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Towards a Formal Process for Beyond Economical Repair Decision Making

Mark Errington
University of Exeter

Stephen J Childe
University of Exeter

Corresponding Author:
Mark Errington
Harrison Building
North Park Road
EXETER, EX4 4QF
m.errington@exeter.ac.uk
+44 (0) 1392 263613

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Abstract

European legislation such as the WEEE directive is creating greater interest in value recovery techniques such as reuse, repair and remanufacturing. A vital part of all of these processes is efficient inspection and sorting procedures. This research uses a case study in order to identify best practice procedures from companies currently operating in the field. It also aims to identify short comings in their procedure and to provide a model to detail how such processes are currently carried out. This paper presents an initial model developed from a case study with a company which refurbishes equipment for the United Kingdom Ministry of Defence (MoD).

Introduction

Recent European legislation, including the WEEE directive EU (2003), End of Life Vehicles Act EU (2000), Packaging and Packaging Waste Directive and the Batteries and Accumulators Directive, has required the producers of certain equipment to be responsible for its disposal at end of life.

They are often not only responsible for retrieving the used products from their end users but are also responsible for recycling them and at the same time meeting minimum recycling rates. With limited room remaining in landfill sites material recycling is often preferable to land filling, however most of the value added during manufacture is lost.

In order to take back post consumer products it is necessary to create a reverse supply chain. If this is integrated into forward manufacture in such a way that old products are used, at any level, this leads to a closed loop supply chain.

Many consumer products are still working at their end of life, and there are an increasing number of companies that collect these products and return them to market both in the UK and abroad. They provide a cheap alternative to buying new products and appear to have been very successful both as not for profit and traditional organisations.

Other products reach their end of life because of an accumulation of rectifiable faults, the wearing of a small number of components within a product or sometimes because of their age or amount of use. There has been a long tradition of remanufacturing in the auto parts industry and recently manufactures in other industries such as Hewlett Packard and Xerox have started to run very large operations.

Literature Review

The creation of this new business model leads to many new problems which are not found in forward manufacturing. These problems, presented by Guide (2000) are widely agreed upon and include;

- Uncertainty in timings and quantity of returns;
- Balancing returns with demands;
- Disassembly of returned products;

- Materials recovery uncertainty;
- Reverse logistics;
- Materials matching;
- Stochastic routings and highly variable processing time.

A comprehensive survey of automotive manufacturers was carried out by Rick Hammond (1998) to confirm some of these issues in industry. In addition to other findings he found that the factor which made inspection most difficult was the knowledge of the employee carrying out the work. This was stated by 29% of the respondents. A further 21% of respondents stated that identifying defects was their main concern.

This suggests there is a need for some formal methods that can be used to simplify the processes involved in the inspection procedure. Some attention has been focussed on the aspects of design which can facilitate remanufacture; Hammond notes that design for remanufacturing is an issue with automotive remanufacturing. In his survey; profit potential and investment to repair rank highly as responses to how the decision to remanufacture a given product is made in the respondent companies.

The design issue is one that is constantly being visited by researchers. The main task is to decide the most economically and environmentally beneficial end of life option for a given product. There are now many tools that can assist product designers to make this decision.

Feldmann, Meedt et al. (1999), Johnson and Wang (1995), Rose and Ishii (1999) and Bufardi, Gheorghe et al. (2004) all provide models that score products against a number of performance criteria. These typically include recyclability, toxicity, time/cost of disassembly and often the design cycle of a product as well as other metrics. The models presented by Feldmann, Meedt et al. (1999), Rose and Ishii (1999) present the results as spider charts. The model developed by Johnson and Wang (1995) is costs based and is designed to show the most profitable option. In the model developed by Bufardi, Gheorghe et al. (2004) an attempt is made to evaluate a product for its social, economic and environmental performance, the so called "triple bottom line".

Goggin and Browne (2000) and González and Adenso-Díaz (2005) both present bill of materials based approach to end of life decision making. They both calculate the most profitable end of life option. The model presented by Goggin and Browne (2000) can be used to evaluate the profitability of a user selected end of life strategy or it can be used to find an appropriate strategy through the matching of supply and demand for parts and products. In contrast to this, the model presented by González and Adenso-Díaz (2005) generates a set of feasible solutions and finds a near optimum solution using a scatter search algorithm. This can then be edited to match the user's own preferences and then revaluated.

The models discussed here are clearly useful to aid the end of life decision making process at a design stage. However there are factors that are important in end of life decision making that cannot be accurately estimated until a product has reached its end of life. These include its amount of use, cleanliness and damage. These factors all affect individual products rather than families and are only discovered during the inspection stage of the remanufacturing process.

One of the more hidden problems is that faced by companies which carry out both new manufacturing and remanufacturing in their facilities. Goldberg (2000) states that many companies under estimate the potential profitability of remanufacturing through the use of incorrect costing methods. They often state that the labour cost is too high for the venture to be profitable.

It is not surprising that many manufacturing companies considering remanufacturing use the wrong costing methods. Drury, Braund et al. (1993) state that approximately 70% of the companies that responded to a survey use questionable information as a basis for decision making. He reports that most of these were using distorted product costs derived from financial accounting practices. There is no reason to think that this situation would be any different for remanufacturing operation costing. Initial case studies carried out as part of this research appear to confirm this.

Research Objective

It has been shown that there are a large number of tools to help designers to target their products for the best end of life option but they offer little help to those who have no control of the design of the EOL products they receive or those who are seeking to improve the value recovery processes they are already undertaking. There is a clear need for more research to be carried out in the processes involved in value recovery operations. Guide, Jayaraman et al. (1999) state that one of the major weaknesses of previous operations management research in remanufacturing is that little has been done to document present industry practices in case studies or surveys.

One of the key problems identified in the survey by Rick Hammond (1998) is the skill and knowledge of the employees when carrying out the inspection process.

The aim of this research is to develop an idea of the business processes currently used in industry to determine if a core is suitable for processing. It is hoped that this could be used to streamline the process and to insure that cores that have the potential to generate profit are not discarded and that cores that are too costly to process are routed to another disposal option without excessive loss of investment.

Methodology

This research used case studies to gather data. This methodology was selected as the needs of the area of research closely match with the strengths of case research. These are stated by Benbasat, Goldstein et al. (1987) as being;

(1) The researcher can study information systems in a natural setting, learn about the state of the art, and generate theories from practice.

(2) The case method allows the researcher to answer "how" and "why" questions, that is, to understand the nature and complexity of the processes taking place.

(3) A case approach is an appropriate way to research an area in which few previous studies have been carried out.

Research in the area of take back and reverse logistics is seen to be immature, despite a huge amount of technical expertise within companies that in some cases have been carrying out these activities far over two decades. A grounded theory approach was taken in order to establish the state of the art and generate theory.

Rigour was ensured through the following of a framework for case research developed by Voss, Tsikriktsis et al. (2002). Interviews were carried out with operations managers, then the results were triangulated through visits to the factory floor and further interviews with production staff. After each visit, the case notes were sent to the interviewees to ensure their accuracy.

Initial Results

Initially interviews were held with three companies. The main aim of these visits was to compare and contrast the processes carried out at each company.

Milco, is a military equipment manufacturer who are increasingly more responsible for refurbishing more and more equipment for the MoD. Compco, a not for profit organisation, refurbishes end of life computer equipment before selling it to charitable organisation for distribution in the third world. The third company, Jetco overhaul jet engines on a regular basis as part of their wider operations.

The case study visits that have been carried out to date confirm that there is a need for an accurate way of determining a core's suitability for processing. The following section presents a brief description of how the case study companies visited currently carry out the initial inspection process.

Milco

Milco has a contract to supply the MOD with a range of equipment. The contract does not specify that the equipment that is supplied should be new or refurbished. The products supplied must meet a level of reliability set out in the contract.

The company has some indication about the condition of the cores within a batch however each is not individually inspected before it is disassembled. The company currently costs all of its production jobs based on the same labour rate. More details about the findings from Milco are detailed later in this paper.

Compco

Compco processes end of use computers collected from businesses. It carries out minimal tests to ensure that the computers are working before selling them to third parties who then donate them to schools and non government organisations in the developing world.

Compco has a very interesting approach to dealing with uneconomical repairs. It has very strict guidelines for the type and functionality of computers that it will take from businesses. It gives minimum specifications and states that all computers must be fully functional. If the computers that are supplied do not meet these requirements the donor company is charged for the additional costs incurred in addition to the cost of disposal.

This process insures that minimal testing is required and means that the vast majority of computers that arrive for processing will be fully working. This simplifies the refurbishing procedures since it eliminates the need for rigorous testing and repair.

Compco works out how much to charge for each unit by dividing its costs per period by the number of computers refurbished in that same period. It charges the same price for a computer regardless of its specifications. Compco is a specialist desktop computer refurbisher and only rarely does it process laptops.

Jetco

Jetco is a manufacturer of turbine engine components and turbine based generators. In addition to this they offer a maintenance contract with their generators, this work is carried out by the company. Initial visual inspections are carried out at the location of the equipment after a fixed number of operational hours. If the engine is found to be in need of repair then it is replaced with a temporary engine. The faulty engine is then shipped to Jetco’s facilities where it is repaired.

After a certain period, each engine is sent to Jetco's facilities for an overhaul. This is essentially a remanufacturing procedure. The engines are disassembled and inspected, faulty parts are replaced, and the engine is then reassembled and tested before being returned to the customer. All engines that are returned are currently overhauled. No estimates have been made by Jetco of the cost of this procedure or the profitability of the process.

Discussion

All of the three companies cost their processes using a calculation based on the number of hours labour put into a process. This is not a problem for Compco which only carries out refurbishing operations in a very small area. Two of the three companies have very advanced forward manufacturing processes which use expensive, high precision machines. It is unfair for the cost of these overheads to be shared out among the refurbishing processes which use very basic equipment and a large amount of labour. Milco is paid at a set percentage profit over its costs for refurbishing equipment for the MoD. It therefore has little short term incentive to change this process until it is forced to by the MoD.

Both Jetco and Milco do not currently formally inspect cores before they start to process them. Compco was found to only carry out minor inspection as it had systems to pass this responsibility on to its supplier. This is commonly done in forward supply chains, where goods-in inspection has been phased out in many situations, and it is interesting to see this in remanufacture.

Focus on Milco's Inspection Procedures

After the initial visits, it was concluded that there was a need to investigate the inspection procedures with a particular focus on the costing methods used to make any decisions.

It was found that a triage principle formed part of the procedure. Some parts of the assembly were always replaced; these were the active element which wears out with time and parts that are shaped for an individual "fit" during manufacture. Other parts of the assembly are always reused. These include components such as weights. The third class of components are inspected visually and sometimes tested before they can be reused. If they fail the test they are often repaired rather than being replaced. It is this class of component where process costing is likely to play the biggest role in determining suitability for reuse.

This is a particularly interesting case because Milco is the product OEM however it has to manufacture according to plans given by the MoD. Since it is not currently responsible for the design of this product it is not in a position to use any of the models discussed in this paper. Any reduction in operating costs cannot come from redesign but could come from efficiency improvements in its operating procedures.

It was found that the following process was being carried out at Milco. Notification is given that a batch of end of use items is due to arrive. Often this notice can be as much as a month in advance. On arrival, the batch is inspected and classified according to the age of the products. If many of the batch are older, the cost of work is estimated to be higher, this is due to minor design changes that must be carried out to older equipment. A quote is given on this basis to the MoD who then decide whether the items are considered to be “Beyond Economic Repair”. Once the quote has been accepted, all of the cores in the batch are disassembled without further product inspection.

After the first stage of disassembly the modules are separated by type into three streams. Some modules are always scrapped, some are always disassembled further and some are sent for further inspection. This process is detailed in the IDEF0 diagram shown on the following page.

After inspection the separation process is carried out once more. This time the routing is dependent on part type as well as its age and performance. All modules that pass inspection are sent for reuse. The routings for other modules depend on their type. Some modules are always sent for repair if they fail inspection others for further disassembly and the remainder are scrapped.

This process is repeated until all of the parts and modules that can be reused have been recovered.

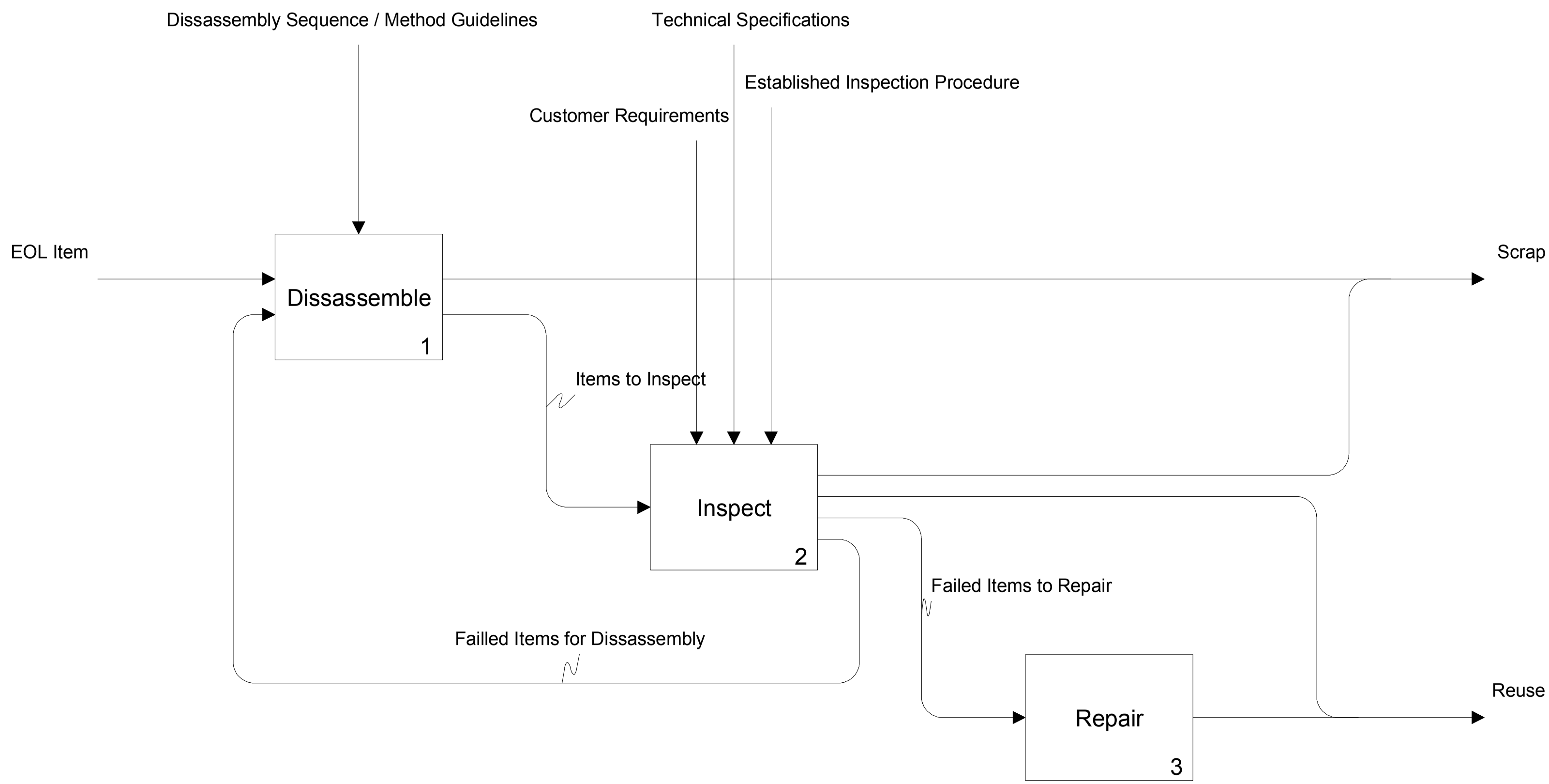

Figure 1: IDEF0 Diagram for the Disassembly and Inspection Procedure at Milco

It is interesting to note that cost is not considered as a factor once a job has been accepted. Any decision to determine if a batch of cores is beyond economical repair is taken by the MoD and not Milco. Once the cores are disassembled, components are rejected it is feasible for them to be used or if they have become obsolete and no longer meet the standards required by the MoD. If components cannot be reused because they are obsolete, they are disassembled further and some of the parts are reused.

An inspection procedure is followed for some of the components in order to establish if it is of acceptable quality to be reused. Failing components are sent for repair by a third party company. No parts are currently rejected for reuse based on their cost of repair only due to not meeting specification or not being reusable.

Some parts of the assembly are always repaired if it is possible even if it is more expensive than ordering a replacement. This is due to the long lead times for some of the components of the item. This has obvious parallels with the make or buy decision where a trade off is sometimes made between cost of manufacture and lead time.

It is possible that the costing method currently used by Milco is unfair to its remanufacturing operations and makes them appear less profitable than they actually are. The facility where the operations take place also designs and manufactures products using much more expensive resources. It is possible that this has lead to an over pricing of the refurbishing operations.

Conclusions

This research has shown that there is a need for further research into the "beyond economical repair" decision making process. It has presented initial case study findings that appear to indicate a lack of understanding and clear costings of the processes involved. Milco has a very well defined remanufacturing process, however, they appear to use an inappropriate costing method. There is a clear need for research to be carried out in order to identify how inaccurate currently used costing methods could be. Only when this has been done can decisions to accept or reject cores be based on cost. The research shown in this paper will be widened to discover the basis for the reuse decision in other remanufacturing processes.

The wider research will develop existing case studies and see new ones in less advanced companies where the beyond economical repair decision making process is carried out. It is thought that areas where a large number of different models and makes are present, such as mobile phone reuse, will help the model presented as Figure 1 to be further developed.

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