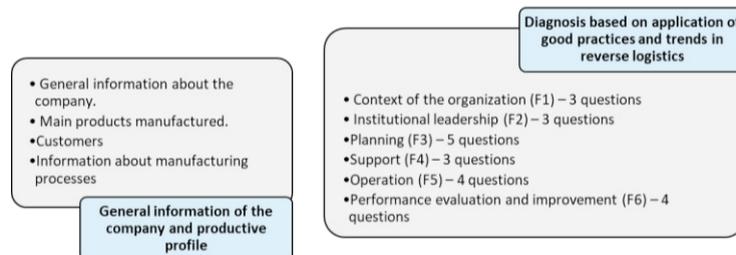


Fig. 5. Structure of the survey for diagnosis of the application of good practices and trends in reverse logistics

Subsequently, the survey was applied in the 35 selected companies (71% of the companies considered to belong to the SME segment and 29% of the large companies.) The survey consists of six components or factors, each with questions associated with the sub-factors within each element as shown in Fig. 5. Each item is rated by the companies taking into account the following evaluation scale adapted from [17] (refer to table 4).

Table 4. Rating scales for the application of survey

Rating scale	Level	Description
1	Without application	Not implemented
2	Basic	There are plans to implement it at the related levels
3	Advanced	It is beginning to be implemented at related levels.
4	Expert	It is applied in most of the related levels of the company
5	Mature	It is applied at all levels of the company

4.3. Design of Improvement Strategies

Finally, with the calculation of the weights of the factor and sub-factors, the scores of the diagnosis in good practices in reverse logistics of each of the participating companies were calculated, and the ranking of the companies was obtained as shown in Fig. 6. In the top five, 3 companies are in the large segment, and 2 companies are in the medium-sized section, these companies have more than 20 years of antiquity, and their operations are developed both nationally and internationally. On the other hand, small companies were located in the last places of the ranking, so it is necessary to design and implement plans for improvement in their overall performance. Table 5 shows an example with the results of one of the companies analyzed and the calculation of the GAP [13,14,18], at a general level and by the factor, which serves as the basis for the approach to improvement strategies, both at an individual level as per business segment. For example, for the company analyzed in Table 10, despite the excellent results obtained, it must design and implement strategies to improve the associated factors of "Planning" (F3), "Support" (F4) and "Operation" (F5) in order to increase the performance in adoption of good practices and trends in reverse logistics.

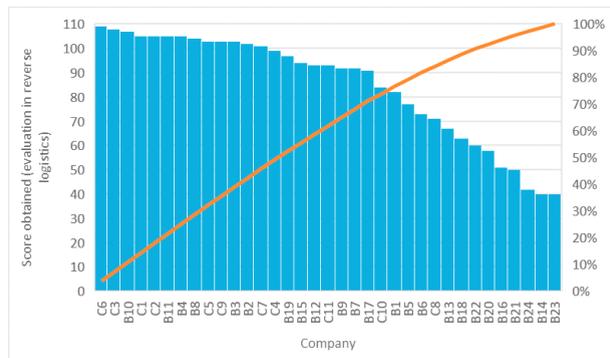


Fig. 6. Pareto diagram with ranking of classification companies when assessing the performance in application of goods practices and trends in reverse logistics

Table 5. Example of results diagnosis in application of good practices and trends in reverse logistics

Company: C1	Factor						Total Score
	F1	F2	F3	F4	F5	F6	
Score obtained company	15	15	24	14	17	20	105
Score max	15	15	25	15	20	20	110
% of compliance	100%	100%	96.0%	93.0%	85%	100%	95%
GAP	0%	0%	4.0%	7.0%	15%	0%	5%

4. Conclusions

The results of this study allowed identifying that the Leadership factor is the most important when evaluating the application of good practices in reverse logistics. This factor depends on the other elements being developed, without

neglecting other important criteria such as planning, the context and improvement, which affect the support processes and operations to recover the value of the products. It was identified that the large companies are the ones that present the best performance in the use of good practices in RL. There is a potential for improvement, not only for these companies, but also for the medium and small ones, where the improvement plans should be developed to a medium and long term. It is also necessary to take into account the characteristics, resources and culture of each company.

Acknowledgements

The authors would also like to thank the companies in the plastic sector participating in this project and technical experts, for their willingness, cooperation and for their contribution to this work.

References

- [1] J. Arandes, J. Bilbao, D. Lopez. Reciclado de residuos plasticos. *Revista Iberoamericana de Polimeros*, 5(1) (2004) 28-45.
- [2] Dinero Magazine [Web]. Hacia un mundo que consume menos plástico: ¿Qué pasa con Colombia? 2016 [cited October 4 2018]. Recovered from: <http://www.dinero.com/economia/articulo/oportunidad-para-colombia-en-el-mercado-mundial-de-plasticos-/217899>
- [3] J. Rojas. “Colombia entierra millones de pesos por no reciclar” 2016. Recovered from: <http://www.contactoverde.com.co/colombia-entierra-millones-de-pesos-por-no-reciclar/>
- [4] G. Jimenez, Procedimientos para el mejoramiento de la calidad y la implantación de la Norma ISO 9001 aplicado al proceso de asesoramiento del Centro de Investigaciones y Desarrollo Empresarial y Regional en una Institucion de Educacion Superior basados en la gestion por procesos. In: Congreso de Gestion de la Calidad y Proteccion Ambiental GECPA 2014, Habana, Cuba, (2014) 1–22.
- [5] G. Jimenez, E. Zapata, Metodologia integrada para el control estratégico y la mejora continua, basada en el Balanced Scorecard y el Sistema de Gestión de Calidad: Aplicacion en una organizacion de servicios en Colombia. In: 51a Asamblea Anual del Consejo Latinoamerica-no de Escuelas de Administracion CLADEA 2016, Medellin, Colombia, (2016) 1–20.
- [6] J.P. Guiltinan and N.G. Nwokoye, Developing distribution channels and systems in the emerging recycling industry". *International Journal of Physical Distribution*, 1 (1975) 28–38.
- [7] C. Carter, L. Ellram, L. (1998), Reverse Logistics: A review of the literature and Framework for future investigation. *Journal for Business Logistics*, 19 (1998) 85-102.
- [8] S. Senthil, K. Muruganathan, A. Ramesh, Analysis and prioritisation of risks in a reverse logistics network using hybrid multi-criteria decision making methods. *Journal of Cleaner Production*, 179 (1) (2018) 716-730.
- [9] S. Agrawal, R. Singh, Qand Murtaza, Q. (2015). “A literature review and perspectives in reverse logistics”. *Resources, Conservation and Recycling*, 97, 76–92
- [10] P. Gonzalez, B. Adenso, Reverse logistics practices in the glass sector in Spain and Belgium. *Internet Business Review*, 15(5) (2006) 527-546
- [11] S. Kumar, V. Putnam, Cradle to cradle: Reverse logistics strategies and opportunities across three industry sectors. *International Journal of Production Economy*, 115(2) (2008) 305-315.
- [12] B. Mwanza, C. Mbohwa, Drivers to Sustainable Plastic Solid Waste Recycling: A Review. *Procedia Manufacturing*, (2017) 649-656
- [13] G. Jimenez, L. Hernandez, H. Hernandez, L. Cabas, J. Ferreira, Evaluation of Quality Man.t for Strategic Decision Making in Companies in the Plastic Sector of the Colombian Caribbean Region Using the TQM Diagnostic. Report and Data Analysis. In: Stephanidis C. (eds) *HCI Intern. 2018 – Posters' Extended Abst. HCI 2018. Communications in Computer and Information Science*, Springer Cham, 852 (2018) 273-280.
- [14] G. Jimenez, L. Novoa, L. Ramos, J. Martinez, C. Alvarino. Diagnosis of Initial Conditions for the Implementation of the Integrated Management System in the Companies of the Land Cargo Transportation in the City of Barranquilla (Colombia). In: Stephanidis C. (eds) *HCI International 2018 – Posters' Extended Abstracts. HCI 2018. Com. in Computer and Information Science*, Springer Cham, 852 (2018) 282-289.
- [15] M. Şükrü, A. Coşkun, Drivers of Reverse Logistics Activities: An Empirical Investigation. *Procedia - Social and Behavioral Sciences*, Volume 58, (12) (2012) 1640-1649
- [16] MA. Ortiz- Barrios, B. Kucukaltan, D. Carvajal- Tinoco, D. Neira- Rodado, G. Jiménez, Strategic hybrid approach for selecting suppliers of high- density polyethylene. *Journal of Multi- Criteria Decision Analysis*, (2017) 1–21. <https://doi.org/10.1002/mcda.1617>.
- [17] AENOR Norma No. 66177. Guía para la integración de sistemas de gestión (2005)
- [18] L. Hernández, G. Jiménez, Characterization of the Current Conditions of the ITSA Data Centers According to Standards of the Green Data Centers Friendly to the Environment. In: Silhavy R., Senkerik R., Kominkova Oplatkova Z., Prokopova Z., Silhavy P. (eds) *Cybernetics and Mathematics Ap Intellig Systems. CSOC 2017. Advances in Intelligent Systems and Computing*, vol 574. Springer, Cham, 574 (2017) 329-340
- [19] G.Santos, J.Barbosa, QUALIFOUND - a modular tool developed for Quality Improvement in Foundries. *Journal of Manufacturing Technology Management* (2006), 17 (3) 351-362
- [20] C.Marques, N. Lopes, G. Santos, I. Delgado, P. Delgado, Improving operator evaluation skills for defect classification using training strategy supported by attribute agreement analysis. *Measurement* (2018), 119,129–141.
- [21] M. Doiro, J.F. Fernández, M. Félix, G. Santos, ERP - machining centre integration: a modular kitchen production case study. *Procedia Manufacturing* (2017) 13, 1159–1166.
- [22] L. Bravi, F. Murrura, G. Santos, Attitudes and Behaviours of Italian 3D Prosumer in the Era of Additive Manufacturing. *Procedia Manufacturing* (2017), 13, 980–986