



The best vendor selection for conducting the recycled material based on a hybrid MCDM model combining DANP with VIKOR

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ABSTRACT

Environmentally conscious manufacturing and product recovery (ECMPRO) has become an obligation of manufacturers, and it has been extended to be the policy and strategy of businesses. Producing recyclable products and using recycled materials are optimal strategies for ECMPRO. Vendor selection (VS) is one of the multiple criteria decision-making (MCDM) problems in strategic supply chain management. The purpose of this article is to propose how the best selection to conduct the recycled materials can be implemented for enhancing and increasing the efficiency of using resources in the manufacturing process through recycled materials VS. Aluminum composite panel (ACP) is a global product, and ACP companies in Taiwan use recycled materials in more than 80% for their products on a quantity basis. Therefore, we selected the ACP industry of Taiwan as an empirical model to study VS and to reveal methods of improving gaps in each criterion for achieving the aspired levels of performance. We use the MCDM model combining DEMATEL-based on ANP (called DANP) with VIKOR to solve the recycled materials VS problems of multiple dimensions and criteria that are interdependent, instead of the independent assumption of an analytic hierarchy process, for mimicking the real-world scenario.

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1. Introduction

Environmentally conscious manufacturing is concerned with developing methods for manufacturing new products from conceptual design to final delivery and ultimately to the end-of-life (EOL) disposal such that environmental standards and requirements are satisfied. Conversely, product recovery aims to minimize the amount of waste sent to landfills by recovering materials and parts from old or outdated products through recycling and remanufacturing (including reuse of parts and products) (Gungor and Gupta, 1999).

The increasing interest in product reuse originates not only from the reinforcement of environmental awareness legislation but also from the fact that the engagement in reuse activities has been proven profitable in many industries (Kannan et al., 2009). So, suppliers face increasing pressure from their customers to improve their environmental performance (Delmas and Montiel, 2009). Mena et al. (2011) identified the main root causes of food

waste in the supplier-retailer interface and compared practices in the UK and Spain. Zhang et al. (2012) analyzed the demands, possibilities, difficulties and suggestions for waste cooking oil recycling in China. For these reasons, green manufacturing, that is, making environmentally sound products through efficient processes, can be good for business and is a current trend in business around the world (Melnyk et al., 2001; Venus, 2011).

In the automotive industry, most companies are putting the ability to recycle parts on the same level as safety, fuel economy, and costs when they design new vehicles. The 15-nation European Union is considering a rule that would require 85% of a car by weight to be recycled or remanufactured. This would increase to 95% by 2015. The source of recycled material is post consumer waste (PCW), of which paper, metal, glass, and plastics are the largest categories (Field and Sroufe, 2007). Olugu et al. (2011) developed a set of measures for evaluating the performance of the automobile green supply chain.

According to a long-term study in the US during 1960 to 1996, the amount of plastics consumed annually have been growing steadily from 0.5% to 12.3%, by weight of municipal solid waste (Subramanian, 2000). And the polyethylene, including high density polyethylene and low density polyethylene, forms the largest fraction of plastics in municipal solid waste about 49%. For example, aluminum composite panel (ACP) is a multi-layer sheet that is

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- 1 PVDF (Kynar 500) coating
- 2 Epoxy resin primer
- 3 Chromate treatment
- 4 0.5 mm Aluminium outer face
- 5 3 mm Thermoplastic core
- 6 0.5 mm Aluminium inner face
- 7 Chromate treatment
- 8 Internal coating

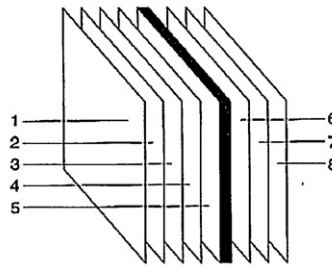


Fig. 1. The composition structure of ACP.

produced by laminating two pre-treated and coated aluminum with a fire resistant mineral-filled or polyethylene (PE) core under a continuous high pressure and heat process (Fig. 1). ACP is a construction material that has been applied to the decoration of buildings both inside and outside of the wall. ACP can be 100% recycled for both aluminum and plastic materials at its EOL.

To introduce the ACP recycling loop, we modified the product life cycle, recycling states and activities figure of Chen et al. (1993). Fig. 2 shows the general stages and the associated activities of ACP recycling. Although the primary recyclable ACP components include aluminum and plastics, this study focus on recycled plastics, such as, low-density PE (LDPE) and high-density of PE (HDPE).

As we know, one of the competencies essential to supply chain success is an effective purchasing function (Cakravastia and Takahashi, 2004; Giunipero and Brand, 1996). Vendor selection (VS), the first step of purchasing function, has a very important role in the supply chain of manufacturing companies Therefore, the purpose of this article is to enhance and increase the efficiency of using resources in the manufacturing process through recycled materials vendor selection (VS). As the demand for environmentally friendly products has grown, the technology for converting PCW into new products has improved, and more recycling programs have been implemented. As a result, the demand for recycled

materials and the availability and variety of products with recycled content continues to increase (Field and Sroufe, 2007). For example, according to production records of Taiwan's aluminum composite panel (ACP) manufactures' they used recycled plastics in their products has grown from 0% to 80% on a quantity basis in the past 10 years. Chinese ACP manufacturers use an even higher ratio of recycled plastics. Moreover, this tendency will continue to increase following improvements in environmental management systems and recycling technology in the future.

This is the essential reason for our focus on VS, as regarding recycled materials in the ACP industry expect to support acquisition by companies of environmentally friendly materials with stable quality and quantity, reasonable cost, on-time delivery, and good service. As VS is a type of multiple criteria decision-making (MCDM) problem, we propose a hybrid MCDM model combining a decision-making trial and evaluation laboratory (DEMATEL) method with an analytic network process (ANP) and 'ViseKriterijumska Optimizacija I Kompromisno Resenje' (VIKOR; translates into multicriteria optimization and compromise solution) method in this study.

The DEMATEL method (Fontela and Gabus, 1976) was designed to determine the degree of influence of the VS criteria and apply them to normalize the unweighted supermatrix in the ANP. The ANP is an extension of the analytic hierarchy process (AHP); indeed, it is the general form of the AHP. The ANP handles dependence within a cluster (inner dependence) and among different clusters (outer dependence). The ANP is a nonlinear structure, whereas the AHP is hierarchical and linear with goals at the top and alternatives at lower levels (Saaty, 1999). The ANP has been used successfully in many practical decision-making problems, such as the project selection, supply chain management, and optimal scheduling problems (Lee and Kim, 2000; Meade and Presley, 2002; Momoh and Zhu, 2003; Sarkis, 2003).

A hybrid model combining DEMATEL and ANP (we call this model DEMATEL-based ANP; DANP) has been widely applied to solve a variety of applications in solving MCDM problems, such as e-learning evaluations (Tzeng et al., 2007), airline safety measurements (Liou et al., 2007), and innovation policy portfolios for Taiwan's silicon/semiconductor intellectual property (SIP) Mall (Huang et al., 2007). Strategic management decisions influence the relative importance of the various criteria in the VS process (Weber et al., 2000). The majority of VS models in existing publications ignored the fact that evaluation criteria must be aligned with a firm's environmental strategies (Chou et al., 2007).

As mentioned in the previous paragraph, this work is different from previously research in three ways. First, we aligned the criteria with the firm's strategy of environmentally conscious green manufacturing to use recycled materials with VS dimensions and criteria. Second, we adopted a hybrid MCDM model of DANP to evaluate and improve the performance of vendor's dimensions and criteria, which are interdependent for achieving the best alternative in VS. Finally, we combined DANP with VIKOR to evaluate/improve the

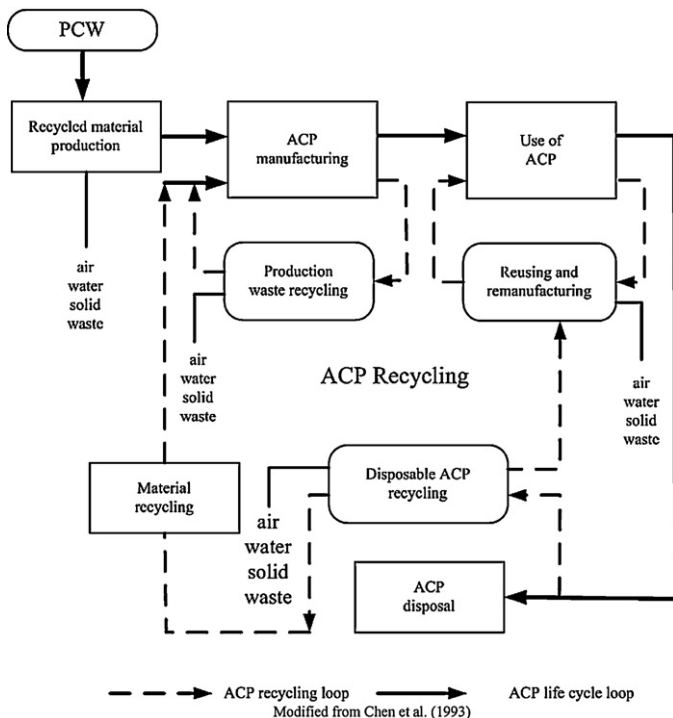


Fig. 2. ACP life cycle recycling stages and activities.

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