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Reducing and reusing industrial scraps: a proposed method for industrial designers

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ABSTRACT

Designers often develop products without a real vision of industrial dynamics, not taking into consideration how their choices can affect environmental and economical aspects of the product development process. Our research concentrates on industrial scraps. How can designers actively reduce scraps since early product development phase? To answer this, we firstly analyzed the existing norms within Italian and European jurisdiction and classified various case studies, where design was carried out taking into consideration industrial scraps. We then developed a method to be followed by products designers and companies, intended to help them obtaining both environmental and economical advantages by sustainable practices in an industrial context. The approach consists in a simplified procedural methodology that indicates all needed steps to design industrial products based on these practices. Finally we applied and verified the feasibility of this methodology on specific and original case studies. In our conclusions we summarize limits and advantages of the method and how designers and companies can develop new industrial products through this ecodesign approach, raising consciousness during the design process and giving the chance to achieve better economic and sustainable standards by applying the tool here developed.

1. Introduction

In this research we combine the fields of industrial wastes production with product design, assuming that there are great economic and environmental potentials (Plouffe S. et al., 2011; Borchardt M. et al., 2011) in designing products by adopting sustainable design practices such as reusing industrial wastes and, more in detail, scraps. Ecodesign processes have been analyzed and developed in order to define the best operative strategies and the tools needed to assess products' environmental requirements (Pigosso D.C.A. et al., 2009; Bovea M.D., Perez-Belis V., 2012). Our research consists in a new design method focused on minimizing and reusing industrial scraps in order to obtain serial products who can lead to economic and environmental advantages for the company. Interactions between industrial designers and engineers sometimes are difficult to achieve, and some ecodesign strategies were developed in order to solve this problem (Rio et al., 2012). Our research consists in a design driven application whose aim is to understand the feasibility of developing products based on waste reuse. In order to define all the procedural steps of the used method, we start from analyzing several manufacturing processes and wastes related to them (Thompson, 2007), defining potentialities and limits of each technology here presented. Parallel to these technological considerations we present design case studies based on waste reuse, demonstrating on one side that the interest of international design research related to this topic is growing, but on the other side that the usual industrial designers' approach related to waste reuse is often unstructured and unrepeatable. Especially this last point evidences, the need of this method to outline a design driven approach able to support the product development phases in order to design components and parts with a coherent approach from an industrial point of view.

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The three procedural steps of our methodology represent a useful model for designers to organize concepts and design proposals based on industrial scrap reuse in a structured and simple way, in order to better understand which is the most preferable solution to follow.

2. Industrial wastes and scraps

2.1. Italian legislation

Waste production and management are themes of great interest for Italy due to the large amount of companies, capitals and resources involved in industrial processes, even if sustainable oriented practices and methods such as LCA started to being applied in the country just in recent years (Tarantini et al., 2009). Italian legislation in the past fifteen years has been very active in structuring norms designed to change the approach to industrial wastes' treatment, managing them in a more sustainable way for the environment. The 2006 Legislative Decree (Dlgs)152/06 defined a more structured approach to sustainable wastes' management, introducing tools such as the Strategic Environmental Assessment (VAS) and Environmental Impact Assessment (VIA). In 2008, European Parliament approved the 2008/98/CE directive, defining a hierarchical order for wastes' management and handling, establishing as prior design operations their prevention and preparation for reuse, followed by recycling and energy recovering activities, considering landfill disposal as last preferable above all. The 2008/98/CE was received in Italy in 2010 with Dlgs. 205/10, which introduced in the national legislation the hierarchical prevention order disposed by the European directive with the active participation of Sistri, a service born to facilitate wastes' traceability and monitoring.

2.2. Wastes' production and management

According to the Dlgs 205/10, urban and special wastes consist in material produced by someone who needs or has to discard it. While urban wastes come from domestic and public areas, special wastes are generated by private sectors such as agriculture, industry, handicraft or waste treatment plants. We focus this research on special wastes production. In 2011 the ISPRA Institute published the Special Wastes Report, a document which analyzes data and statistics on wastes' production and management in Italy. The report shows how in 2009 there was a deflection in wastes production compared to 2008, for a total of 128.5 millions tons. The manufacturing processes generated a large amount of wastes, for a total of nearly 36 millions tons, equal to 28% of overall production. Registered data related to waste management in 2009 showed how recovery and recycling operations represented in Italy the most practiced choice, involving 77.7 millions tons of material, equal to 67.7% of the overall special waste production. While this is an encouraging statistics, there were still 13 millions tons of special wastes landfilled, equal to an overall 11.3%.

2.3. Design strategies for product optimization and waste reduction

A big role in reducing and optimizing the use or resources and energy is represented by simplicity. We present how it has been approached in past and contemporary industrial design history (Maeda, 2006). Design for Assembly (Boothroyd and Alting, 1992), Design for Disassembly (Crowther, 1999) and Design for Environment (Billatos and Basaly, 1997) are practices aimed to facilitate factory assembling operations and end-of-life products' recovery. Whole System Design (Stasinopoulos et al., 2008) and Whole System Engineering (Pahl et al., 2007) define a different approach to design, focusing on the entire product-system optimization instead of simply considering single components or single assemblies. This olistic approach needs to be adopted since the earliest phases of product development, also highlighted by Front Ended Design (Blanchard and Fabrycky, 2006). Lean Manufacturing (Sugimori et al., 1977) is an industrial management strategy conceived to improve internal logistical organization of material and worker fluxes in order to reduce energy and time wastes, focusing on the real perception of value for the customer. Mainly developed to solve or reduce environmental issues caused by industries, Design for Environment (Giudice et al., 2006) and Life Cycle Assessment (Curan, 2012) are practices whose aim is to define valuable strategies to reduce harmful impacts related to an industrial production after analyzing and evaluating all the phases of a product life cycle. All of these strategies need to be planned from the earliest moments of the definition of the concept design, since at this step the 80% of the production phase costs are already set (Anderson, 2008), and design changes adopted on the subsequent phases might become really unproductive for a company.

We present also some of the recent scientific studies which demonstrate the potential economical and environmental advantages achievable from practices such as reuse, recycling and remanufacturing. Chongqing Technology and Business University developed a redesign methodology (Du et al., 2012) based on an axiomatic design theory which demonstrates how designing remanufacturing strategies for product refurbishing could lead to significant results. Refurbished components have to maintain the same original functions and can't be modified too much, but through strategic and well-designed remanufacturing operations it is possible to obtain the same original performances even in complex machines such as an industrial lathe.

A work by Castro-Gomes J.P. et al., 2011 (Castro-Gomes et al., 2011) presents the potentiality of reusing wastes derived from mining and quarrying activities in order to realize polymer-based composite materials for artistic and mechanical products instead of traditional landfill disposal. Ceramic wastes could be used to obtain new concrete formulas improving mechanical and durability performances compared to traditional ones (Pacheco-Torgal and Jalali, 2009).

Reusing industrial wastes in processes such as vitrification allows the reuse of industrial hazardous wastes in order to obtain inert glass-based products such as fibers, foams, nucleation and sinter-crystallization glass-ceramics (Colombo et al., 2003). Another significant application for hazardous wastes is constituted by their use as reinforcing fillers in polypropylene composites, obtaining different mechanical and technical performances depending on the type of processing typology applied to the waste itself (Zheng et al., 2008).

The management of more structured end-of-life scenarios and industrial waste reuse could lead to several advantages in terms of environmental sustainability and many national and international researches (mainly based on LCA method) have been conducted related to this aspect (Glew D. et al., 2012; Vermeulen I. et al., 2012; Tsai W.T., Chou Y.H., 2003).

3. A proposed method for industrial designers

3.1. Scraps, rejects and reuse

Industrial wastes are produced by many manufacturing sectors involving different materials and technologies. Wastes can be defined also as the non-value results of a manufacturing process set up to realize specific components. They can mainly be divided in two typologies: scraps and rejects.