

Design Methods

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2.1 Designing from Objectives

Contribution 1

Title: New Designs of the Ceramic Bricks of Horizontal Hexagonal Hollow.

Authors: David Corbella, Francisco Fernandez, Francisco Hernández-Olivares, Pedro Armisen, Cristina Corbella.

Key Words: product design, industrial design and creativity, industrial innovation, product manufacturing, graphical analysis.

Technical Drawing is a multiple tool of expression and communication essential to develop inquiry processes, the scientifically basis and comprehension of drawings and technological designs being able to be manufactured. It is demonstrated graphically and analytically that spatial vision and graphic thinking allow the user to identify graphically real life problems, develop proposals of solutions to be analysed from different points of view, plan and develop the project, provide information needed to make decisions on objects and technological processes. From the knowledge of Technical Drawing and CAD tools graphic analyses have developed in order to improve and optimize the geometry of the rectangular cells of conventional bricks by hexagonal cells, which is protected by a Spanish patent owned by the Polytechnic University of Madrid. This new internal geometry of the bricks will improve the efficiency and the acoustic damping of walls built with the ceramic bricks of horizontal hollow, maintaining the same size of the conventional bricks, without increasing costs either in the manufacture and the sale. A single brick will achieve the width equivalent to more than four conventional bricks.

Full Article: 05-dm-98

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Contribution 2

Title: Improving the Modular Structure of a Product to Facilitate The Redesign Process: an Example for Eco-Design.

Authors: Marco Malatesta, Michele Germani, Fabio Gregori, Roberto Raffaeli.

Key Words: modular design, product lifecycle design, eco-design , LCA.

Products are continuously redesigned to offer new variants and penetrate new market niches. Changes are often dictated by improvements which are necessary in specific Design Contexts (DC), such as performance, eco-sustainability, assembling, cost, usability. Modularity is a well consolidated approach toward the rapid product reconfiguration and is beneficial to limit the scope of changes to product subsets. However, this consideration needs to be included in the design of the modular structure of a product. The concept of Design Context Module (DCM) is introduced as a module implemented in components that will strongly affect a certain DC, letting the designer to restrict

the number of the parts to be modified. The approach moves from the traditional modularization based on the functional decomposition and introduces an iterative procedure to refine the DCMs structure. The optimization is driven by the maximization of similarities and dependencies among components of the same module and by indexes expressing the impact of the components on specific DCs. The approach has been tested in the field of the household appliances. The modular structure of a freestanding cooker has been redefined in consideration of redesign activities aiming to improve the eco-sustainability of the product. The application of the approach has led to the identification of few modules characterized by high impacts on the environment.

Full Article: 02-dm-68

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Contribution 3

Title: Seat Design Improvement Via Comfort Indexes
Based on Interface Pressure Data.

Authors: A. Lanzotti, A. Vanacore, D. M. Del Giudice.

Key Words: office chair, sitting comfort/discomfort
assessment, interface pressure distribution.

Literature on seat comfort recognizes that seat interface pressures are the objective comfort measures that most clearly relate to users comfort perceptions about sitting experience. The above relationship is quantitatively investigated by performing simple but effective explorative analyses on seat comfort data collected during experimental sessions involving 22 volunteers who tested 4 office chairs (differing in terms of cushion softness). Statistical data analyses show that subjective sitting comfort/discomfort ratings are significantly related to several combinations of pressure variables. The joint analysis of synthetic indexes based on seat interface pressures reveals to be a useful tool for comparative seat comfort assessment. Besides valuable suggestions for the definition of an effective strategy for seat comfort assessment, the results of data analyses provide useful information to support the product design phase. In fact, the sitting experience results to be significantly improved by: (1) a balancing of pressures between the bilateral buttocks, and (2) a balancing of contact areas between buttocks and thighs.

Full Article: 03-dm-72

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2.2 The Design Process

Contribution 1

Title: Design Process and Trace Modelling for Design Rationale Capture.

Authors: Emna Moones, Esma Yahia, Lionel Roucoules.

Key Words: design process, design rationale, design trace, decision making, product design.

To face the high industrial concurrence and to remain competitive, companies are asked to work in a context of collaborative engineering environment where design rationale is a prerogative to reduce their product development time. Design rationale aims to capture the knowledge from the product design at a very early stage as those decisions have higher impacts in terms of time, cost and quality in the later product lifecycle stages. We propose, in this paper, a three-layer framework to answer to the need to capture the process design knowledge and to use the construct captured to visualize the process performances and to derive rules in order to help and assist the designers.

Full Article: 04-dm-76

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Contribution 2

Title: Design Synthesis Methodology for Dimensional Management of Assembly Process with Compliant Non-Ideal Parts.

Authors: Pasquale Franciosa, Abhishek Das, Darek Ceglarek, Luca Bolognese, Charles Marine, Anil Mistry.

Key Words: design synthesis, product and process simulation, design task integration, non-ideal compliant parts, dimensional management.

A design synthesis methodology is proposed: it is dedicated to dimensional management of assembly processes with compliant non-ideal parts which allows to integrate the critical and heterogeneous

design tasks with conflicting or coupled objectives and design constraints such as: (1) tolerancing and variation simulation analysis (VSA); (2) fixture layout design optimization; (3) part-to-part joining process parameters selection and laser beam visibility analysis; or/and; (4) in-process measurement gauge visibility and accessibility analysis. The proposed methodology is based on the Adaptive Task Graph (ATG) that has capability to model design tasks by integrating Key Product Characteristics (KPCs) and Key Control Characteristics (KCCs) with their impact on the Key Performance Indicators (KPIs); this allows to dynamically capture interactions between design tasks as well as to generate tasks sequence. The design synthesis methodology is based on the development of: (i) assembly surrogate model linking KPCs to KCCs; (ii) sensitivity analysis with capability to model and analyse the interdependencies among design tasks and KPCs, KCCs and KPIs; and, (iii) ATG model which represents the hierarchy of design tasks and is used to generate the sequence of design tasks to minimize their interdependencies during design synthesis. The proposed methodology is illustrated and validated in the process of designing configurations for automotive door assembly with remote fiber laser welding joining process. The methodology shows potential to reduce engineering changes necessary during door assembly process build and testing by 25%.

Full Article: 09-dm-107

Page: 112

Contribution 3

Title: About Wear Damage in Straight and Crowned Misaligned Splined Couplings.

Authors: Cuffaro Vincenzo, Curá Francesca, Mura Andrea.

Key Words: spline couplings, fretting wear, misalignment, test rig.

The spline coupling tooth geometry may influence the surface fear pattern. In particular the difference between straight teeth and crowned teeth spline coupling is considered. The different tooth profile brings to different contact pressure distributions that, associated to the relative motion between engaging teeth may create different wear patterns on the contact surfaces. Also the effect of the lubrication conditions has been considered. The investigation has been carried on by means of

a dedicated spline coupling test rig capable to perform wear tests on components working in misaligned conditions.

Full Article: 07-dm-113

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2.3 Embodiment and Conceptual Design

Contribution 1

Title: Development of Tools For Multi-Material Design.

Authors: F.X. Kromm, H. Wagnier, M. Danis.

Key Words: multi-material, design, architected materials, material selection, optimization.

Multi-material design implies the selection of various parameters such as the nature of the components, their morphology (or architecture), their volume fractions, etc. Although selection methods have been developed for monolithic materials, a single method dealing with all these parameters has not been created yet. Several tools that can guide the designer in this task are described. The firstone consists in a statistical analysis of the material properties to see whether some requirements are incompatible. In this case, the result allows the separation of these requirements and helps the components selection. Another study deals with the selection of the components when the architecture of the multi-materials is known. The important benefit of the method is a filtration of the candidates that decreases drastically the number of solutions that have to be evaluated. Finally, an architecture can be selected and optimized.

Full Article: 01-dm-33

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Contribution 2

Title: Comparison of Different Multiple-Criteria Decision Analysis Methods in the Context of Conceptual Design: Application to the Development of a Solar Collector Structure.

Authors: Mehdi El Amine, Jérôme Pailhes, Nicolas Perry.

Key Words: multi-criteria decision aid methods, selection methods, aggregative methods, conceptual design, consistency.

At each stage of the product development process, the designers are facing an important task which consists of decision making. Two cases are observed: the problem of concept selection in conceptual design phases and, the problem of pre-dimensioning once concept choices are made. Making decisions in conceptual design phases on a sound basis is one of the most difficult challenges in engineering design, especially when innovative concepts are introduced. On the one hand, designers deal with imprecise data about design alternatives. On the other hand, design objectives and requirements are usually not clear in these phases. The greatest opportunities to reduce product life cycle costs usually occur during the first conceptual design phases. The need for reliable multi-criteria decision aid (MCDA) methods is thus greatest at early conceptual design phases. Various MCDA methods are proposed in the literature. The main criticism of these methods is that they usually yield different results for the same problem. An analysis of six MCDA methods was conducted. Our analysis was performed via an industrial case of solar collector structure development. The objective is to define the most appropriate MCDA methods in term of three criteria: (1) the consistency of the results, (2) the ease of understanding and, (3) the adaptation of the decision type. The results show that TOPSIS is the most consistent MCDA method in our case.

Full Article: 06-dm-104

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Contribution 3

Title: Contribution to the Embodiment Design of Mechatronic System by Evolutionary Optimization Approaches.

Authors: Didier Casner, Rémy Houssin, Jean Renaud, Dominique Knittel.

Key Words: mechatronic systems, design, optimization, optimization-integrated design.

Mechatronic systems are multidisciplinary devices and therefore require specific approaches to design and optimize them, unlike most approaches that consider the optimization as a manner to identify

the optimal process through a redesign strategy and at the last phase of design. Therefore optimization has limited efficiency. This paper contributes to the integration of the optimization in the embodiment design process, as part of a routine or innovative approach. The optimization will now be considered as a manner to design and optimize innovative mechatronic systems. This approach considers an evolutionary case-based reasoning process to design a technical solution from a concept by reusing, adapting and optimizing solutions or cases that have previously been used to solve similar problems. The main approach has been applied to the design of an XY table for laser cutting applications.

Full Article: 08-dm-102

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2.4 Integrated Design

Title: Product Design-Process Selection Planning
Integration Based on Modelling and Simulation.

Authors: Von Dim Nguyen, Patrick Martin, Laurent
Langlois.

Key Words: modeling, simulation, product design, process
selection, process planning.

As a solution for traditional design process having many drawbacks in the manufacturing process, the integration of Product design-Process selection-Process planning is carried out in the early design phase. The technological, economic and logistic parameters are taken into account simultaneously as well as manufacturing constraints being integrated into the product design. As a consequence, the most feasible alternative with regard to the products detailed design is extracted satisfying the products functional requirements. Subsequently, a couple of conceptual process plans are proposed relied on manufacturing processes being preliminary selected in the conceptual design phase. Virtual manufacturing is employed under CAM software to simulate fabrication process of the potential process plans. Ultimately, the most suitable process plan for fabricating the part is recommended based upon a multi-criteria analysis as a resolution for decision making.

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