

https://dspace.org/

A multi-criterion decision analysis (MCDA) approach to pallet material selection for varying supply chain networks

Chama, Chama

2019

https://hdl.handle.net/10539/29377

Chama, Chama. (2919). A multi-criterion decision analysis (MCDA) approach to pallet material selection for varying supply chain networks. University of the Witwatersrand, https://hdl.handle.net/10539/29377

Downloaded from a DSpace repository. https://dspace.org/

ABSTRACT

Pallets maintain a pivotal role in the storage and transportation of products within a supply chain. Although pallets have been traditionally constructed from wood, there has been a shift towards plastic and other composite materials for pallet construction. Subsequently, debate has inundated the industry with questions pertaining to the identification of ñthe bestò pallet material type in relation to a supply chain, which could be highly subjective.

As such, the aim of this research is to provide insights into the impact that these materials of construction (MOC), of a pallet, have on a supply chain network and examine the limitations and drawbacks as well as strengths and benefits associated with pallets of a particular MOC. The goal is to assist the end consumer come to an informed decision when making the choice between pallets of different MOC. In order to achieve this, the main objective of the research was to develop a decision support tool that can be used by industry professionals when deciding between alternative pallets for their supply chain.

Four main facets were used in order to conduct the study namely: (I) a theoretical framework and market analysis, which laid the foundation of the study; (II) a material analysis phase which looked at the material properties of the selected pallets with the incorporation of modelling; (III) a macro study phase which looked at the ñbigò picture in the form of a case study; and (IV) a final phase which culminated the findings of the study and presented the backdrop for the formation of a decision support tool. A mixture of qualitative and quantitative research methods, feature in this study in order to fully examine the research objectives.

In addition to the literature review, surveys were circulated to prominent pallet manufacturers and consumers within the local South African (SA) market. This was the method of choice for data collection in phase I. Within phase II, the materials used for pallet construction were characterized by scanning electron microscopy (SEM) and atomic force microscopy (AFM)

for surface morphology and topology characteristics respectively. Fourier transform infrared spectroscopy (FTIR) analysis was used to confirm the chemical structure of the MOC and assess if major additives were present that could affect pallet performance. Lastly tensile testing was carried out as a means by which to assess mechanical properties of the pallet MOC and provide useful data for the simulation models. A case study was the main feature of phase III.

Pallets of wood and plastic were introduced into 3 different supply chain types namely: i) a cold chain loop in the frozen vegetable sector, ii) an ambient goods chain primarily featuring household cleaning agents and iii) a perishable foods chain. This then presented the opportunity to substantiate test results (from phase II) with real world data. In the final phase, a multi-criteria decision analysis (MCDA) tool is formulated using analytic hierarchy process techniques.

From the first phase of the study, a survey was used to evaluate the local landscape and market perception of pallets from a consumer and manufacturer perspective. The survey results confirmed the dominance of wood as a MOC in the SA marketplace with 86 % of the total pallet market being wood, as per respondents from pallet manufacturers and poolers alike. With 85.71 % of respondents asserting that they supplied fast moving consumer goods (FMCG) industries, the decision to conduct the case study in this field also proved justified.

The characterization of the MOCs provided critical material data for use in the pallet modelling and provided insight into the chemical and mechanical properties that the materials possess. In terms of pallet tests, all the pallets performed well in the stacking and racking tests. Average deflections of 5.7 mm, 3.7 mm and 5.0 mm in the racking tests were recorded for the wood (Pallet B ï SA Pine), plastic (Pallet A ï HDPE + PP) and plastic (Pallet C ï PP) pallets respectively. In terms of the stacking tests, deflection rates were 4.0 mm, 3.5 mm and 4.8 mm for these pallets as well.

The case study results indicated that each pallet had areas of strength and weakness with respect to a particular supply chain network or operating environment. The scorecards for each pallet were specified and derived from site observations (based on performance within supply chains). The plastic (Pallet C ï PP) pallet was however the best performer overall (as an aggregate across all 3 supply chains was considered) with an average rating of 4.81/5 and closely followed by wood (Pallet B) at 4.70/5 and lastly 4.54/5 for the Pallet A plastic pallet. These results stem from a comparison of the pallets across a number of criteria with a focus on the various stages along the supply chain.

As a consequence, the study also proved that deciding on a pallet type for a particular supply chain is an arduous task due to the complexity of assessing pallets in different scenarios and the varied performance attributes presented and requires consideration of multiple criteria.

Therefore, the proposed solution may have practical implications for all users of pallets in that the formulated tool can support in optimising the consumerôs supply chains by choosing the best pallet solution to meet their needs. The resulting MCDA tool along with pertinent media from the case study is hosted on the following web address and can be accessed at: https://pallet-mcda.firebaseapp.com. Here the tool will perform the relevant calculations on the basis of customer requirements and output a suggested pallet solution.

Keywords: Analytic Hierarchy Process (AHP); Fast moving consumer goods (FMCG); Multi-criteria decision analysis (MCDA); Pallet; Supply chain network (SCN)