Reuse Issues in Reverse Logistics: A Disposable Camera Operation

Environmental Issues track

This paper models the relationships in reverse logistics. It explores reuse issues in a disposable camera operation. In the literature, reuse issues are primarily studied in “pure” remanufacturing environments. The factors deemed important in this environment may not be a concern in other environments. This study indicates that companies involved in reverse logistics are involved in a variety of reuse tasks. Important issues appear to be product complexity, process complexity, and production volume, which impact reuse choice, which determines factors of concern, thus impacting production control decisions and manufacturing performance.

Monique L. French, Department of Management, Clemson University, 101 Sirrine Hall, Clemson, SC 29632, (864) 656-4807, mfrench@clemson.edu.

Introduction

Reverse logistics are becoming more important for operations managers as an increasing number of industries recycle or reuse products after the consumer is finished with them (e.g., Kleiner, 1991; Kroon and Vrijens, 1995; Melnyk, Stroufe, and Calantone, 1999). Firms may be motivated to do this because of their own environmental awareness or because of governmental and consumer pressure. In the European Economic Community (EEC), government regulations are increasingly requiring manufacturers to take back and recycle products at the end of their useful life cycle. For example, the EEC requires that, by 2004, 90% of packaging waste be recovered with 60% being recycled (Byrne & Deeb, 1993). German regulations go further and require private industry to recycle not only packaging material but the products as well. The need to recycle post consumer materials requires manufacturers to understand reverse logistics, or the management of the logistics of return flows from the user to a recovery facility and finally into the production of a usable product (Fleischmann, Bloemhof-Ruwaard, Dekker, van der Laan, van Nunen, & van Wassenhove, 1997).

Once a decision is made to accept post consumer products, managers must determine how best to reuse these products. There are several options available to manufacturers for "reuse" of returned products. These are direct reuse, repair, recycling, and remanufacturing (Fleischmann et al., 1997; Thierry, Salomon, van Nunen, & van Wassenhove, 1995). Direct reuse identifies the minor maintenance or cleaning required by an item and returns it to service (e.g., returnable packaging materials). Repair identifies and restores the lost product functionality either completely or with an acceptable loss of quality. Recycling recovers the materials in the product, which are then reused as raw materials in other products. Remanufacturing maintains the product identity, but restores it to the quality level of new products. Different levels of disassembly are required for each form of reuse (Thierry et al., 1995). While direct reuse involves no disassembly, repair involves disassembly to the product level; remanufacturing, to the part level; and recycling, to the material level.

Numerous issues arise when considering product reuse. In addressing the remanufacturing option, Guide & Srivastava (1998) cite several concerns that complicate reuse and require changes in how production planning and control is handled. These are probabilistic recovery rates, unknown condition of the recovered parts until inspected, different routing requirements dependent on condition, complexity of a remanufacturing shop structure, and differences between supply of and demand for the remanufactured product.

Statement of the Problem

While there are a few articles that discuss and define reuse options and consider the potential problems that might be encountered, most of the work addressing these problems has been done primarily in a remanufacturing environment with the constraint that a facility is dedicated to remanufacturing and that the remanufactured goods are reassembled to be resold, usually at a decreased price. However, the work does not consider that there may be environments that do not clearly fit this definition of remanufacturing and may actually be a mixture of reuse options as captured in the above described definitions. These environments may have different concerns and issues than a "pure" remanufacturing environment. This paper seeks to explore this issue through a case study of a disposable camera reuse operation. The objective is to present the issues deemed important in the literature, then revise this "list" based on the case study. This is a preliminary attempt to determine factors that might impact various aspects of the reuse environment, thus affecting manufacturing performance. This can then be used for further theory building research as relationships between the issues and performance can be proposed and tested.

The following section provides a literature review of research into reverse logistics and reuse issues. It will conclude with a summary of the issues considered in the literature. This will be followed by a description of the methodology used, a description of the operation studied, a discussion of how it fits into the context of the Fleishmann, et al. reuse option definitions discussed earlier, and a discussion of the important issues in this environment and how they differ from the issues in the literature. A conclusion will follow with a revised summary of proposed performance issues to guide future theory research. A discussion of future research options concludes the paper.

Literature Review

Most articles on reverse logistics are from trade publications and do not involve academic research. While they all stress the environmental impetus for reverse logistics, many of the articles deal more with the issues of "reverse distribution" rather than how to handle the material once it gets back (USF Logistics Acquires Reverse Logistics Specialist, 1999; A Breakthrough in Reverse Logistics, 1994; Outsourcing: Reverse Logistics Push into High Gear, 1999; Shear, 1997; Meyer, 1999). The need for disposal or disposition is mentioned as an aspect of the reverse logistics process, but the internal issues of the manufacturer are not addressed. An academic contribution is Jayaraman, Guide, & Srivastava's (1999) development of a logistics model for determining facility location, which addresses collection issues. It provides for determining the optimum location of both collection facilities and remanufacturing facilities.

Another body of material considers the return and recovery of packaging material (Cooke, 1992; Cooke, 1993; White,1994). An important point is that recyclers are considered to be independent facilities. Another article examines reverse logistics of returnable containers (Kroon and Vrijens, 1995). Other studies have examined environmental concerns involved with post consumer products (Gooley, 1998; Wu and Dunn, 1995), designing for disassembly (Giuntini & Andel, 1995), and process development to allow for use of recycled materials (Byrne & Deeb, 1993). In general, these articles do not address the difficulties involved in the manufacturing environment itself. So what is happening in operations regarding reuse and returned materials?

Fleishmann et. al. (1997) review the relevant reverse logistics research with a focus on the quantitative models that have been proposed. Their framework divides the field into three areas: distribution planning, inventory control, and production planning. The inventory control and production planning areas, as they define them, are relevant to in-plant concerns. In their review of the inventory area, the issue of multiple product flows due to varying forms of reuse (i.e., disassembly resulting in additional "raw material" inventory or repair resulting directly into additional finished goods) is not addressed. The review of production planning, primarily focuses on the difficulties of remanufacturing and indicates that traditional MRP systems do not adequately address the additional uncertainty of the return flow or the additional disassembly level and that there are few alternatives proposed in the literature. This study does not address environments that may deviate from the strict definitions presented.

Inman (1999) stresses the need for disassembly for repair, recycling, and remanufacturing and that MRP logic does not provide for planning for disassembly. A "green MRP" system is proposed by Melnyk, Sroufe, Montabon, & Calantone (1999) that addresses using MRP as a key part of waste management but looks only at internal process waste, rather than addressing product returns.

These reviews all stress the difficulties of remanufacturing due to the disassembly aspect. There has been a stream of research in the remanufacturing area addressing production issues. Guide & Srivastava (1998) discuss three distinct subsystems that exist in a remanufacturing environment: disassembly, remanufacturing, and reassembly. This presents unique problems compared to traditional manufacturing environments. The impact of “disassembly release mechanisms” is addressed by Guide and Srivastava (1998). They raise the issues of the need for release mechanisms between subsystems, inventory buffers between subsystems, and complexities due to serial number specific reassembly operations. The same authors evaluate repairable inventory system models (1997c), which raises the issue of optimal stocking of replacement parts, and order release strategies in a remanufacturing environment (1997b). The order release article raises the issues of uncertain recovery rates and uncertain product condition resulting in variable routings through the shop and stresses the greater degree of uncertainty present in a remanufacturing environment. The same issues are stressed in several other articles (Guide & Srivastava, 1997a; Guide, Kraus, & Srivastava, 1997; Guide, Srivastava, & Spencer, 1997; Guide, Srivastava, & Kraus, 1997).

Overall, the literature review indicates a variety of research into “reverse distribution” aspects of reverse logistics and product recovery management, but research on issues once the product has been returned to the plant focuses on remanufacturing. In summary, the issues considered important by researchers include some that are applicable to several reuse environments: uncertainty of return flows or product recovery rates, condition of returned products, and inventory of replacement parts, as well as some that are specific to remanufacturing environments: need for release mechanisms between subsystems, inventory buffers between subsystems, and serial number specific versus common parts reassembly. The literature indicates that these concerns are expected to impact manufacturing performance through their impact on material planning, capacity planning, and shop floor scheduling. The bulk of these issues were studied in a “pure” remanufacturing environment, but what if a reuse environment does not neatly fit the definition of remanufacturing? Are these issues important? What other issues are important?

Methodology

Due to the exploratory nature of this study, a case study approach was chosen. Eisenhardt (1989) proposes that case studies are appropriate for theory building when perspectives on a particular issue are limited. As evident from the literature review, the predominant focus of much work on reverse logistics issues has been on reverse distribution issues, rather than addressing the production issues involved. Also, when production issues have been studied, the majority of the research has been on remanufacturing environments, thus perspectives on reuse options are limited in that environmental factors have not been considered and work has generally considered only “pure” environments – only one type of reuse option used.

In selecting a case for this research, a case was selected that was thought to be a remanufacturing environment, although with a different type of product than those typically studied. The intent was to extend theory and revise issues that were found to be important in the literature. However, as the study progressed, it became obvious that the different environment found in this company raised the issue of the environmental impact on reuse options and that differing environments would have different concerns.

Methods used were consistent with Eisenhardt (1989). Multiple data collection methods, a combination of observation and interviewing, were used to gather data and understand the issues important to the company. Only one investigator was used and data collection and analysis were overlapped. An initial visit and interview were followed up with additional questions as analysis progressed and questions were raised. As only a single case was analyzed, only within-case analysis was used. The following section will describe the disposable camera operation and discuss issues the company faces in its camera reuse operation.

Disposable Camera Reuse

A key concern faced by disposable camera manufacturers was what to do with the camera bodies and parts once the film was removed and developed. This company had been involved in waste minimization and recycling programs for several years and was concerned about the final disposition of these products. Also, a competitive issue in this environment is “pirate” cameras. Companies would buy the spent cameras from film developers, slice open the body, insert new film, and repackage and resell the “remanufactured” cameras. Disposable camera manufacturers found themselves competing against their own cameras being sold at lower prices.

Numerous decisions were involved in designing a reuse operation. Once the company began reclaiming spent cameras, they were faced with determining how best to handle the returns. Once returned to the plant, cameras could be disassembled to component parts, then the parts could be recycled or reused. In considering their reuse options, the value and reusability of the component parts was considered. The primary components of the camera include a resin body, a flash unit, a mechanical unit (to provide the functional picture- taking operation), batteries, and the film can. The resin body would be destroyed in the disassembly process and is relatively inexpensive to manufacture. It is also readily recyclable by resin producers. The flash unit is the most expensive part of the camera and is amenable to functional testing to ensure reusability. The mechanical unit is also a high value item in the camera and has reuse potential. The batteries are readily recyclable, while the film can is not returned with the camera. This company’s decision was to disassemble the camera, “remanufacture” the flash unit and the mechanical unit for reuse, and sell the resin body and battery to other users for recycling.

Preprocessing

The facility studied only disassembles flash cameras. An initial issue to be addressed was a sorting process. The cameras that are collected are a mix of flash and non-flash cameras from multiple manufacturers. Some are “pirates” (have already been reused at least once by a “pirate” company as described above), while others are “pures”, and some are older technology that are not usable. A careful sorting process was developed that is done by subcontractors at a central location. The process results in two reuse streams: “pures” and “pirates”, both consisting of only useable (current technology) flash cameras.

The Reuse Process

The processing for these two streams (pirates and pures) differs initially. The basic operation for both involves disassembly, testing, repair (if necessary), retesting, a final quality check, then inventory. The pirate bodies have been sliced open then re-taped or glued so they cannot go through the automated disassembly operation. They are sent to a manual disassembly center where the camera bodies are opened, the flash units and mechanical units are removed. The flash units are sent for testing, but as the mechanical units will only be reused once, they are sold for recycling. The resin bodies are collected and also sold for recycling.

The pure cameras are sent to an automated disassembly operation where the body is cracked and the flash unit and mechanical unit are removed. As the cameras are loaded on the line, any cameras that were manufactured as private label products for another company are removed and sent to manual disassembly as their mechanism is slightly different and cannot be processed on this line. The flash units leave the line to be sent to the testing center, while the bodies leave the line and are immediately ground to be sent to a recycler. The mechanical units continue on the line where they are checked and sorted further. Only “27-frame” units are reused. All units that have already been reused once (determined in the checking process) are removed from the line and sold for reuse in other industries. The lens is replaced on the units that are determined to be usable. They leave the line and are 100% visually inspected before going to inventory for reuse in new cameras.

The flash units are sent to an automated testing line, with private label and pirate flash units also routed here from manual disassembly. The flashes are tested for useful life to determine if they are reusable. Those that fail are sold for reuse in other industries. For those that pass, three additional components of the unit are tested. If any of these fail, the unit is routed to any of three repair stations for replacement parts. After repair, the unit is returned for retesting. Finally, all units are 100% visually inspected before going to inventory for use in new camera manufacturing. Approximately 75% of the flash units pass initial testing and are sent to stock; 15% are repaired; and 10% are rejected and sold elsewhere for reuse.

Additional Process Information

About two weeks of inventory of "remanufactured" parts is held. The parts have unique part numbers for production control and traceability. Overall, operations managers do not feel there is much uncertainty impacting the operation. The supply of returns is fairly known and purchases for new camera production are planned about three months in advance with production needs for new parts based on last year's level of remanufactured parts. The disassembly is not driven by demand for the end product of the operation as it might be in other remanufacturing operations, since the parts are inventoried for use in new camera manufacturing. The extensive sorting process that occurs prior to cameras arriving at the facility removes a large amount of the uncertainty in the condition of the returns. The parts needed as replacement parts can be forecasted based on previous usage and historical failure rates and are the same parts used in new production, so their proportion of overall component usage is small.

Analysis

In terms of the Fleishmann et al. (1997) reuse definitions, this operation has aspects of remanufacturing, but does not fit clearly into one of the defined categories. The product is disassembled, but the whole item is not remanufactured, then reassembled, thus this environment does not have the reassembly issues mentioned earlier – serial number specific versus common parts reassembly and need for an inventory buffer between remanufacturing and reassembly. Certain parts are checked and remanufactured, but then become inventory for new production. This is unlike remanufactured auto parts, which are sold as remanufactured parts. Even though auto parts are brought back to like new condition, they are not used as inventory of parts for new cars. This difference eliminates the issue of demand requirements impacting planning for the items. The production planning in this operation is not affected by demand for the remanufactured parts as production planners include them as only one source of supply to go into new items. This raises the issue of potential uncertainty of this source of supply, but due to the volumes that are remanufactured, the company has historical data to use for forecasts and does not feel this uncertainty is an issue. Uncertainty of return flows also is not an issue in the production planning and control of the reuse operation due to the use of historical information as well as the fact that the remanufactured parts are only one source of supply.

Typical remanufactured operations studied in the literature are high value, complex items such as automobile parts, jet engines, and copy machines. This operation involves a much simpler item manufactured in high volume. The possible routings in the remanufacturing portion are few and needed replacement parts are not only few in number, but are also only needed in very small quantity relative to the quantity of parts needed for new production. This minimizes the potential problems of inventory for the replacement parts. The fact that the remanufacturing operation is conducted at the site where the "end user" of the parts is located also simplifies many issues addressed in the literature.

One key aspect that has been addressed is the condition of the returned products. This uncertainty was not as much of an issue when the operation was only manual, but had to be considered when designing the automated disassembly operation. Much of this uncertainty has been handled through the use of the sorting operation done by a subcontractor prior to arrival at the plant. This has minimized the impact of the uncertainty on the plant itself.

In summary, this operation differs from reuse environments studied in the literature in that it is not a true remanufacturing operation. While the product is disassembled, only high value parts are remanufactured, then inventoried for use in new production. It is, in a sense, a combination of remanufacturing and recycling – the remanufactured parts are used as "raw material" in production of new cameras. It may be into the same model camera, but the item does not truly retain its identity. The product is much less complex and is manufactured in high volumes compared to typical remanufacturing environments studied. These differences serve to eliminate many of the issues of concern presented in the literature. The high uncertainty that is characteristic of reuse and, particularly, of remanufacturing environments, is minimized through the sorting process and the high volume production of new cameras. The lack of a reassembly operation also eliminates some issues from consideration. The primary issue addressed by this company that is mentioned in the literature was the condition of the returned products.

Conclusion

The original intention when initiating this case study was to determine issues of importance and develop an initial theory addressing the issues in remanufacturing environments that impact manufacturing performance. However, it quickly became evident that this operation did not fit cleanly into the "cubby holes" defined in the literature and that certain aspects of the environment and the product eliminated many of the issues of concern found in the literature. The company wrestled more with collection issues than with in-plant issues. While the issues mentioned in the literature are important in some complex environments that have been typically studied, more work needs to be done to determine how different environmental factors impact the issues involved in reuse decisions and thus on manufacturing performance. A proposed broad theory that results from this study is that environmental factors, including product complexity, process complexity, and production volume, impact reuse option decisions, which in turn impacts reuse issues of concern, thus impacting production planning and control issues which impacts manufacturing performance.

See Figure 1

These proposed relationships are very general. Obviously, there are sub-issues that require determination and study. The literature clearly indicates many of the "reuse issues of concern" in purely remanufacturing environments; also, certainly, there are more environmental factors that must be considered. The choice of reuse option may not fit neatly into current definitions, but be a hybrid of sorts as in this case. If future research could identify what environmental characteristics typically result in a certain reuse option and the issues of concern relevant to that option, this would simplify practitioners' development and implementation of reuse operations. This could result in a steepening of the learning curve involved, thus faster payback and higher return on investment.

References available from the author upon request.

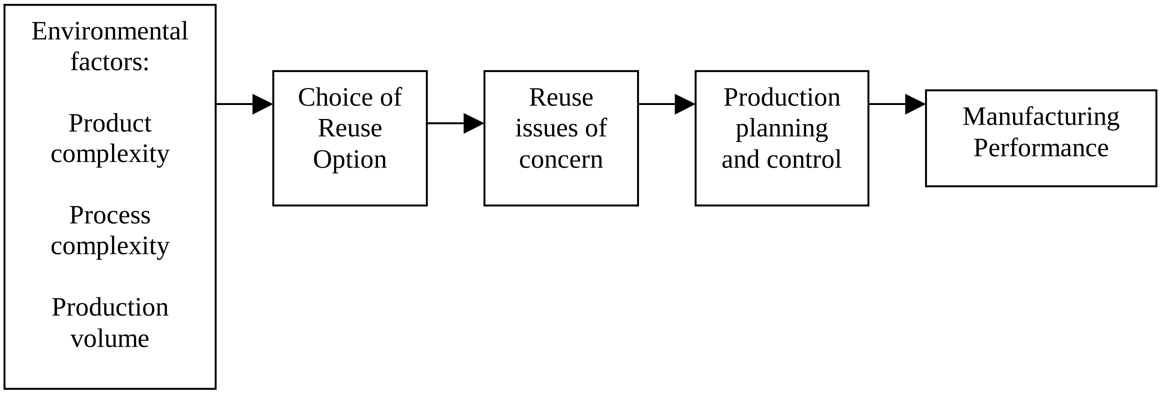

Figure 1: Proposed relationships