A practice based approach to further high level reuse in equipment manufacturing offering business opportunities in a circular economy

Jan Venselaar, Dimitri van de Kelft
Avans Hogeschool - University of Applied Sciences, Research Group Sustainable Business Operation
PO Box 90116, 4800 RA Breda, the Netherlands, j.venselaar@avans.nl

Summary
An effective option for companies to implement circular economy concepts is reuse and remanufacturing. It concerns the (re)use of modules and parts of used and discarded equipment in 'as new' or 'first class' reused equipment. It is not just an effective way to reuse materials; it is also economically very sound.

A method is developed, called WARM[1], to assist a producer, in particular SME's[2] whether and how reuse might be a promising business opportunity. It covers the essential steps in the technical, organisational and market issues that have to be addressed. It is a tool to decide best options for making the production chain a closed loop on equipment and parts level. Crucial aspects are product design and redesign, assembling and disassembling, marketing and sales method, services and maintenance, reverse logistics and necessary actions regarding cleaning, inspection, repair, refurbishment and upgrading. The approach can be used for existing products with or without redesign and also for products which are still under development. It is phasewise to save unnecessary time and costs: first a quick-scan to determine a go or no-go, second the selection op best options, third a new 'circular business model' and set-up of cooperation with key partners for closing the loop. A fourth actually more parallel phase is improvement of the design and changes in operations to optimize the reuse process.

In the course of the program observations are made on possible and profitable business models but also about the factors that hinder companies to introduce reuse on this level. The approach is being adapted to handle that. At the same time it offer insight in the practical aspects of stimulating and implementing circular economy approaches in companies in general.

Introduction
Remanufacturing is already long term practice for some OEM[3] companies [Lund 1996, Michaud etal 2006]. Examples of successful practices are office equipment, copiers and printing machines, soft drink vending machines and coffee dispensing equipment. Besides there exist companies specialised in refurbishing and refitting equipment and selling it on the high end of the 'second hand market' (B+ market). That has proven to be economically attractive because reused parts can be much cheaper in many cases. It contributes also to sustainability by closing the material cycle and reducing energy use due to a much shorter production chain. It further creates jobs regionally where the reuse and remanufacturing process are done. It is a good mix of people, planet and value.

It contrasts with recycling in which only the materials are being recovered and as basic resource are brought back to the first step of a total production chain. For some materials and parts there is no alternative, but in many cases much of discarded products is still in such condition that it can function again in 'as new equipment' [Steinhilper 1996].

SME's however have mostly not knowledge nor the experience to apply it. Actually we did find in our studies and projects that many smaller companies do practice some sort of reuse. It is often subconsciously, for instance by 'cannibalization' of equipment returned due to a guarantee claim or used for testing and demonstration. Organizing this business model in a systematic and efficient way is mostly seen as too complex for smaller companies however. There is a lack of knowledge and clear and simple instruments to do assist them. Therefore we have developed an approach that fits in particular SMEs. It works on a step by step basis to assess the feasibility of reuse for their product,

[1] WARM is a Dutch acronym '**W**instgevend **A**fdank en **R**etour **M**anagement' (profitable **W**aste **A**nd **R**ecovery **M**anagement)
[2] SME: small and medium enterprises, officially from 1 till 250 employees
[3] OEM: Original Equipment Manufacturer

selects the best options and indicates the necessary steps to implement reuse using an 'circular' business model.

WARM approach

The objective of the WARM-approach is to examine the commercially interesting options that exist for reuse of (parts of) products. Because WARM is a time-efficient and simple approach it is well suited for smaller equipment manufacturers. It offers also insight in the constraints that exist and options to deal with them.

Development

The development was done through practice based research in direct cooperation with companies looking for remanufacturing opportunities[4]. Companies with a track record in reuse and remanufacturing (in particular Xerox, Océ, AC-Reuse) joined in and were quite willing to share necessary expertise and practical experience such as electronically testing returned modules [Krikke etal 1999, Hulsken etal 2004]. The University of Tilburg was involved for specific expertise such as reverse logistics and new business models. Case studies were done by engineering and business students and workshops held with groups of companies and experts. Pilot and feasibility studies were being done to further develop and amend the approach and instruments. At the same time a program was initiated to promote the concept of reuse and remanufacturing through workshops on 'advantages of reuse', 'marketing and reuse' and 'recognizing opportunities of reuse', with 'best practices' supplied by the companies involved as examples. Development is still continuing. It is used in projects with companies and equipment manufacturing industry organisations that wants to promote sustainability and better resource use. That involved studies for instance regarding waste of electronic equipment [Soeteman etal 2010] and contributions in industry sector programs to promote circular economy. It has also proved to be a successful framework for education, in particular for business engineering students as part of the topic circular economy [vdKelft etal 2010, 2011]. Research and case studies are aiming for better understanding the effectiveness in selecting critical innovations and stimulating actual implementation. That latter step is still very complex.

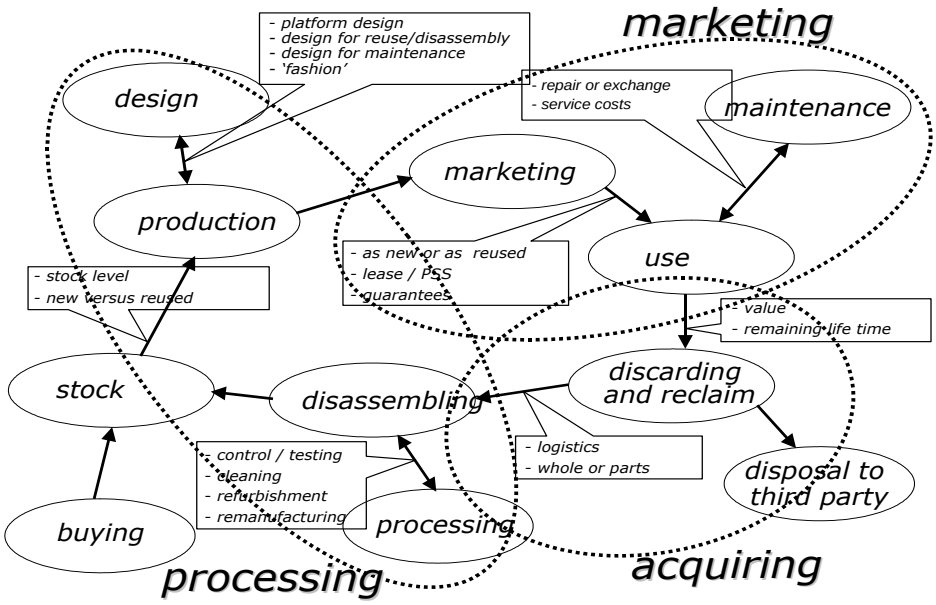

Figure 1. The reuse framework (end-of-life management)

Structure

The WARM approach consists of four phases.

1. A quickscan to determine if reuse and remanufacturing could be of interest for the specific type of equipment (existing and already on the market or new).

[4] The start was made possible through a grant by the Province Noord Brabant.

2. Determining which options (parts and modules) exist for reuse, based on technical, economical and market feasibility.
3. Developing the business model, economic model, market approach, reverse logistics, cooperation with suppliers and refurbishment companies.
4. Optimizing based on observations: improving the design for reusability, form of cooperation and contracts with customers and suppliers, reverse logistics, disassembly and refurbishment.

The framework of the approach is based on a division of the 'closed production loop' processes in three parts: marketing, processing/production and acquiring of used products, each with the different issues that have to be considered (fig. 1). It also illuminates the complexity encountered.

Phase 1, the quickscan, is done in the form of interviews. It is done in a few hours. This step makes the company aware of the actual possibilities that reuse offers in their case. Since it takes so little time, the threshold for a first contact to just discuss it, is low. For each part of the loop a score between 0 and 100 is determined based on a set of standardized questions. Above 50 indicates that the part offers not too many problems. It that is for all part the case, a profitable case for remanufacturing seems likely. Even if the quickscan gives a negative score for one part, some companies continue to consider reuse. Problems still were considered to be solvable by just simply introducing an innovative procedure or minor adaptation to the design.

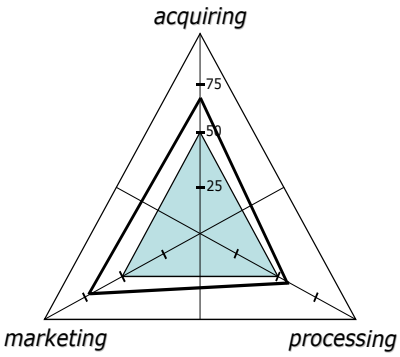

Figure. 2 Quickscan diagram

Phase 2 identifies the critical factors determining the feasibility of reuse for parts and modules:

- technical aspects, expected wear and remaining lifetime;
- testing method and guarantees that have to be given;
- costs for refurbishment and remanufacturing against remaining value, by 'activity based costing';
- market options;
- specific company priorities and ambitions.

In some cases it is concluded that up to 90% of parts could be reused. Nevertheless, for practical reasons companies were advised to start with a limited number of high-value parts such as electrical motors, the main frames of the equipment. Refurbishment for these parts is not very complicated and redesign is mostly not directly required, so a producer can start reusing the parts in their present form immediately. (Otherwise one has to wait a whole lifecycle for reusable parts)

Phase 3 is done in discussion, if possible workshops, with the various stakeholders involved, inside but preferably of course also outside ones, such as suppliers, customers and specialised refurbishment firms. There is no fixed format. As yet it is the most complex phase and is often offering a too high threshold to go further, for that moment, in the studies done.

Phase 4 is not actually a separate one. During the assessments and discussions many aspects and issues come up that directly or at a later moment are to be addressed to improve feasibility.

Circular business models

A main issue is always selection of the best business model to be able to generate most value from reusing parts and modules. In the case studies and pilot projects a variety of options were discussed. It very much depends however on the type of equipment and how it is used, sales numbers and equipment lifetime. Crucial is the position of a company in the whole product chain: supplier of intermediates and parts or final OEM that services the end-user. A generic model does not exist.

A good basis for attractive models is the so-called 'product service system' (PSS): 'not selling a (physical) product but only its function'. A company keeps the ownership of the physical product and therefore control over its condition, place and can easily recover it when necessary. The customer has less to worry about so it can be profitable for both. It is presently getting much attention due to growing concerns about resource availability. As yet it is not easily adopted due to organisational and financial complexities [Tischner etal 2002, Lindhal etal 2009].

Representative examples of business models which have been observed and discussed during the studies (the first three based on PSS):
- Leasing and renting (production equipment, expensive medical equipment, cars, bikes, but also offices, plants and houses)
- Customers paying only for number of times equipment is used or through the specific materials that are needed (beverage selling equipment, office printing and copying).
- Delivering a function (light, energy) with equipment that stays owned and serviced by the supplier.
- An OEM or importer recovering its own brand equipment when discarded and refurbishing it. That can be sold on the B+-level market to compete with cheaper imports (production equipment, ground moving and agricultural machinery).
- Reused parts: cleaned, tested and refurbished, as less expensive option (already customary in car repair).
- Intermediates and parts supplier refurbishing its products for customers when returned.

Constraints

In the studies and pilots several issues form clear constraints. They can be grouped in:

- business continuity: uncertainty about return rate, changes in technology during the lifetime;
- economics: financing 'more expensive but longer living equipment and parts', cheaper production is lower turn-over (higher profit);
- guarantees, certification, regulations (such as for safety): clear for new equipment, not always for remanufactured ones;
- marketing and psychology: do customers accept it, sudden changes in 'fashion' and rapid developing technology.

Conclusions

In general the companies involved found the approach informative and useful. Many concluded that some reuse was indeed sufficiently profitable, as they suspected when they asked for assistance. Their intuition was already that not reusing perfectly useful materials and parts 'had to be wasteful'. As yet most are still very reluctant to adopt it wholeheartedly due to the constraints mentioned. A complete change of business models, manufacturing products entirely on the basis of reused parts and modules, has not occurred as yet. The major aim of the program was therefor and still is: creating 'best practice cases' to stimulate others to start with reuse as well. This needs cooperation with industry sector organisations, in particular with those of the equipment manufacturers.

REFERENCES

Hulsken, G., A. Di Bucchianico, T. Figarella, M.H. Jansen, H. P. Wynn, (2004)
'A Multi-scale Approach to Functional Signature Analysis for Product End-of-life Management', Quality and Reliability Engineering International Volume 20 (2004) 5, 457-67, (Special Issue: Business and Industrial Statistics in Practice)
Krikke, H.R. , A. van Harten, P.C. Schuur (1999), 'Business case Océ: Reverse logistic network re-design for copiers', ORSpectrum 21 (1999)3, 381-409
Lindahl, M., T. Sakao, E. Sundin, Y. Shimomura (2009), 'Product/Service Systems Experiences – an International Survey of Swedish, Japanese, Italian and German Manufacturing Companies', Proceedings of the 1st CIRP IPS2 Conference: Industrial Product-Service Systems (IPS2), 74-81.
Lund, R.T. (1996), 'The Remanufacturing Industry: Hidden Giant', Boston University, Boston, MA, 1996
Michaud, C., D. Llerena (2006), 'An economic perspective on remanufactured products: industrial and consumption challenges for life cycle engineering'. Proceedings of LCE 2006
Steinhilper, R. (1998), 'Remanufacturing The Ultimate Form of Recycling', Fraunhofer IRB Verlag
Tischner, U., M. Verkuijl, A. Tukker, (2002) ,'PSS Review'. SusProNet Report first draft 15 December 2002,
Van de Kelft, D., J. Venselaar (2010), 'Reuse and remanufacturing, a practice based approach as base for integrated training for sustainable production', EESD5 conference, Gothenborg, Sweden, October 10-13, 2010
Van de Kelft, D., J. Venselaar (2011), 'Reuse and remanufacturing as a sustainable business strategy for small and medium enterprises, *A practice based approach',* 1ST Int Conf On Sustainable Intelligent Manufacturing, Leiria, Portugal, June 28-july 1, proceedings H.Bartolo etal.(eds)