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Satish Nukala
Northeastern University

Surendra M. Gupta
Northeastern University

Laboratory for Responsible Manufacturing

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Contact Information

Dr. Surendra M. Gupta, P.E.
Professor of Mechanical and Industrial Engineering and
Director of Laboratory for Responsible Manufacturing
334 SN, Department of MIE
Northeastern University
360 Huntington Avenue
Boston, MA 02115, U.S.A.

(617)-373-4846 ***Phone***
(617)-373-2921 ***Fax***
gupta@neu.edu ***e-mail address***

http://www.coe.neu.edu/~smgupta/ ***Home Page***

PLANNING AN EFFICIENT CLOSED-LOOP SUPPLY CHAIN NETWORK: A UNIFIED SINGLE-PHASE APPROACH

Satish Nukala and Surendra M. Gupta*
(*Corresponding Author)
Laboratory for Responsible Manufacturing, 334 SN, Department of MIE
Northeastern University, 360 Huntington Avenue, Boston, MA 02115 USA
Phone: (617)-373-4846, Fax: (617)-373-2921, E-mail: gupta@neu.edu

Introduction

Economic incentives, government regulations and customer perspective on environmental consciousness (EC) are driving more and more companies into the product recovery business, which forms a reverse supply chain. The combination of traditional/forward supply chain and reverse supply chain is called a closed-loop supply chain (CLSC). A Supply Chain involves three stages of planning, viz., Strategic, Tactical and Operational. Strategic planning primarily deals with the design (what products should be processed/produced in what facilities etc) of the supply chain that is typically a long-range planning performed every few years when a supply chain needs to expand its capabilities [1]. Tactical planning involves the optimization of flow of goods and services across the supply chain and is typically a medium-range planning performed on a monthly basis. Finally, Operational planning is a short-range planning that deals with the day-to-day production planning and inventory issues on the factory floor.

Problem Addressed

We concentrate our efforts on the strategic and tactical planning stages of a CLSC, of which, identifying the most economical used-product to re-process in the supply chain, identifying efficient production facilities and transporting the right mix and quantity of goods across the supply chain form the three important steps [1].

Much work is done in the areas of designing forward and reverse supply chains; however, not many models deal with the combination of both simultaneously. While the forward supply chain models do not address the issue of EC, the reverse supply chain models assume each incoming used-product is economical enough to re-process and each available recovery facility is efficient enough to carry out the re-processing. As a result, there is a risk of re-processing uneconomical used-products in inefficient production facilities. Pochampally and Gupta [1] address these drawbacks in a reverse supply chain and propose a multi-phase mathematical programming approach for its strategic planning. This paper extends their work to a CLSC and addresses the critical issues in its strategic and tactical planning.

Methodology

In this paper, we formulate a single-phase linear physical programming model in designing a CLSC. This model when solved addresses simultaneously the critical issues, mentioned above, in the strategic and tactical planning of a CLSC.

The criteria considered in the problem formulated include, the used-product collection cost at the collection centers, disassembly and remanufacturing costs at the production facility, new products production cost at the facility, transportation costs across the supply chain, inventory carrying costs, disposal cost of broken/unfit used-products and revenues from the sale of remanufactured products, new products and recycling of used-products that are not fit for remanufacturing but have some residual material value.

We consider the following scenario in our model. Suppose that the manufacturer has incorporated a remanufacturing process for used products into her original production system, so that, new products can be manufactured directly from raw materials or remanufactured from used-products. The final demand for the product is met either with new or remanufactured products.

Linear physical programming (LPP) [2] is a newly developed method whose most significant advantage is that it allows a decision maker to express his preferences for values of criteria for decision making in terms of ranges of different degrees of desirability, but not in traditional form of weights as in techniques such as Analytic Hierarchy Process, which is criticized for its unbalanced scale of judgment and failure to precisely handle the inherent uncertainty and vagueness in carrying out pair wise comparisons. Also, a unified single-phase approach yields better results compared to multi-phase approach that solves the problem on hand in discrete phases [3] [4].

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