

Sustainable eco-design for fixture index mechanism in crankshaft speed sensor assembly line

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Abstract

The purpose of this article is to examine the relationship of sustainable manufacturing process and sustainability performance, which considers the environmental, economic, and social aspects. Sustainable manufacturing considering ecological system and corrosion properties has attracted interest in gaining deep insights into the application of daily business operations. Currently, there is an internal pressure in the firms to reduce the costs of production, increase the product quantity with quality, minimize the defects and reliability as well as facilitate faster and flexible delivery. In addition, these firms attempt to seek to satisfy end users and improve operational efficiency. Market pressure, society's demand for environmental-friendly process, and regulatory compliance are mostly discussed as additional pressure to the green operations initiative in the automotive firms. In this article, an existing model was designed using the computer-aided design software and the results were analyzed to fill research gaps in the effects of the eco-system on environmental and operational performance. This study provides new research opportunities for developing models in building simulation-based design of eco-efficient systems. Finally, the article suggests that the operations should apply parsimony principles of ecosystem measurements to foresee the imminent organizational outcome to enlighten industry counterparts with guidance to enhance further robust statistical modeling and construct development.

Keywords

Sustainable manufacturing, ecological system, corrosion, eco-efficiency, simulation

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Introduction

Design modification has become imperative, especially in the automotive sector, for producing sustainable components. Efficient utilization of resources plays a major role in sustainable development.¹ Conventional design process² has to be replaced by eco-design principles to improve environmental regulations.³⁻⁵ Eco-design tools need to be developed to upgrade product sustainability integrating environmental aspects into the design stage itself.⁶ The use of such tools enables to understand the mediating effects of environmental and operational performance.⁷ The tools entail in reducing cycle time and money⁸ and help conduct sustainability

assessments. When manufacturers become more environmental-friendly and socially responsible, products of high operational efficiency with competitive


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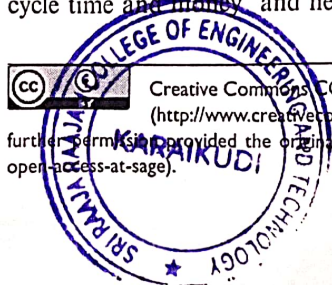
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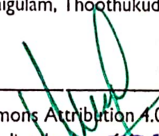
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advantage can be produced.⁹ In this context, this article reports the study of ensuring sustainable design of the alternator holding plate in the machine used for soldering of automotive components using computer-aided design (CAD) and sustainable manufacturing with environmental impact analysis of ecological parameters using AutoCAD Ecoinventor 99 and SimaPro 8.0 software. This case study begins with CAD modeling of a pneumatic motor holding plate followed by sustainability analysis to determine the environmental impact in terms of carbon footprint and energy consumption on the existing and proposed models for materials of mild steel (low carbon) and aluminum alloy.

Literature review

Sustainability in products, process, and materials is of pure significance, of which process sustainability is more important as it is concerned with impacting both energy and environment. The concepts of sustainable manufacturing system are described¹⁰ and highlight the methodology toward efficient utilization of resources. The challenges confronted to the sustainability issues are discussed.¹¹ Sustainability assessments have to be made in order to facilitate decisions that affect sustainability in various aspects such as industrial, regional, natural, and global factors.¹² Manufacturing processes toward the machine component material are the key factor for the design of a product. The combined material and manufacturing system selection is the primary stage of the design process.¹³ An automated evaluation tool of environmental input of the manufacturing process was presented by W Faulkner et al.¹⁴ emphasizing three main factors, namely, emission, waste production, and material hazard for evaluation. An overall sustainability performance of operational parameters in the process industry was addressed by a framework. HA Verfaillie and Bidwell¹⁵ and Kaebernick et al.¹⁰ developed an assessment tool that initiates environmental and energy metrics for evaluation wherein the tool predicts energy consumption for process but not transportation. Life cycle assessment (LCA) is used in the earlier stage which helps identify the critical phase of the product's environmental performance that can be improved.¹⁶ An approach of LCA deals with ISO 14040/44 standards.¹⁷ Besides, this demonstrates the real troubles associated with the manufacturing systems.¹⁸ The powerful tool of LCA has been used to analyze the environment impact.¹⁹ Life cycle thinking has been the primary assessment of overall improvement of the organization. The advantages of light weight, reduction of energy utilization, and minimal CO₂ emissions in aluminum are also used in the development of the manufacturing industry.²⁰ For selecting technical materials and manufacturing processes, the

integration of management methodologies^{21,22} in LCA helps identify critical areas in which the product's environmental performance can be improved.^{10,13} The LCA is one of the powerful tools that have been used for analyzing an environmental impact. Consideration of manufacturing process and product life cycle is essential for overall improvement of the organization. The advantages of aluminum is light weight, low energy utilization and less emission of carbon dioxide for the development of manufacturing industry.^{23,24} The integrated manufacturing methodologies applied for selection of materials and manufacturing processes^{25,26} with product environmental performance can be enhanced.

Research gap

The literature review demonstrates that amalgamations of sustainable creativity and innovation techniques to the sustainable production process system with design criteria are highly restricted. As sustainable practices were not adapted by manufacturing sectors, the issues of environmental impact have considerably increased. This research enables to reduce the gap by providing a methodology to produce components that are eco-friendly and environmental prone.

Research methodology

The methodology adopted provides a creative design to develop a new servo motor seating plate design of the motor in this research. Based on the application and concept of vision, the pneumatic motor was replaced by the servo motor to apply sustainable concept.

Case study

Existing background details

The case study has been carried out in an automotive component manufacturing organization located in Gangaikondan, Tamil Nadu, India. The organization aspires to enhance environmental friendliness in their product design and manufacturing process development practices. Since the industry shows great interest in measuring the existing sustainability level, this study has adapted a new system encompassing and enhancing the sustainability. The organization has put into practice world-class approaches such as ISO 14000-2000 environmental management systems. The firm manufactures around 5000 various automotive components every month.

A speed sensor is an electronic device used in an internal combustion engine, both petrol and diesel, to monitor the position or rotational speed of the crankshaft.