

Strategic Factors on Interpreting Remanufacturing Quality-Certifying Framework to Address Warranty Aftermarket for Malaysian Industry

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Abstract. While the concept of remanufacturing is gaining popularity globally, literature and theory on strategic decision-making on certifying for warranty in this area remain limited. A strategic and establish concept flow is developed based on extensive literature review and surveys with experienced experts who are dealing with remanufactured, reconditioned, rebuilt and reused components. The remanufacturing research on evaluating quality assurance of remanufactured component targets macro-level parameters and the indicators which must be confirmed for evaluation. The strategic remanufacturing factors identified from the literature review are discussed in a brainstorming session with a number of remanufacturing researchers and academic experts. The study is further broadened by industrial surveys and case studies to justify the inputs on developing a framework to certify remanufactured components. Preliminary results have established the key factors of remanufacturing quality control that might lead to the strict quality assurance of remanufactured components. Later, the developed framework can be used as a benchmarking tool to certify remanufactured components and warranty issuance. The findings serve as the foundation for further research concerning Original Equipment Manufacturer (OEM) or Original Equipment Remanufacturer (OER) and Independent Equipment Remanufacturer (IER) in the Malaysian Remanufacturing Industry.

Keywords: remanufacturing quality-certifying framework; quality assurance; quality control; remanufacturing warranty, developing country

1. Remanufacturing scenario

Remanufacturing in Malaysia is nascent and has just begun to emerge. In practice, the terms recycling, reuse, rebuilding, and remanufacturing are confused from the perspective of Malaysian automotive sector. A clear framework should be established for a better aftermarket sector profile. Intensive study to perform a framework suits for Malaysian remanufacturing industry is a must for future industry. In the aftermarket business, a remanufacturer may be classified into two groups: Original Equipment Remanufacturer and Independent Equipment Remanufacturer.

Research done by [1] stated that a key problem for remanufacturers is how to balance the contradictory needs for low cost, high quality, and short lead time. In other studies by [2] indicate one



of the core management issues in remanufacturing dealing industry is to effectively match demand and supply by dealing with uncertainty of the quality of returned products and of the market demand. In every aspect quality is extremely important and for remanufactured components quality is very challenging because the origin of each component has their own history during the life span and the ended of their useful life may vary. Continuous quality control is the best possible ways to achieve high quality remanufactured components as on OEM components that have appropriate development from the design concept through the manufacturing production, remanufactured components should have appropriate processes that merge with definition of continuous quality control.

Further, survey done by [4,5] listed nine Remanufacturing Decision-Making Factors (RDMF) for automotive industry companies engaged with OEM and IAM businesses included; financial impact of remanufacturing, core management, protection of intellectual property, green perception, OEM component specifications, government regulations, integrated organizational alignment, design for remanufacture (DfRem), and brand erosion. Out from the nine factors, core management and OEM component specification are two important factors in the remanufacturing processes in order to meet OEM sound conditions. From perspective of [5] criticized the issue of Original Equipment automotive suppliers which try to expand their portfolio of remanufactured components in the current state (without an upfront remanufacturing strategy), as the remaining service life requirements become only a key factor in their decisions to do remanufacturing. Not only the performance of component on remaining service life, remanufacturing need the re-issuance of the warranty period and coverage for aftermarket components in order to distinguish remanufacturing with other aftermarket businesses to secure its quality. Certification and trademarks of remanufactured component will help to counter this kind of issue in the grey market.

In this study, the quality of remanufactured components is the subject highlighted. Important factors or determinants which may reflect the quality outcome of remanufactured components is crucial to determine thorough the remanufacturing process, core management, quality management, and many other factors discussed in literature per summarized in Figure-1. A Remanufacturing-Quality Factors is important to perform in order to distinguish remanufacturing industry from other aftermarket businesses such as recycling, reusing, and reconditioning. Research is focusing on mechanical remanufactured parts, as applicable mostly in the Malaysian automotive, heavy machinery, marine equipment and aerospace industries.

2. Important factors for strategic quality interpretation

2.1 Core design

Used components or products going to be remanufactured are called core. Core selection for remanufacturing is very important as same as material selection for manufacturing processes to fabricate new products. Studies by [6] reported, the automotive industry in Malaysia, many have agreed that most components or parts intended for future remanufacturing should be designed in such a way that they would be able to undergo certain processes in making those components or parts usable to a certain extent, even after their originally planned life-cycle. Findings from [6] strengthen findings by [3,7] that the OEM/Supplier companies are making decisions on remanufacturing components late in the component life cycle, resulting in weakened remanufacturing results which makes DfRem is a key issue for remanufacturing. As extension of life-cycle process does not have a negative impact on component specification [8], or a negative impact on component performance after remanufacture, it may deteriorate the reliability and durability to a certain extent. Reliability is among the eight dimensional models for product quality [9]. Hence, it is important that such a design concept (Design for Disassembly, Design for Remanufacturing, Design for Reuse and so on) is incorporated before the components or parts are manufactured. The issue here is that three-quarter of remanufactured component are not designed for disassembly and this has a significant impact on the remanufacturing processes [10]. Parts without a reengineering concept may be prone to damage during assembly; desired final specifications are not achieved and this may increase the scrap rate.

2.2 Production layout

Does non-existence of proper production layout jeopardize the quality of remanufacturing processes? This question is only answerable by an authorized entity or government body by rules or regulations as set up. Flexible or standard remanufacturing looks significant to represent the remanufacturing processes, from Entrance Diagnosis to the end of Final Component Testing. To prove that remanufacturing is a sustainable business and not just a backyard junk business, here it must be emphasized that a planned layout is requirement. As volume of core is an issue in remanufacturing business, flexible production plan is the best alternative to set up.

In forward manufacturing industry, working manual is kind of Standard of Procedure (SOP) need to be issue to the production plan. Without a production layout, SOP is hard to document and it is not easy to ensure that remanufacturing processes are as efficient as possible. According to [11], organization and layout of the production system and network are enablers of, and have effects on, the efficiency of production processes. This is applicable to forward manufacturing and this rule should be applied to reverse manufacturing or remanufacturing as well.

Since there are no well-known strategies for evaluating the remanufacturing processes, methods for evaluation of ordinary manufacturing process were used as indicate in research by [6, 7], as facility layout is important to an aftermarket process organization. Through a literature study, [13] summarized Flexible Manufacturing Systems, Process Sequence Cell Layouts, Flow Processing and Mixed Model Flow Processing which can directly respond to facilitate flow processing within the remanufacturing environment. As long as a remanufacturer can justify their production layout, it shows that they understand the necessity of processes to be carried out and for high-quality production not just doing local workshop repairing work.

2.3 Remanufacturing processes

Previous study indicates, six processes should involve in the remanufacturing components; disassembly, cleaning, inspection and sorting, reengineering, reassembly and final testing [14]. To reach the same quality, warranty, reliability safety, effectiveness, lifetime and safety standards as a new component, adequate quality assurance measures are applied in every step. In particular, the final test of every component to be sold is not an independent “sixth step”, but an integral part of the whole remanufacturing process chain [14]. The testing, measurement, and quality control methods used should similar to those in original manufacturing. The only difference is that remanufacturing requires 100% inspection because in remanufacture all parts are presumed faulty until proven otherwise [15].

Existing claimed remanufacturing companies operate their processes according to varying strategies based on the characteristics of component they remanufacture, because they have no developed theory on how remanufacturing processes should be done. Some companies may have diagnosis entrance system for the components; some may knock down components up to single part and check for the condition and; some may just remanufacture the components according to needs based on their manual judgment. The lack of standard procedure on how remanufacture should be performed makes it harder to bring remanufacturing up to the ultimate level of end-of-life cycle processes. All strategies, theories, and processes in remanufacturing business which can bring out the high quality of remanufactured components have not yet been integrated in order to issue remanufactured components that same as new OEM. Warranties to match new OEM components are a must to complete the remanufacturing definition.

Analyses by [12] on remanufacturing facilities, for household appliances and automotive parts revealed that the cleaning and repairing steps are most critical in the remanufacturing process. In a remanufacturing study by [15], three key areas of inspection during the remanufacturing process were found to be very important: core inspection/testing; part inspection/testing; and finished component inspection/testing. This was embraced by [17] where agreed that remanufacturing always requires 100% inspection rate at one or more stages during the remanufacturing process. This is a quite detailed

process but makes sense to determine quality of remanufactured components, as testing on final output only seems unreliable for remanufactured components.

2.4 Data measurement/ Documentation

‘Lack of documentation of remanufacturing procedure’ is one of remanufacturing problem considered under study done by [15]. However, only 2 out of 5 companies under the case study find that documentation significant for their businesses. In addition, [18] revealed that many companies do not have an ISO9001 or ISO14001 certifications, since the management does not see the value of having these since there is no customer demand [18] nor enforcement from government body for having it.

Findings by [18] contradict to latest finding by [19], who found that the end-of-life vehicle (ELV) management industry is well established in North America and the processing technologies are generally understood, while specifics about each stage or unit operation of the ELV management process are not well documented. This issue in the remanufacturing industry means it operates like a black market business without any auditing. Business and operations related compliance, documentation and reporting must be performed to standardize remanufactured output as same as a new OEM part or else it just a reused component without any quality assurance and warranty given.

However, in recent years, remanufacturing is developing as an industry for future business. In order to declare a company as remanufacturer and provide a warranty for remanufactured components, they must run their business as any other manufacturing company. Everything must be clear and documented for auditing purposes. Remanufacturing is not a backyard or lame industry but a new business for future industry.

2.5 Management expert and skill workers

As revealed by [15] in a study, a company stated that the most important task of remanufacturers is obtaining the correct blend of technical skill, component knowledge and component history and scarcity of skilled was cited as the top concern among USA remanufacturer [20]. These criteria reflect the needs of expert and skill worker in remanufacturing sector. Skilled workers here represent experienced workers or skilled person with technical flexibility. Experienced technical workers are a great need for flexibility in remanufacturing businesses because this can help to increase worker productivity.

Repairing, rebuilding, reconditioning or other restoration procedures need a lot of experience and skill. For an example, local mechanics repairing all types and brands of vehicle without knowing the original condition and details of each part of component may fix most vehicle problems. It takes a great deal of experience as learning processes to cater all problems but basically, the fundamental element of repairing vehicle parts must be mastered. Skilful persons are crucial and the documented procedure and judgment criteria should be documented in a database as a systematic approach. Practically, most remanufacturer and reuse company only depend on traditional inspection to either rejected or remanufactured/ reused the components [21].

2.6 Organizational alignment

An integrated organizational alignment between OEM and independent remanufacturer is important to remanufacture a component. Compatibility of remanufacturing concept with current organization's policy and direction is one of the main point researched by [6] for Malaysia Automotive Remanufacturing Sector. Manufacturing data such as design tolerance, component specifications, and testing are required to return components to their original condition or perhaps even upgrade them to a better level. However, the sources of data are not easily to be access and it is confidential for most manufacturers. Hence, integrated organizational alignments supported by regulated bodies are important to perform in order to assist the independent remanufacturer to get support from the OEM in order to establish remanufacturing businesses.

By practices, some remanufacturers are depending reverse engineering strategy make profiles for the ELV components. For an example 3D scanner is used to develop the cores profiles, how far it can

take place for a legal business is thing to be find out. Until present, based on report by Asia-Pacific Economic Cooperation, Malaysia does not have a single regulation on Remanufacturing Businesses. This is a strong argument for Malaysia to come out with legislation and regulation for Remanufacturing industry for a clear organizational integration.

2.7 Serviceable and aesthetic

One thing is certain; high quality means pleasing the consumer, not just protecting them from annoyances [9]. That quote reflects our developing remanufacturing industry in this decade. From [9] the eight quality dimensions that can serve as a framework for strategic analysis: performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality. From literature performance, serviceability, aesthetic and reliability and conformance are the elements can be studied under remanufacture components. Capturing original OEM performance is the goal for remanufactured components.

During the warranty period, a component usually is applicable for service or and inspection from the authorized dealer or maker. In remanufacturing case this issue is not been highlighted, maybe because the industry itself is not established and run on a big scale. However, remanufactured components are applicable for same warranty as the New OEM and this issue should be discussed further to makes it a fair business for forward manufacturing players and aftermarket players. Furthermore, warranty and services are criteria for insurance claim purposes. In the other hand, originality in term of shape, surface finish and is might be important to retain in remanufactured components but goods surface finish sound like an additional cost for remanufacturer to bear.

2.8 Complementary performance

Complementary performance here is trying to highlight the factors to be investigated before decided to remanufacture component, whether the component is reliable to undergo remanufacturing processes. This includes the condition of component return and total life span the component can serve the end market. Safety and reliability issues still play a key role in serious and often controversial discussions about the future of remanufacturing and reuse of parts [17]. Reliability is the most important quality dimension to be understood to make sure remanufactured components can serve without failing within the warranty period.

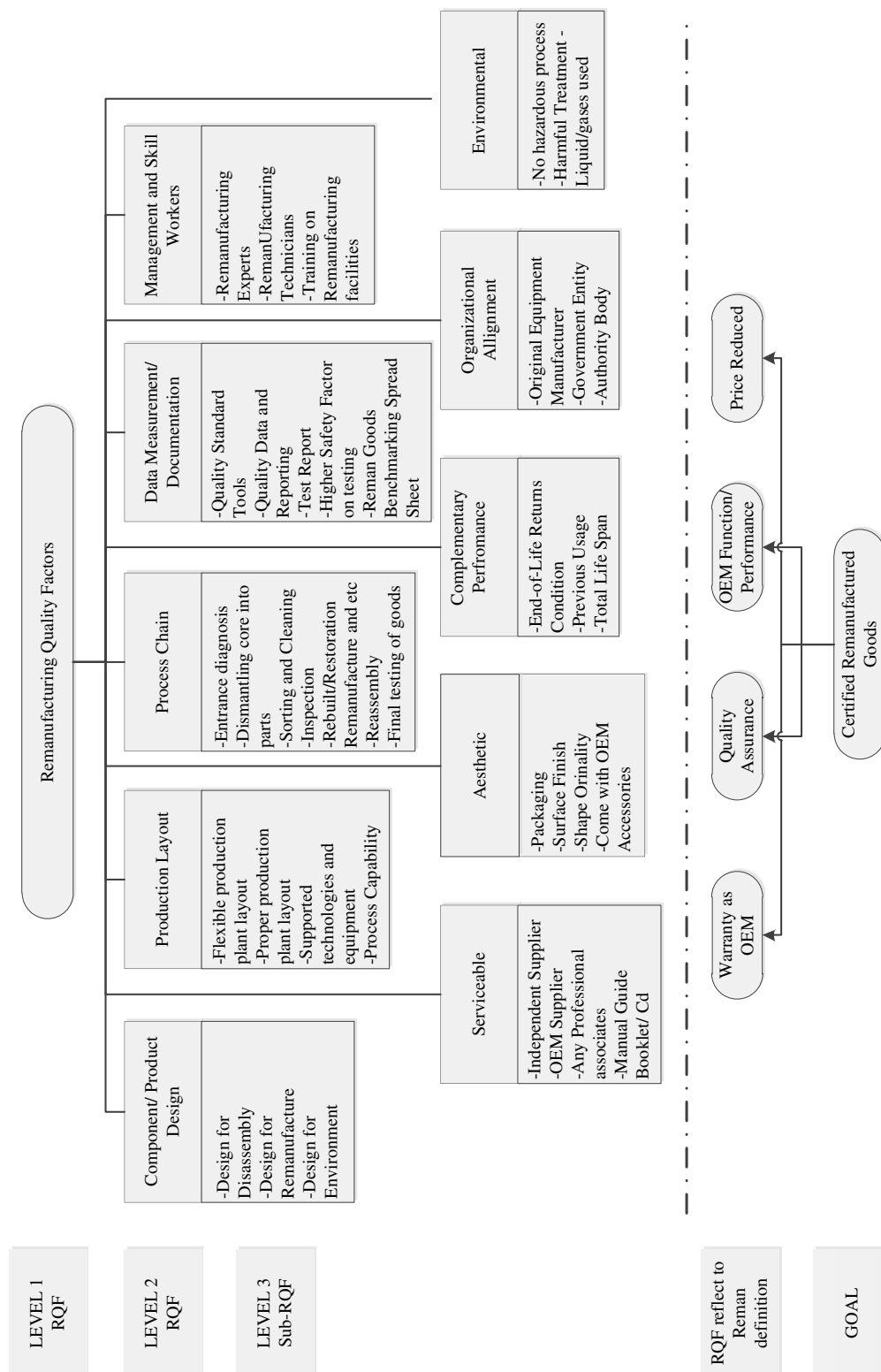


Figure 1. Remanufacturing-Quality Criteria for Remanufacturing Industry

2.9 Environmental issue

6Rs is a greening approach for a sustainable future. The goals of 6Rs close-loop lifecycle are to keep the better environment and sustain nature and besides preserving mineral and natural resources. With this reason, remanufacturing process must be practiced in cleaner and non-hazardous environment. For an example, no extreme chemical should be used through cleaning out the excessive oil and liquid from the used components. From surveys in Malaysia the excessive oil which is pumped out from used component are not well managed, where most of the components are transporting from outside Malaysia.

3. Methodology

A framework is developed by literature study and expert opinion because of limitation of industrial players in remanufacturing sectors in Malaysia. A comprehensive literature study is done to find the important criteria in remanufacturing area which may reflect to component quality and warranty issuance. Brainstorming sessions with researchers involved in remanufacturing and recycling activities are conducted in the preliminary stage to make sure the future developed framework is significant and reliable. Further, feedback has been gathered to finalize and construct the preliminary framework base on researchers and academics points of view.

This methodology needs a joint effort and commitment from government and related bodies, aftermarket manufacturers (remanufacturer/ recycler/rebuilder and so on) and researchers to standardize a system in order planning and evaluated quality remanufactured of components in perspective of industrial expert and academic expert to fill up the gap. After intensive literature study, brainstorming session and interview conducted with a few recyclers/ remanufacturer in Malaysia resulted as Figure- 1 where items are grouped into categories. Final frameworks have been constructed by an interview with representative from Ministry of International Trade and Industries (MITI) in Malaysia for initial validation of research work.

4. Finding and discussion

From preliminary survey it shown that remanufacturing is mixed up with recycling, reusing and rebuilt industry. With no regulations on remanufacturing, Malaysia already has total of 39 registered remanufacturing businesses in five different sectors: aerospace (1), automotive/heavy duty (10), electronic (19), heavy machinery (5), marine equipment (1) and plant machinery (8). Each remanufacturing sectors has different strategies for bringing used components at par with new OEM components. Practitioners remanufactured cores depending on consumer demand and acceptance.

In term of recyclers and rebuilders population, Malaysia have hundred them under different association. However, from their valuable experience and feedback, author tuned it to academic components and finds that recycling and rebuilding can be upgraded to remanufacturing business with additional of processes and quality management system. All information from surveys is gathered and categorized in Figure-1 based on themes selected from literature.

On current situation it is promising and shown positive sign of future remanufacturing industry in Malaysia as industrial player has interest in this business and certainly profitable. To help remanufacturing industry growth in Malaysia remanufacturer and the government/ authorities body need to cooperated and negotiated with the existing industrial players to fulfil the basic needs of having qualified remanufacturing sector. There is no regulation or standard procedure performs in order to acknowledge remanufactured component/ product is better and reliable rather than repair, refurbished, reconditioned, reused, rebuilt or other execution mode.

The methodology presented in this paper provides a comprehensive evaluation of RQF, covering stages of the remanufacturing processes, management system, and component early designing stages which reflect good remanufacturing practices for quality and warranty issuance. Through these stages, the authors have found that remanufactured components have issues with reliability and the reliability should been understood before components being dismantled. Component history and original design

is a must to be understood. Reliability study is the best indicator for remanufacturer to gain confident on their remanufactured quality and finally provide a warranty to their remanufactured components.

5. Conclusion

From the 10 elements of Remanufacturing Quality Factors (RQF) proposed above, process chain and expert management/ skill worker are the two elements practices by most remanufacturers in Malaysia regardless they are OER or IER. For recyclers and rebuilders the most important to on running their business is expert management/ skill worker only. However, to accredit component/ product of remanufactured good, every aspect of component/ product must fulfilling the requirement as per remanufacturing definition (refer GOAL in Figure-1). Further study will be conducted from the perspective of quality, safety, and component warranty in order to come out with a RQF that helps as a blue print for Malaysia remanufacturing industry. Which and how factors will bring the warranty as same as OEM new component/ product warranty will be finalized further.

Further RQF be applied by both OER and IER to justify their remanufactured components are meets the quality for second life use through reliability point of view. Besides helping recyclers and rebuilders upgrading their business, RQF can be auditing benchmark criteria for a consortium or government body to examine the quality of remanufacturer outputs. Since there are no standard strategies for evaluating the remanufacturing procedure in Malaysia, factors for evaluation in Figure-1 is the basic need for IER and OER to work as independent/ authorized remanufacturer.

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