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Transition Decision-Making Framework for Remanufacturing: A Case Study in Malaysia Automotive Sector

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Abstract:

For the past few years, an increase in automotive production in Southeast Asia has led to serious concerns related to the environment. Pursuing a sustainable business while maintaining business profitability is a subject that has attracted major interest in Malaysia. Some of the positive steps adopted towards environmental protection and sustainability include on-going initiatives and cooperation from the government and different stakeholders, which focus on promoting environmental awareness and implementation of the 4Rs: repair, rebuild, recycling and remanufacturing. This is specifically applicable for manufacturing and has consequently become a research priority in this sector. On the other hand, the transition from other green strategies towards the practice of remanufacturing has resulted in a significant challenge that entails addressing the requirements from a diverse range of perspectives, such as the viewpoints of society, the government, and different stakeholders. Most of the research conducted in Malaysia tends to consider the development of remanufacturing, focussing on the critical factors that will contribute towards the success of remanufacturing, and analysing the impediments in remanufacturing implementation. Also, while the studies tend to emphasise on analysing the potential advantages of remanufacturing regarding society, the environment and economic factors, less attention has focused on the analysis and development of transitioning business operations towards remanufacturing. Therefore, this study aims to develop a Transition Decision-Making Framework (TDMF), where the remanufacturing and transition elements were identified through an extensive literature review and validation by undertaking two empirical case studies from the Malaysian automotive sector is required. The Analytical Hierarchy Process (AHP) can also be employed and used to implement the framework developed for the criteria and prioritisation of elements within the framework for future research.

Keywords: *Repair, Rebuild, Remanufacturing, Recycle, Transition Decision-Making Framework*

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I. INTRODUCTION

Increasing use of natural resources such as fossil fuel (about 65 per cent increase) has caused significant concern by all industry players and humanity given the escalating rate of depletion, environmental pollution and energy consumption [1]. Although strategic and practical efforts to minimise the use of non-renewable materials should help to address this issue [2]. Recently, there has been a growing trend towards the development of sustainable business practices regarding management, technologies and institutional practices which require fewer resources, and in-turn, minimises emissions, is environmentally compatible, society oriented, affordable, and not affecting our lifestyle [3].

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On the other hand, remanufacturing has become increasingly attractive and has been discussed in Malaysia for many years since the initial announcement of the National Automotive Policy (NAP) in 2014 by the government under the aftermarket segment. However, remanufacturing remains at the premature level and requires continual effort and cooperation both from the government and stakeholders. Remanufacturing differs from other green practices as it is the restoration of end-of-life (EOL) parts which involve engineering processes in order to convert them to new parts, similar or at least better than the OEM standard with a warranty provided [4].

However, the transition from other green strategies such as repairing, rebuilding and recycling (the 3Rs) towards remanufacturing is challenging since it is extremely demanding to meet the requirements from a different perspective by the government, stakeholders and society. Accordingly, this research aims to identify and draw the emerging elements or actors between business transitioning and remanufacturing as a key focal point for these enterprises.

II. IDENTIFICATION OF TRANSITION DECISION-MAKING ELEMENTS

Many previous studies have investigated the business transition process and approaches. However, one of the interesting research studies presented by [5] stated that there are four significant elements in business strategies related to sustainability which include the strategic element, tactical element, operational element and reflexive element. This was also supported by other researchers [3]. This section elaborates on how the transition remanufacturing actors are merged with transition business elements.

A. Strategic Element

The strategic element is a level which requires strategic activities that are exposed to change and reflection.

- **Company Vision and Goals on Green Practices**

The transformation from current business activities is not as easy as planning. The first aspect that needs to be clarified is expanding the company's vision and goals, especially towards engineering, sustainability, environmental safety, alignment with society and company profitability [6]. The vision and goals should also be perceived as part of a holistic vision and designed beyond their own capabilities, considering future challenges in sustaining the business [7]. As repair, rebuild, and recycling companies in the automotive industry in Malaysia consider remanufacturing as part of their overall business plan going forward, they must first evaluate the potential of remanufacturing.

- **Financial Strategy**

Profitability in the remanufacturing industry has been proven to be economically viable in many industrial countries globally, such as in Germany, the United Kingdom (UK), the United States (US), South Korean, and China. However, the transition of business operations requires individuals, organisations and societal considerations for success. Sound financial strategies and financial support are required as both play an important role in transitioning business performance. For example, a large player in an industry can hire many skilled employees and procure advanced technology in their operations compared to an enterprise-level company [7].

- **Supply Chain Activity**

Strategic changes in supply chain management (SCM) such as the integration of the supply chain have improved company performance. The SCM function can be utilised in acquiring competitive and sustainable benefits in the marketplace. Likewise, an efficient supply chain system can advantage and benefit the company by reducing operational costs and strengthen customer service [8]. As such, potential remanufacturers need to reconnoitre the prospect and benefits and to appropriately structure the supply chain model and network to align with the remanufacturing process [9].

- **Marketing Strategies**

Increased concern and focus on marketing is necessary during the transition management process or any other related innovation business activity. As a remanufacturer, a company must build a new market which is valuable for the development and sustainability of the company's products and services [3].

B. Tactical Element

The tactical element is the process of spreading and developing a network or collaboration during transition pathways to achieve the sustainability

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objective. The sub-elements are further explained and described by the points below.

- **Organisation Structure Support**

In the tactical element, most activities or subcomponents are proposed based on the requirement of multi-perspective support to achieve sustainability objectives [10]. To compete globally in the remanufacturing business, a robust organisational structure is required, which will become an innovative resource for the company and management [11]. In contrast, a weak organisation structure supporting the implementation of sustainable business approaches or green practice will become a major barrier in the implementation of remanufacturing [12].

- **Government Collaboration**

Legislation or enacted regulation is important for the successful implementation of remanufacturing in most European and other countries such as German, UK, US and Brazil. Asian countries like South Korea and China have received government support in developing their remanufacturing industry through the introduction of several regulations and national policies [13]. However, in Japan, the national policy and associated legislation have meant that remanufacturer companies are restricted by the lack of support from the authorities. This began with the enactment of the Environment Pollution Basic Law in 1967, in which most stakeholders still experience difficulties and other hardships in recognising legal support for their expansion in remanufacturing. Even though a two certification system was introduced in 2001 being the End-of-Life Vehicle Recycling Law and The Home Appliance Recycling Law, this is still the case [14].

- **OEM Collaboration**

Coalition with Original Equipment Manufacturers (OEM) would facilitate organisations transitioning into remanufacturing. Remanufacturing is a process which reproduces used parts back to their original function and is covered under warranty given the quality is at least equal with the OEM standard or better than the OEM specification. As such, OEM owns the property rights and assists with product specifications. Otherwise, the company needs to design an alternative for manufacturing by reverse engineering in meeting the quality and warranty and OEM standard. This coalition with OEM will prevent the avoidance of product commercialisation due to the perception of cannibalisation of new products [14].

- **Research Institute Collaboration**

Regarding the transition in moving to the remanufacturing system, an organisation may need to collaborate with other institutions for product research and development (R&D). Likewise, the existence of a strong network and the interaction between a university or educational institution and the company is seen as an added advantage to enhance business practices and by providing additional resources and knowledge to both parties [15]. For example, collaboration with two agencies in South Korea, the Automotive Technology Institute (KATECH) and Korean Technology and Standard (KATS) has established a certification process and quality standard for product development.

C. Operation Element

The operation element aims to gain and thrive and is examined by various prospects of revolution ally concepts and ideas having the potential to accomplish the strategic vision and provide more sustainable systems.

- **Production Layout**

The main focus on production or facilities layout is to establish an efficient timeframe needed in the production process. Specifically, it is involved with the disposition of functioning, tools and machinery as well as space optimisation to achieve the systematic movement of products [16]. Hence, the manufacturing flow is more predictable on process sequences compared with remanufacturing.

Most remanufacturing production is more complex and uncertain, given the connection and reliance on the availability of core supply, quality of supplied core and demand for the remanufactured product. Consequently, it will affect lead times, the manufacturing process and schedule and the remanufactured product price. Therefore, proper selection and designing an efficient facilities layout for transition the process will have a significant impact on productivity and reducing operating costs up to 50% [17].

- **Core Management Process**

Core material for remanufacturing, reconditioning, repair and the recycling business

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originate from the end-of-life vehicle (ELV) which is the registered vehicle and will be disposed of by the owner due to several reasons. The quality status of the core is uncertain [18] and increasing in numbers of ELV have caused many researchers to suggest a proposed solution on ELV management, such as a study by [19].

The process chain in remanufacturing activities is different from other alternative green practices. Moreover, the remanufacturing sequences are different based on the products and their remanufacturable characteristics. Generally, the remanufacturing process begins after the incoming core is received from the supplier, arriving at the company's storage facility. All core will go through multiple industrial processes such as disassembly, cleaning, assembly, repair, reconditioning, inspection, replacement and quality testing to restore the product to its original functionality and condition to at least a similar quality as the OEM standard with a warranty provided.

- **Data Management**

As a future industry operating business model in Malaysia, it is similar with conventional manufacturing, although remanufacturing must have appropriate data management related to the concessions, operational reports and standard operating procedure (SOP) which must be achieved to justify the remanufacturing practice by providing both quality and warranty assurance to customers. A transparent document management process could also assist the company with the external auditing process conducted by authorised government bodies. Also, a proper data management system could provide a solid foundation for an organisation to construct on-going enhancement and increase the company's efficiency [20].

D. Reflexive Element

From the transition management perspective, all elements described above should involve the process of deliberation and a progress assessment concerning the viability and the societal environment. Likewise, the aims, targets and actions must be combined and linked to strengthening an efficient transition process as described below.

- **Human Resources Development**

Implementation of green practices requires the integration of various quality achievements such as knowledge evolution, organisational incitement, and skills advancement among employees. Further, it assists with idea [innovation] improvement, competency on managing advanced technology, knowledge sharing and related-problem solving abilities [21]. Notably, the lack of human resource development due to inadequate training and education could hinder the successful implementation of green practices such as remanufacturing [22]. Therefore, investment in human resource development is important for the company in encouraging the production of technical expertise which provides a positive impact on the implementation of remanufacturing.

- **Organisation Evaluation**

Organisation evaluation is one of the significant presentation tools for firms to evaluate business performance, benefiting both employees and the employer. Furthermore, it is a medium to gather opinions, to identify serious problems in business and to generate optimal and alternate solutions for future performance. The evaluation process for the improvement process can be undertaken for many aspects such as human resources, technology facilities, administrative and production operation which will help the company achieve its goals and objectives [23].

- **Society Engagement**

Societal acknowledgement and perception on the transition pathways, including the product, is a significant challenge faced by every organisation. In fact, it has become one of the most significant barriers in the implementation of remanufacturing. As such, the company should understand the pattern of purchasing intention and behaviour in the case of transformation towards remanufacturing to offer alternative solutions in product development [24].

III. METHODOLOGY

In conducting this study, an extensive literature study was conducted to identify strategic transition approaches, which also included conducting several meetings and discussions with an expert from the Malaysia Automotive and Robotic IoT Institute (MARii) related to remanufacturing and the transition of business operations. In addition, case studies were conducted to generate the theory based on the interpretation of observations made in natural settings.

This paper focused on the characteristics related to Company Vision and Goals on Green Practices,

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Financial Capability, Organisation Structure, Business Collaboration, Production Layout, Core Management Process, Data Management, Human Resource Development, Organisation Valuation and Society Engagement as cited and identified in the previous section. The case studies involved two companies using similar procedures and data collection method to allow cross-case exploration to develop the TDMF along with in-depth understanding and to gain access to the present situation. The data were collected during site visits and interviews with key personnel from each company. The interview approach applied a semi-structured questionnaire with open-ended questions. The survey instrument comprised of two parts. Section one required the respondent to provide general information regarding the organisation, and section two aimed to describe the 4R's activities in each company.

IV. CASE STUDIES

Due to the research agreement and confidentiality, both companies were depicted as Company A and Company B. The interviews were conducted using the semi-structured questionnaire with open-ended questions. A summary of the case studies is depicted in Table 1.

A. Case Study 1- Operation of Company A

Company A is an enterprise rebuilding company for heavy-duty vehicles and is a member of the commercial vehicle rebuilders Association of Malaysia, holding ISO 9001:2000 accreditation, specialised for reconditioning and reassembly of used commercial vehicles. The company's primary activity cuts across numerous markets in Malaysia. From being a relatively new company, it has developed and grown to become a major player in the industry. The factory is supported by modern equipment, which can produce approximately 60-70 units per month. The company reconditions and reassembles a diverse range of rebuild commercial vehicles for domestic and for selected export.

The top management of company A mentioned that all green practices such as repairing, rebuilding, recycling and remanufacturing are different regarding the process, quality and policy. The company is still in the educating [learning] process related to remanufacturing. Notably, significant profitability is gained in the rebuild business in Malaysia with their main involvement and customers residing within the automotive sector.

The rebuild operation comprises many steps: dismantling the part, cleaning, inspection, functionality testing, reprocess and reassembly. Each vehicle component is disassembled into a single part. However, due to safety issues highlighted by the government, there are a few parts which are restricted to be rebuilt or repaired, such as brake components. The parts are sorted accordingly to their section such as the brake section, chassis section, engine section and bay section, etc. All work is performed manually by company employees, and all parts are rebuilt to enhance their visibility and physical appearance during an inspection. Any part which fails in this process is sent to the recycling section for waste storage.

Concerning product quality, various methods are used to perform individual part performance by using a variety of testing machines. Any core that passes this initial test will go directly to the reconditioning process. Otherwise, for any faulty or unsatisfying result, the core will be disassembled into its subcomponents, repaired and reconditioned. All cores are assembled following the repair and reconditioning process. The company requires high skills of employees to combine everything as a whole. The manager of company A mentioned that a few staff had been sent to attend 4R2S training conducted by MARii. Once a product is ready for commercialising, the part is labelled with the company sticker along with a warranty covering the part for 90 days. All this information such as the SOP, any related compliance requirements, service and warranty are maintained in the company's filing system for auditing purposes.

Trucks and transport users require only the functionality of the product without calling into question the existence of the remanufactured parts used in the vehicle. To enhance the company's profitability, good customer service is always their criteria after the selling segment. Maintenance services are available and performed by the product's skilled personnel supported by a warranty. According to the line manager of company A, social perception and choice are the two options based on the offered price between rebuild and remanufacturing the product to a new product which is a great challenge for them. The customer will often prefer to buy a new product manufactured from China rather than buy a rebuilt product which offers a competitive price even though the core comes from Europe.

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B. Case Study 2- Operation of Company B

Company B is an enterprise for the restoration of turbochargers, established in 2014. The company's main activity is in the repair and reconditioning of all ranges of turbochargers for domestic and selected export markets. The company's main focus is towards part distributors, individual garages and the general public. The company also sells new turbochargers imported from Japan.

The operation consists of five steps which begin from visual inspection, part disassembly, part cleaning, repairing, replacement and reassembly. No specific inspection tool is used by the company to detect any fault level of parts and even for the final quality check/inspection of the product. Any part which requires major repair will be immediately replaced with new components due to the cost-effective consideration made by the company. The company uses a sandblasting machine for the cleaning process. The employee manually carries out all steps in the process. Two shop lots are used to operate the business, one of which is used for dyno tune.

Regarding product quality, there are no specific tools used to verify the performance of an individual turbocharger. Each task relies on the experience of each worker and no proper engineering SOP, job checklist and warranty are documented. The employees are trained to multitask in operating the business. Unfortunately, none of the employees had been sent for any training and instead, it depends on the instructions given and knowledge sharing by the manager. In the current practice of the business, the company has no collaboration with OEM, any government agency or a research institute for the development of products.

V. RESULTS

Based on the two case studies, both companies defined the remanufacturing process satisfactorily. Although, both companies failed to have much in commons relating to each element since they were both of a different business nature as summarised in Table 1.

Table 1: Case Study Summary

Element	Sub-element	Case Study 1	Case Study 2
Strategic	Vision and Goal	Able to differentiate all types of green practices.	Able to differentiate all types of green practices.
	Supply Chain System	Performed by the supplier No third-party core supplier involved.	Performed by the supplier. Secure the core by exchange and purchasing them.
	Financial Strategies	Good financial capability for technology investment skills, human resources and facilities upgrade.	The financial constraints for technology investment, skills, workforce and facilities upgrade.
	Marketing Strategies	Focus group on construction and heavy-duty vehicle company.	Target customers are from parts distributor, individual garage and the public. Social media and online advertisement.
Tactical	Organisation Structure Support	Proper organisation structure and a sufficient number of employees.	No specific structure in the organisation. Lack of expertise and number of employees in the company.
	Collaboration with OEM	No collaborative partnership between the company and OEM.	No collaborative partnership with OEM.
	Collaboration with Government	Strategic collaboration with government agencies related to auditing, training and legislation.	Lack of collaboration with the government agency.
	Research Institute Support	No collaboration with any research institute for product development.	No collaboration with any research institute for product development.
Operation	Production Layout	Large and flexible space for various activities.	Small and limited space for the production process.
	Core Management	Procedures: dismantle, cleaning,	Procedures: dismantle, cleaning,

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Element	Sub-element	Case Study 1	Case Study 2
	Process	physical inspection, initial testing, core dismantle, repairing, replacement part, rebuilding part, core assembly, core testing, labelling, vehicle assembly.	visual inspection, repairing, and replacement.
	Data Management	Provide details and systematic documentation such as for Import and logistics, quality records, and engineering process manual.	Unsystematic documentation system. Lack of manuals, checklist and record forms or documents.
Reflexive	Human Resource Development	Continues advanced training for engineer and technician.	Lack of advanced technician training. Depend on verbal instruction and individual experiences.
	Organisation Performance Valuation	Periodical evaluation of company performance and audit from authority agencies.	Lack of examining company performance.
	Society Engagement	Lack of engagement by society in rebuilding the core. Customise exterior vehicle design based on customer requests.	Public involvement is important as the products are accordingly on public classification and opinion.

VI. CONCLUSION

The enforcement of remanufacturing activities as a key requirement in the rebuild sector has shown a slight improvement in remanufacturing education and practise. Few components have become pilot remanufacturing project for a rebuild company in Malaysia such as for radiators, intercoolers, stators and alternators due to safety concerns. Empirical data validation was useful in verifying the significance of the elements in the current practice both in the rebuild and repair sector, which required improvement for the transitional business area. Accordingly, this should be aligned

with the elements and sub-elements proposed by the author based on the literature review. Therefore, for future work, the author will present the TDMF, and the framework will be analysed and validated using the Analytical Hierarchy Process (AHP) since the nature of different businesses will require different prioritisation of elements.

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