6.4 Sustainable Manufacturing for Indonesian Small and Medium sized Enterprises (SMEs): The Case of Remanufactured Alternators

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Abstract

Achieving sustainability is a great challenge for most of the Indonesian Small Medium sized Manufacturing Enterprises. Remanufacturing has been considered to be a key strategy to attain sustainable manufacturing by maximising the use of old components, and minimising landfill size and energy usage. However, SMEs, which are undoubtedly the engine of the Indonesian manufacturing industry, do not have adequate experience, resources and government support in the remanufacturing area. This paper proposes a new concept for sustainable manufacturing assessment framework through remanufacturing strategies in Indonesian SMEs. In this sustainable manufacturing assessment framework, the existing remanufactured products are assessed using sustainable manufacturing criterion (e.g. reliability, life cycle cost, employee creation, greenhouse gases etc.). This framework identifies improvement opportunities, including eco efficiency, cleaner production and green technology to make existing remanufactured products technically, economically, environmentally and socially sustainable. The sustainability of remanufactured alternators produced by an Indonesian SMEs has been assessed to test the aforementioned sustainable manufacturing assessment framework.

Keywords:
Remanufacturing; SMEs; Sustainable Manufacturing

1. INTRODUCTION

Manufacturing industry is a wealth producing sector of Indonesian economy accounting for 24% of GDP followed by agriculture (15%) and other economic sectors [1]. Large Enterprises (LE) and Small and Medium Sized Enterprises (SMEs) accounted for 43.28% and 56.72% of the total GDP in the manufacturing sector, respectively, while the SMEs alone represent 99.96% of total number of manufacturing industries (3.27 million companies) and also absorbs employment for 87.47% of the total industry workers [2].

The proportion of SMEs for total manufacturing export and GDP is still low compared to the large number of the enterprises due to the lack of innovative technology, inefficient production processes, limited skilled workers, insufficient capital investments, unqualified and unclassified standardization products and lack of government policies [3]. Most of SMEs exports are dependent on large enterprises and their contribution is unrecorded and undermined. As a result, SMEs cannot expand market independently [4], and many of them cannot compete globally. Therefore, most of these SMEs have changed their business to be smaller or even out of business (bankrupt) [5]. Furthermore, many Indonesia manufacturing SMEs are not environmentally conscious, and contributes large amount of pollution, and resource depletion due to inefficient equipment usage [6].

Thus Indonesian manufacturing SMEs do not comply with the economic, social and environmental objectives of sustainable development. This is because the objective of sustainable manufacturing is to develop and improve human life continually over time through optimization of production and consumption activities by conducting efficiency on material and energy consumptions, focusing on poverty reduction and maintaining the resources for human beneficial reasons [7].

The main strategies for attaining sustainable manufacturing are remanufacturing, reuse, recondition and recycling [8]. Remanufacturing which is defined as a series of manufacturing steps acting on an end of life (EOL) part or product in order to return it to like-new or better performance, with warranty to match [9], appears to be the most appropriate strategy to attain sustainable manufacturing in Indonesia.

Firstly, it fulfils three objectives of sustainable manufacturing. Remanufacturing is economically viable by maximizing the use of old components or product, and it is environmentally friendly by reducing size of landfill, minimizing the energy usage, and it is socially viable by providing employee opportunities and develop prosperity flows [10-12]. For example, an automotive engine remanufacturing company reduced metal consumption by 7.65 thousand tons, conserved energy of 16 million kilowatt-hours, and decreased emission of about 11.3 – 15.3 thousand tons CO_2 [13]. In UK, remanufacturing contributes workforce around 50,000 employees and provides £ 5 billion GDP annually [14], while in USA, 73,000 remanufacturing industries employed about 480,000 people [15]. In addition, the increased employment opportunity, job satisfaction, income and clean environment will improve the quality of human life. These advantages significantly place remanufacturing as the main contributor to the sustainability of prosperity [11].

Secondly, since 1997 – when the economic crisis took place Indonesia – the new products became unaffordable and expensive for majority of the Indonesian people. Consequently, refurbish, recondition, cannibalized, reused and remanufactured products such as electronic, household appliance, automotive components, office furniture etc. have become usual products in Indonesian market [16].

Unfortunately, the development of remanufacturing industry which is mainly held by SMEs is still undercover, neglected, and environmentally unfriendly. Many SMEs feel doubtful that their remanufacturing business will continue growth due to high competency in the global market. Only few giant companies (e.g. PT Sanggar Sarana Jaya, PT Komatsu Remanufacturing Asia) have recognized the valuable of remanufacturing strategies in Indonesia that offering economic, social and environmental benefits in the future [17, 18].

This paper discusses a new concept of sustainable manufacturing for addressing sustainability issues through remanufacturing operations as experienced by the Indonesian SME. An integrated sustainable manufacturing model is developed to address sustainable manufacturing issues for Indonesian SMEs. Firstly, the paper reviews the state of the art of Indonesian remanufactured auto part industries. Secondly, it explains the model for assessing sustainable manufacturing operations. Thirdly, the model has been tested with remanufactured alternator as case study. Finally, the paper suggests the policies/supporting structure for achieving sustainable remanufacturing in Indonesia.

2. THE STATE OF ART OF INDONESIAN REMANUFACTURED AUTO PARTS

Automotive industry sector is growing alarmingly in Indonesia in the recent years. The production growth was about 35.21 % during 2009 - 2011 while the market growth was 37.54 % [19]. The total number of automotive industries is around 445 which mainly held by SMEs absorbing around 185,000 to 204,596 employees [20]. In the case of motor vehicle industries, the sales was 894,164 units in the last 2011 and the prediction shows that the percentage will be increased to 50% in the next 5 years [19, 21]. As a result, the use of auto parts such as engine, transmission, steering gear, starter and alternator will increase.

Alternator is a part of automotive components which can potentially be remanufactured. The remanufactured alternator dominates the remanufacturing market around 22% [22]. The remanufactured alternator offers 50% cheaper costs than the new ones and consumes 60% less of energy and 70% less material compared to the new product. Also about 80% of the alternator parts can potentially be reused [23, 24].

The legislations (e.g. End of Life Vehicle (ELV) Directive and Energy-Using-Product (EUP) Directive) which are crucial drivers for successful implementation of the remanufactured products in developed countries (e.g. UK, Japan) [11], have totally been found absent in Indonesia. The next important driver is market demand. The Indonesian automotive components market is divided into original equipment market and market for low cost and minimum standard product which are manufactured mainly by SMEs. Due to affordable price of remanufactured products [25], the remanufactured alternator are expected to dominate the market.

Most of SMEs are not effectively producing remanufactured alternators, except for few (e.g. Galeri alternator). The Indonesian SMEs producing remanufactured alternators experienced a number of challenges. Firstly, the SMEs have lack of financial supports and available parts and are highly dependent on the imported components, and thus these SMEs could not conduct production activities effectively and efficiently. Secondly, the orientation of product standardisation based on the domestic market generates low quality, less reliability and short warranty period which reduce the attractiveness of the remanufactured alternators in the market. Thirdly, most of the industries are not environmentally efficient and produces more pollution that due to lack of advanced technology and waste management. Fourthly, unsupported government policy on remanufacturing operation and lack of economic intensive (e.g. rebate, subsidies etc.), have affected the progress alternator remanufacturing SMEs in Indonesia.

Thus this paper provides remanufactured alternator as a case study to test the sustainable manufacturing model for both assessing and improving the SMEs remanufacturing auto parts in Indonesia, and seeks to come up with the best solutions and strategies to overcome aforementioned problems.

3. THE MODEL FOR SUSTAINABLE MANUFACTURING

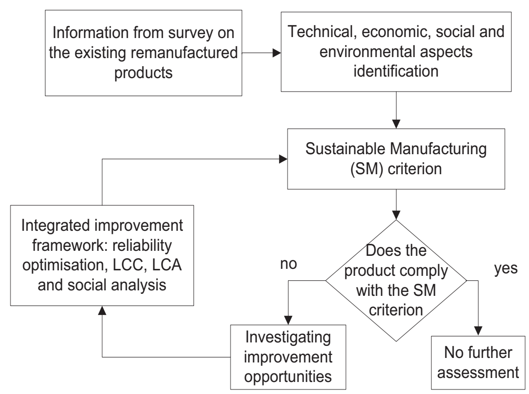

Figure 1: Model for Sustainable Manufacturing

Referred to Figure 1, the steps for assessing the sustainability of remanufactured products have been stated below.

Firstly, the existing remanufactured products are assessed using the sustainable manufacturing criterion, including technical (i.e. reliability), economic (i.e. life cycle cost, sales) environmental (i.e. solid waste, GHG emission), and social aspects (i.e. employee creation, warranty). Secondly, the calculated values of these criterions are compared with the threshold values of sustainability criterion. These threshold values are derived from the standard Indonesian and International literature discussing Indonesian and global remanufacturing issues. The examples of the threshold values of the technical, economic, social and environmental are reliability (99%), life cycle cost (50% cost of new product), warranty period (2-3 years) and greenhouse gases emission (2.58 $kgCO_2$-eq) which are appeared in the remanufacturing sectors [24, 25]. Thirdly, the remanufactured products not complying with any of these sustainability criteria are considered as unsustainable remanufactured product and are then redefined by investigating improvement opportunities through an integrated improvement framework involving reliability optimization, life cycle cost (LCC), life cycle assessment (LCA) and social assessment. The objective of this integrated improvement is to determine technically feasible solutions which are economically, socially and environmentally feasible and meet the sustainable manufacturing criterion. Figure 2 shows the detailed version of the integrated improvement framework.

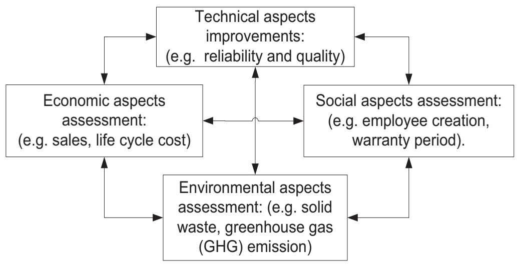

Figure 2: An integrated improvement framework

Firstly, technical criterion involving reliability of the remanufactured products is assessed. Using this criterion, the material, method, man, machine, energy and information are analysed and appropriate technical feasible solutions involving the best available technologies, processes, technical skills, and energy and material consumption are proposed. Along with technical feasibilities studies, LCA analysis of the technically feasible solutions are carried out following ISO 14040-43 guideline [26] to determine environmental criterion including greenhouse gas (GHG) emissions and solid waste. If technically feasible solutions are not environmentally viable, "hotspot" or the process producing the most pollution is identified to apply mitigation strategies (e.g. cleaner production, eco efficiency, green technology, industrial symbiosis).

These two analyses are carried out simultaneously until both technically feasible and environmentally friendly solutions are obtained. Once technically and environmentally feasible solutions are obtained, the socio-economic viabilities of these options are assessed involving sales and life cycle cost assessments. The economic viability is attained when sales and life cycle cost are equal or greater than threshold values. Similarly, social criterion such as employee creation and warranty period are required to meet the threshold value. If the revised version of technical option is not socio-economically viable, different socio-economic policies including rebate, subsidy and education are considered to attain socio-economic feasibilities.

Once technically, economically, socially and environmentally feasible solutions are determined, some appropriate institutional framework, including policy instruments, stakeholder responsibilities, key actions, targets and key performance indicator are developed to implement sustainable manufacturing in SMEs. The institutional framework, takes into account the constitution of direct (e.g. remanufacturer, supplier, consumer) and indirect (e.g. Government, research institution, bank) stakeholders who participate in decision making process for sustainable remanufacturing.

4. THE CASE STUDY OF REMANUFACTURED ALTERNATORS

4.1. The existing situation of SME remanufactured alternators

A survey has been conducted in a SME producing remanufactured alternators in Dinamo Tanjung enterprise, Central Java, Indonesia to test the propose modell and the framework. The remanufacturing operations have begun with a recovery process where alternators were collected directly from used alternator collection centres (e.g. service centre, auto junkyard).

In the factory line, disassembly is the first step where housing, stator, rotor, regulator, rectifier, brush, bearings are dismantled using simple tools and manual methods. Then all parts have been cleaned and dried by gas heating. Following this, testing including inspection and sorting of parts have been done for reconditioning on the basis of the reusability of parts. Then the reconditioned and new parts have been reassembled to make remanufactured alternator. The alternator is tested before they were packed and ready to deliver to customer. The assessments of the existing remanufactured alternators have been done in the following ways.

Technical assessment

In this case study, the number of alternators failed in 3 years (2008-2010) is 3838 alternators. The failure of the alternator components was happened mainly due to the failure of regulator (63.68 %), followed by rectifier (13.25 %), brush (11.97 %) and other components such as stator, rotor etc. (11.11 %).

The reliability of the remanufactured alternator is calculated using the Weibul ++8 software. Intensive data including failure identification of the alternator, time of failure of the alternator and sales of the alternator were identified. The purchasing date, failure date and failed parts are collected to determine the time to failure. Data related to the number of failed alternators, suspended alternators and status (e.g. Failure/F or suspended/S) were also involved to get the valid reliability result of the remanufactured alternator. Based on the calculation using Weibull distribution, the Weibull reliability plot presents the shape parameter (β) which is 2.4 and the scale parameter (η) which is 1288 days.

However, the reliability of new product is 100% in the early of its life and gradually declines during its life time [27]. The mean time to failure (MTTF) of the alternator is 1142 days, and the reliability model of the remanufactured alternator is presented in following equation.

$$R(t) = exp\left[-\left(\frac{t}{1288}\right)^{2.4}\right] \quad (1)$$

The threshold value of the remanufactured alternator reliability is estimated about 99% which is close to 194 days (6.5 months), while the reliability of the remanufactured product in 1 year is 95%.

Economic assessment

The remanufactured alternator sales performance of this SMEs shows that the sales decreased gradually from 2008 to 2010. In 2009, the sales decreased by 20 % and dropped again in 2010 by 26%. The life cycle cost analysis of the remanufacturing process that includes the cost of product recovery, disassembly, cleaning and washing, inspection and sorting, reconditioning, replacement, reassembling, final testing, packaging and warranty, have been performed. The acquisition cost is not considered in this LCC, because the remanufacturing process was based on the previously used infrastructure and machinery.

Based on the calculation done, the unit cost of the remanufactured alternator product is Rp 183,000.00. The threshold value of LCC used to test the economic criterion of the remanufactured product is 50% of new product [25]. The breakdown of the remanufacturing operation costs of the alternator are shown in Figure 4. The product recovery cost contributed the largest portion (34,84%) of total unit cost, followed by replenishment cost (34,34%), reconditioning cost (21,68%), cleaning washing cost (6,01%), inspection and shorting cost (1%), packaging cost (0,76%), final testing cost (0,50%), reassembling cost (0,43%) and disassembling cost (0,43%).

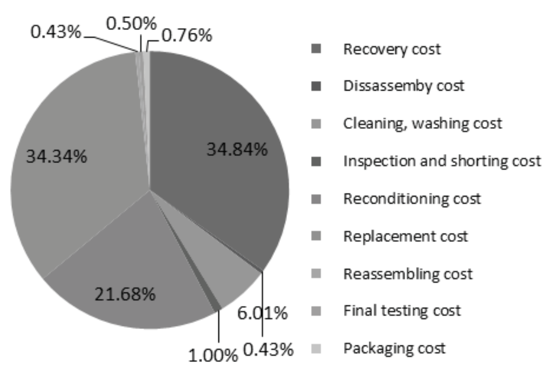

Figure 3: LCC of the remanufactured alternator

Social assessment

Warranty is one of the key social indicators of remanufactured product which represents an industry for its corporate social responsibilities [27]. The warranty of remanufactured product is proposed to maintain the performance of the product to be as good as new, which offers social benefit to the customer. However, the remanufactured alternator SMEs could only provide 1 years warranty against 2-3 years warranty for new alternators. Next social indicator is an employee creation. The higher employee creation could alleviate poverty and social equity by reducing the gap between the rich and the poor. In the case of remanufactured alternator SMEs, where the study was carried out, the employee creation has decreased significantly (24%) in 3 years (2008-2010).

Environmental assessment

The environmental assessment includes the determination of solid waste and greenhouse emissions. After the disassembling, washing and testing processes, 59% of components are reused, 22% of components are replaced with used component, and 19% of components are replaced with new components. Therefore, the old/used parts which have not been used are categorised as solid waste. About 41% (0.83 kg) of the parts have been replaced with the used and new parts consisting of steel (24 %), cast iron (26%), copper (33%), plastic (11%) and carbon (1%). The threshold value used to evaluate the solid waste contributed from the remanufactured alternator is 21% [25].

The GHG emission is calculated using a LCA software, known as Simapro 7.3 [28]. As the remanufacturing processes are conducted in Indonesian SMEs, the Indonesia emission factors for electricity generation have been used to determine the CO2 emission from the remanufacturing process. The emission from the production of new components which replaced the wear out components has also been considered. The GHG emission from transportation activities such as product recovery and shipment of new components from China to Indonesia have been estimated on the basis of the emission factors obtained from the Simapro 7.3 software database. The results show that the remanufactured alternator contributed 5.98 kg CO2-equivalent of GHG, while the threshold value of the GHG emission is 2.58 kg CO2-equivalent for a remanufactured alternator [25]. Table 1 represents the existing scenario of the remanufactured alternator in comparison with the threshold values.

Table 1: The existing scenario and the threshold value

Assessment	KPI	Threshold value	The existing situation	Yes /No
Technical	Reliability	99%	95%	No
Economic	LCC	Rp 172,500	Rp 182,000	No
	Sales	Increase	Decrease 25%	No
Social	Employee creation	Increase	Decrease 24%	No
	Warranty	2-3 years	1 year	No
Environment	Solid waste	0.43kg	0.83kg	No
	GHG emission	2.58kg CO2	5.98 kg CO2	No

The result indicates that the remanufactured alternator industry does not comply with the SMD criterion as all key performance indicators do not satisfy the threshold value.

The integrated improvement framework

The processes, material, labour and machine of the existing situation have been assessed using sustainable manufacturing framework to determine the possible technical solutions to meet the sustainable criteria (threshold values). The possible technically better option identified from this investigation is to replace all wear out components (41%) including voltage regulator, rectifier, insulator, brush, bearings, pulley, rotor etc., with original equipment components in order to increase the reliability. This means that 22% of the components which were previously replaced with used components, now replaced with new components. This is known as new scenario.

By following this approach, the reliability for the improved scenario was assumed to be the same as new alternator, because the improved scenario considered the use of new parts instead of remanufactured parts. However, in order to calculate the reliability of the improved version accurately, some key information such as time to failure, failure data and suspension data associated with the proposed improved version need to be known which is beyond the scope of this project. Figure 5 shows the comparison of new material used between the existing situation and the new scenario.

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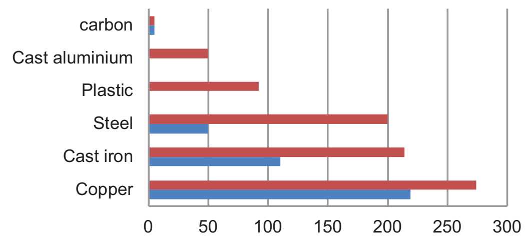

	Copper	Cast iron	Steel	Plastic	Cast aluminium	carbon
New	274	214	200	92	50	5
Existing	219	110	50	1	0	5

Figure 4: The materials used in the existing situation and the new scenario.

Based on the improved scenario, the environmental assessments of this new technical option have been conducted, as shown in Table 2

Table 2: The environmental impacts of technical option

	GHG emission (kg CO_2-eq)	Solid waste (kg)
1.The existing situation	5.98	0.83
2.The threshold value	2,58	0.43
3.The new scenario	14.6	0.83

The results show that the replacement of wear out components with new ones does not satisfy the threshold value of the GHG emission, and so the further scenario, which applies mitigation strategies have been considered to attain the environmental threshold values. These mitigation strategies are [25]:

- Component substitution – recycled components (reducing 83% of GHG emission)
- Recycling process for the solid waste (reducing 88% of solid waste)

Table 3 shows that the both technical and environmental criterion is met by applying these mitigation strategies.

Table 3: The technical aspect and environmental impacts

	Reliability	GHG emission (kg CO_2-eq)	Solid waste (kg)
1.The existing situation	95%	5.98	0.83
2.The threshold value	99%	2.58	0.43
3.Replacement with new parts scenario	99%	14.6	0.83
4.Environmental mitigation scenario	99%	2.48	0.10

The next step is to assess the socio-economic viabilities of the remanufactured alternator for the fourth scenario. The economic analysis is based on the economic parameters in Table 4.

Table 4: The economic data

Additional variable cost for replacement	Rp 15,000.00[1]
Total sustaining cost	Rp 237,000.00
Cost saving	Rp 61,000.00

([1]US$ = Rp 9,700.00)

Table 5 shows that the LCC of the new scenario met the threshold value. Therefore, the increase of the reliability of the remanufactured alternator is assumed to increase the customer satisfaction by 0.2% as determined by following Cook and Ali (2010). The increase in market response is predicted to increase the sales of remanufactured alternator by about 0.2%, which will in turn increase the employee creation by around 0.3%. The warranty period of a remanufactured product is considered to be the same as new product. The increase in reliability is expected to lengthen the warranty period and to reduce warranty cost. Nominal Customer's Risk (NCR) analysis is used to assess the warranty of the remanufactured alternator. Based on this analysis, the warranty of the proposed scenario is about 2 years which is same as the threshold values.

Table 5: Socio-economic analysis of remanufactured alternator with mitigation strategy

	Existing situation	Mitigation scenario	Threshold value
1. LCC	Rp 182,000	Rp 170,600	Rp 172,500
2. Sales	Decrease 25%	Increase 0.2%	Increase
3. Warranty	1 year	2 years	2-3 years
4. Employee creation	Decrease 24%	Increase 0.3%	Increase

However, the implementation of these strategies could not be done unless appropriate policies are implemented by the Indonesian Government, and involvements of stakeholders from manufacturer to customers are required in the policy formulation and implementation process. Socio-economic policies, including rebate, subsidy and education could be considered as policy instruments, plus stakeholder responsibilities, key actions, targets and key performance indicator could be developed to implement mitigation scenario for attaining sustainable manufacturing.

CONCLUSION

The development of sustainable manufacturing is a great challenge for Indonesian SMEs. Remanufacturing is a priority manufacturing option to achieve sustainable manufacturing in Indonesia. This research proposes a sustainable manufacturing assessment model and integrated improvement framework to overcome the unsustainable remanufacturing issues. The case study conducted for SMEs remanufacturing alternator, found that the current situation is not sustainable. Therefore, the mitigation strategy that recycles component was considered to attain the threshold value for sustainable manufacturing, including reliability (99%), GHG emission (2.48 kg CO2-eq), solid waste (0.10 kg), LCC (Rp170, 600.00), sales (increase 0.2%), warranty period (2 years) and employee creation (increase 0.3%). However, the institutional framework including remanufacturer, supplier, consumer, Government, research institution, bank are to be integrated in attaining sustainable industrial development in Indonesian SMEs.

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