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Sustainable design and manufacturing strategies, review in an appliance company

Estrategias de diseño y manufactura sustentable, revisión en una empresa de electrodomésticos

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Abstract

This article describes an overview of the concepts and main techniques related to sustainable design and production that are being developed in companies today to maintain a balance of resources. Using an information documentation method, the practices in a Mexican company that manufactures household appliances are examined. The information obtained suggests that the company has adopted measures and strategies to improve the environmental performance of its products. The product and process design phase is fundamental not only in the search for operational excellence for companies, but also in achieving benefits that have an impact on the environment.

Sustainable, Strategies, Environmental

Resumen

Este artículo describe una revisión de los conceptos y las principales técnicas en torno al diseño y manufactura sustentable que se están desarrollando en las organizaciones hoy en día con el propósito de mantener un equilibrio en los recursos. Mediante una metodología de documentación de información, se realiza una revisión de las prácticas emprendidas en una empresa dedicada a la fabricación de electrodomésticos en México. Con la información obtenida se concluye que la empresa ha emprendido acciones y estrategias para que sus productos tengan un mejor desempeño ambiental. La etapa de diseño de productos y procesos definitivamente es fundamental no solo en la búsqueda de la excelencia operativa para las organizaciones, sino además para la obtención de beneficios que impactan el medio ambiente.

Sostenible, Estrategias, Medio ambiente

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Introduction

Today, it is recognized that manufacturing must play an essential role in the quest for sustainability due to the large amount of resources it consumes and the waste it generates. In this sense, it is possible to obtain greater efficiency in production as a result of the implementation of sustainable design and manufacturing strategies.

The adoption of sustainable initiatives by manufacturing companies is decisive, favoring practices of lower energy consumption, reduced air and water emissions, and less generation of solid waste that can be hazardous to humans.

The rational use of energy and materials by companies cannot be seen as an isolated action. However, it must be linked to a minimization of environmental impact, the conservation of natural resources, a reduction in energy dependence and a better quality of life for society.

From the earliest stages of the design process, considering the environment facilitates the environmental management of the resulting product's life cycle. It makes sense to say that you are unlikely to achieve an environmentally friendly product if you don't start with green design.

Conceptual framework

Sustainable manufacturing

Several studies show that sustainable manufacturing can help organizations achieve better operational performance and improve environmental performance, supporting the sustainability efforts of manufacturing organizations (Monge et al., 2013).

The issue becomes necessary when considering that global manufacturing consumes large amounts of resources and generates huge amounts of waste; it can be said that global manufacturing consumes one third of energy and generates 36% of total CO 2, the main greenhouse gas (GHG)(Perez et al., 2022).

In Mexico, the power generation industry contributes 21% and manufacturing 8% of the gas emission as mentioned above; however, it is the industry that consumes the most energy, representing 60%, while only 30% of the companies in Mexico have an energy measurement system, which shows the low environmental awareness of the companies. Therefore, manufacturing plants should adopt sustainable practices or manufacturing (Monge et al., 2013).

In recent years there have been trends towards a change in the attitude of senior executives in organizations. They prefer to consider the issue of sustainability and its adoption as essential only if it brings short-term economic benefits rather than considering sustainability as an important differentiating factor to achieve competitive and strategic advantages through product and process innovation (Monge et al., 2013) (Perez et al., 2022).

Life cycle analysis

Life Cycle Assessment (LCA), according to (Sonnemann et al., 2004), is an environmental management tool whose purpose is to objectively, methodically, systematically and scientifically analyze the environmental impact caused by a process/product throughout its life cycle, from cradle to grave.

The current economic-productive model that affects the entire global system, whatever the activity or sector, is still mostly linear. The process begins with the extraction of virgin natural resources, which become raw materials to be transformed into products or services that will be packaged, distributed, sold and used, after their cycle of use, ending up in a landfill.

ISO 14040:1997 states that "LCA is a technique for determining the environmental aspects and potential impacts associated with a product, which is performed by compiling an inventory of the relevant inputs and outputs of the system; assessing the potential environmental impacts associated with those inputs and outputs; and interpreting the results of the inventory and impact phases in relation to the objectives of the study" (Boersema & Reijnders, 2009).

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According to ISO 14040:997, LCA consists of four phases: 1. definition of objectives and scope, 2. inventory analysis, 3. impact assessment and 4. interpretation of results (Finkbeiner et al., 2006). The active or dynamic phases, in which data are collected and evaluated, are the inventory analysis and impact assessment. The first and fourth phases can be considered static phases. Based on the results of one phase, the hypotheses of the previous phase can be reconsidered and redirected towards the path offered by the newly acquired knowledge. LCA is therefore a process that feeds back and is enriched as it is carried out.

Design tools

Concurrent engineering is a systematic approach to the integrated design of products and related processes, from conceptual design to market availability, including quality, cost and user requirements (Savii, 2003). One of the design methodologies used in concurrent engineering is Design for Manufacturing (DFM), which is defined as a set of programs, techniques, metrics, tools, and methods to improve the manufacturing of parts or simplify the assembly of part products (Kuo et al., 2001).

The goal of using design for manufacturing applied to a particular process is to design products that are easy to maintain, reliable, take less time, and are simpler and less expensive to manufacture while maintaining their quality (Kuo et al., 2001).

International regulations

Remarkable progress has been made in the field of international regulation. Adopted by the First International Conference on Chemicals Management (ICCM1) on February 6, 2006 in Dubai, the Strategic Approach to International Chemicals Management (SAICM) is a policy framework to promote chemical safety worldwide (Perez et al., 2022). It aims to achieve sound management of chemicals throughout their life cycle, seeking in the future to ensure that chemicals are used and produced in ways that minimize significant adverse effects on human health and the environment. SAICM's strategic approach is a landmark initiative in international cooperation aimed at protecting human health and the environment (Ministerie van Buitenlandse Zaken, 2004).

Chemicals and waste management play an essential and increasingly important role in all economic and social sectors (IOMC, 2019). Sound management of chemicals throughout their life cycle is essential to avoid complex risks to human health and ecosystems and substantial costs to national economies. Similarly, waste management is necessary to maximize the potential benefits of its contribution to human well-being. The Strategic Approach to International Chemicals Management is a landmark initiative in international cooperation to protect human health and the environment.

The management of chemicals and wastes plays an essential role and is increasingly important in all economic and social sectors. Sound management of chemicals throughout their life cycle is essential to avoid complex risks to human health and ecosystems, and substantial costs to national economies. Similarly, waste management is necessary to maximize the potential benefits of its contribution to human well-being.
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The United States of America has a variety of regulatory agencies, standards and laws on chemical safety. In this country they are very concerned about the health and safety of people who use chemicals, so they are concerned about protecting the safety of employees and hold employers responsible for keeping their workers safe. This article discusses some of the laws, regulators, codes and standards and their implications for chemical workers. One of the most important chemical safety laws in this country is the Toxic Substances Control Act (TSCA), which ensures that chemicals are used, stored, and disposed of in a manner that is safe for human health and the environment (Grossman, 2016). This law was passed in 1976 and regulated the use, importation, and disposal of many new and existing commercial chemicals in the United States. It does not regulate food, packaging, pharmaceuticals, pesticides, or chemicals used in cosmetics and personal care products. TSCA gives the Environmental Protection Agency (EPA) the authority to request reports and impose restrictions on chemical substances and mixtures (Grossman, 2016).

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On the other hand, manufacturers and producers who market their products in the European Union (EU) must comply with regulations and certifications such as REACH and RoHS.

REACH is a European Union regulation that came into force on June 1, 2007. Its purpose is to improve the protection of human health and the environment from the risks posed by chemicals (Foth & Hayes, 2008). It also encourages alternative methods of hazard assessment of substances to reduce the number of tests performed on animals. In principle, REACH applies to all chemicals used in industrial and everyday processes such as cleaning products, paints or articles such as clothing, furniture and electrical appliances. Consequently, the regulation affects most companies in the EU.

Another necessary regulation is RoHS, an acronym for Restriction of Hazardous Substances, a European directive that deals with aspects related to electronics and the manufacture of electronic devices (Parliament Europian, 2003). It was created to control the use of hazardous materials often found in electrical and electronic equipment and devices. In addition, it was developed to protect human health and the state of the environment and ensure that electrical and electronic products can be recycled or disposed of safely.

The RoHS regulation affects any company that sells, distributes or manufactures electronic or electrical equipment in the EU. In addition, companies that, for example, sell such products to a third party that distributes them in the EU are also indirectly bound by the directive. As a directive and not a regulation, it is legally binding on all member states. It therefore leaves a particular framework for action when it comes to implementing it and ensuring compliance. The main groups related to the RoHS directive comprise 11 categories, in which various products are listed, the first category being large household appliances such as refrigerators, stoves, dishwashers and washing machines.

Technical and business strategies related to sustainability

A recent study conducted in SMEs in the United Arab Emirates to determine the relationship between total quality management (TQM), green innovation (GI) and corporate sustainable development (CSD) showed that there is a positive influence between them. In addition, green innovation favorably impacts corporate sustainable development and fully mediates the relationship between TQM and corporate sustainable development (Albloushi et al., 2023). It is important to consider the environmental aspect in quality indicators in order to achieve sustainability objectives.

On the other hand, (Farghali et al., 2023) conducted a review of current and new policies regarding energy sufficiency and conservation, concluding that it is only possible to envision a sustainable future if it is considered, as part of the solution, the application of a systemic approach that includes on the one hand the reduction in energy demand, and the promotion of the use of renewable energies in all sectors.
While (Mignon & Bankel, 2023) address the problem of companies struggling to identify, develop and implement sustainable business models adapted to their needs. The authors reviewed 87 cases of companies that have innovated their business models to achieve sustainable models. They identify four main sustainable business models that have been achieved through different innovation strategies (1) involving improvements towards efficiency, (2) that are based on new ways of making the business sustainable, (3) that have a greater orientation towards society and/or the environment, or (4) that are born sustainable. Finally, (Jayawardane et al., 2023) conduct research to adopt circular economy strategies, such as plastic recycling in industrial applications, to reduce waste management. The research group used recycled polylactic acid (PLA) material as raw material for 3D printing of a pump impeller and the performance was compared with using virgin PLA material. They highlight in their results that 3D printed recycled PLA impellers are more eco-efficient compared to 3D printed virgin PLA impellers. The eco-efficiency assessment revealed that recycled materials significantly improve eco-efficiency performance, in addition to revealing positive social impacts of additive manufacturing for employees in terms of health and safety.

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More and more companies are adopting sustainability-related strategies that contribute significantly to economic and social development by helping to solve ecological problems such as water, air pollution and erosion of natural resources.

Methodology

The desk research at the company involved the systematic review and analysis of various types of documents to gather information, knowledge and data related to the factory's operations, processes and performance. The following is an overview of the methodology for the desk research conducted at the companym.

1. The research objectives were defined. The main objective of the research was to carry out a review of the main sustainable manufacturing strategies in a home appliance company.

2. Relevant documents were identified such as publications in specialized magazines, newspapers, safety manuals, regulatory documents and reports that the company allowed to review on site, as well as interviews with personnel from various departments.

3. An analysis of the data collected was conducted and cross-checked for validation to ensure that the research clearly and accurately reflects the company's operations and challenges.

Results

In the company under study, the corporate supplier quality department aims to verify that the parts supplied by its suppliers comply with the specifications established by the company, adhering to the requirements of REACH and RoHS, toxicity regulations in the European Union.

As mentioned above, REACH requires the registration, evaluation and authorization of chemicals produced, used or imported into the European market. RoHS refers to the directive on the restriction of certain hazardous substances in electrical and electronic equipment.

In this context, the "Company Regulatory Declaration" project was initiated in 2020, with the aim of conducting a strict review of suppliers' compliance with the established requirements. Some of the materials are composed of different chemical substances that, if present in a higher percentage than established, would have severe consequences on the health of customers and the environment.

The company has a Technology and Project Development Center (T&D Center), where it has been able to improve its products and the technology associated with the conceptualization, design and implementation of new products. The T&P Center liaises with the other areas for project development and for the solution of specific projects related to the product, materials and service.

Currently, the T&P center is in a design stage to include the topic of eco-design, based on the product life cycle, relating environmental, health and safety objectives throughout the entire life cycle of its products and processes, from inputs to final product packaging (Technology and Projects, 2003), (Alejandro, 2014).

Being aware of the issue of sustainability in all its processes, the company is implementing environmental impact strategies based on the 3Rs. Examples of this can be identified in the reduction of the use of electrical energy that comes from the change to LED lighting in its operational areas; the reduction of waste of its materials, such as the standardization and reduction of screws in the assembly; the reuse of obsolete station modules, for the construction of its new manufacturing cells. Likewise, the rational use of water, by recycling wastewater for irrigation of its green areas.

Regarding design methodologies, those currently practiced and which have predominated in the company are Design for Manufacturing (DFM), Design for Safety (DFS) and Design for Performance (DFPE). The company's own techniques can be summarized as follows.

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Design for Six Sigma (DFSS). It is based on a methodological analysis, by means of the IDOV structure (Identify, Design, Optimize, Validate), achieving the descent of the customer's requirements from the product to the specification of each component, ensuring that the contribution of each one meets the customer's needs (Tecnología y Proyectos, 2003). Within the Six Sigma methodology, the Quality Function Deployment (QFD) tool is used. The QFD technique ensures that the properties, characteristics, design and specifications of its products, as well as the selection and development of equipment, methods and process controls are oriented to the demands of the user (Alejandro, 2014).

Design for Reliability (DFR). In order to guarantee that a component will fulfill its purpose, the evaluation of these is done taking into account the expected useful life of the component and the environment to which it will be exposed (Alejandro, 2014).

The company collaborates with FirstBuild. FirstBuild is GE Appliances' collaborative innovation platform that engages a diverse community in co-creating home appliances. Through open innovation and rapid prototyping, it fosters the development of cutting-edge ideas and solutions. Maker spaces and microfactories provide the tools for participants to bring their designs to life. Challenges and competitions further incentivize the collaborative design process, contributing to the evolution of appliance technology (Alänge & Steiber, 2018).

In the concept of environmental performance of its products, for the Life Cycle Analysis, the company frames issues such as materials, manufacturing processes, means of transportation, type of energy required at different stages of its life cycle and delivery to the distributor or final customer.

Mabe prioritizes innovation, dedicating approximately 1% of its annual sales to research and development, focusing particularly on energy efficiency and the integration of technologies such as the Internet of Things, according to the director of the Technology Center, in an interview for El Financiero (Almanza, 2018).

Emphasizing the market demand for energy efficiency and environmental responsibility, he highlighted the company's commitment to address the carbon footprint and contribute to a greener world. The executive noted that development in these areas not only aligns with market demands, but also generates substantial savings in energy costs for consumers who use Mabe appliances.

In summary, the company focuses on developing sustainable solutions and practices that can be integrated into the life cycle of its products. It focuses on the development of two categories that enable it to strengthen its sustainability strategy. Product. Sustainable features are integrated into products to reduce environmental impacts for the benefit of society. Institutions. Strategic alliances are established and strengthened to maximize the impact of our efforts worldwide.

Conclusions

Sustainable design should be incorporated into conventional design to ensure minimal impact on the resources available for life on the planet. In addition, the life cycle analysis favors sustainable manufacturing, from the extraction and procurement of materials, use, recycling and return of materials to their origin, allowing a lesser effect on the degradation and depletion of natural resources.

According to the company's research, it can be concluded that the initiatives it has undertaken as strategies to reduce pollution and prevent environmental damage caused by materials are the beginning to reduce the health risks associated with exposure to them.

On the subject of design methodologies, it can be stated that the company is making efforts to ensure that its methodologies are focused on the needs of its market. While, in parallel, it seeks to improve the environmental performance of its products, it faces significant challenges as its products become solid waste at the end of their useful life, with risks to humans and the environment.

Finally, the eco-environmental concept is taking on great relevance for the company, creating awareness of its benefits both for sustainability and for optimizing the value of its products.

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