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Conceptual design of automobile engine rubber mounting composite using TRIZ-Morphological chart-analytic network process technique

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ABSTRACT

An engine rubber mounting is one of the important parts of a vehicle. It is a function to isolate or absorb and to reduce vibration to the vehicle body thus to the passenger itself. Due to the engine compartments environment such as heat and massive vibration due to road conditions, the engine rubber mountings lifespan has been reduced. Thus several studies have been conducted to upgrade the material lifespan to make it more reliable and better engine mounting components. This paper presents the conceptual design of kenaf fiber polymer as automotive engine rubber mounting composites using the integration of Theory of Inventive Problem Solving (TRIZ). In this early stage, the solution is generated using 40 inventive principles and TRIZ contradiction method. The solution parameter for the specific design character is the selected using the morphological chart to develop a systematic conceptual design for the component. Four (4) innovative design concepts were produced and Analytic Network Process (ANP) methods were utilized to perform the multi-criteria decision-making process of selecting the best concept design for the polymer composite engine rubber mounting component.

1. Introduction

Conceptual designs are among the most important early stages product development where in general, possible solutions are generated to meet the design goals required for the product [1]. Engine rubber mounting has been used since the early stage of the internal combustion engine. The main objective is to absorb and reduce vibration from the engine. An ideal engine mount system isolates vibrations caused by engine dynamic disturbances in various speed ranges and prevents engine bounce originated by shock excitations [2].

Natural rubber is used in mountings because of its combination of properties. Natural rubber provides high strength, outstanding fatigue resistance, high resilience, low sensitivity to strain effects in dynamic applications and good resistance to creep [3]. In the real condition of the engine rubber mount beside absorbing vibration, the mounting also exposes to heat and chemical spills. Heat generated from the engine itself, near to exhaust manifold and some time spill from brake fluid, coolant, petrol will tend to reduce its lifespan. The engine operating temperature was above 80 °C and can reach over 100 °C at the nearest exhaust manifold or catalytic converter. The operation at the high temperature must need to use an expensive silicone rubber for the engine mounting. The temperature of the engine mount can increase if the available space for ventilation was decreased [4]. There is some design consideration for engine mounts such as mount configuration and torque axis [5]. Others design approach simplify a multidisciplinary optimization problem by reducing the total number of the design objectives based on the natural characteristic of engineering structure [6].

In product design stage, it is important to make the design with proper dimension without sacrifice the strength and reliability of the product component. The rigidity of a mount's supporting structure, along with mount system strength and geometry, are very important considerations [4]. Design plays an important rule in producing a good product. An improvement on the product selection or product design with proper thickness will give a good result on its mechanical properties [7]. Advantages of proper design

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selection can reduce up to 73% of weight, freedom to design complex shape with low weight high strength to encourage manufacturer for a polymeric-based composite [8]. From the statement above clearly, the issue of durability of engine rubber mount and design needed to be improve.

In this study, a conceptual design of automotive engine rubber mounting composite is developed by using kenaf fiber polymer composites. The conceptual design of engine rubber mounting is developed to replace the existing rubber-based engine rubber mount in order to reduce the component's weight while maintaining the required structural strength for safety and functionality performances. Based on the project requirements, a new concurrent engineering approach using the integration of TRIZ, morphological chart, and ANP methods approach was applied in the development of the conceptual design for the polymer composites automotive engine rubber mount component. Four (4) main stages were involved during the development process which is: idea generation, idea refinement, concept design development and concept design selection using the mentioned methods. Four (4) new concept designs of the component were produced at the end of the development process and the best concept design was selected based on the product design specifications.

2. Applications of TRIZ in concurrent engineering for new product development

The TRIZ technique founded by G.Altshuller in 1946 originating at Russia through which the manner rest on studies of resourceful principles utilized in patents to achieve ideas for the form solutions [9]. Among the most characteristics of TRIZ structure is its aim to dispose of any compromise that could rise up in the gap chanced on by specializing in the difficulty seed result in and obviously identifying the point of the subject. There are four (4) particular approaches to the solution that can be selected throughout the TRIZ method looking on the level of involvement of the problem which is 39 engineering parameter and 40 inventive principles [10]. The special benefit of TRIZ particularly because the diagnostic medium is it provides a methodical freedom description and modernization method of dealing with the issue various traditional brain-storming innovation program that is repeatedly impromptu and decidedly depending on luck [11]. There are many studies related to selection of design and materials for automotive component such as kenaf composite for car spoiler [12], hybrid composite for car anti-roll bar [13] [14], material and design selection of car bumper beam [15–19], and spall liners for ballistic protective door panel made from composite [20]. In material selection using expert system software also proved to be faster, more interactive and effective in material selection process [21].

The applications of TRIZ in concurrent engineering for product evolution purposes are gaining higher attention as reported by a number of researchers. Among them is the integration of TRIZ with ANP in developing mobile healthcare device product as reported by Shih [22]. Based on his studies, he manages to build 3 conceptual design for shock absorbers and finally selecting the suitable design using ANP. Another sample of application of TRIZ integrated with AHP such as design selection of door panel [23].

ANP is a generalization of AHP dealing with dependence and feedback in the entire decision structure [24]. One well-known method is the analytic hierarchy process (AHP) to prioritize customers' requirements. According to the review by Ho [25], 16 papers combine QFD and AHP, applying the integration to different areas. However, the limitation is the independence among customers' requirements, leading ANP to become an appropriate method instead.

3. Application of TRIZ–Morphological Chart–ANP technique in conceptual design: a new product development case study on automotive composite engine rubber mounting component

Fig. 1 shows the automotive part as what we called engine rubber mount which available in most of all moving vehicle which uses internal combustion engine either in the air, land or sea. This product mostly made by using injection moulding technique. The main component of these engine rubber mount is the rubber/elastomers composite which it is the main component that functions as isolator or vibration absorbent. Natural rubber or known as the natural polymer is the most widely used as engine mounting. There are several synthetic polymer composites that are used such as the polyurethane (PU) but it is highly cost and non-environmental friendly.

Due to several changes of policy in automotive manufacturer related to the environment protection, automakers worldwide are shifting into green product/material to use in their component. The researcher has been given the task to fulfil the task of producing the green material and friendly to the environment [26].

In this project, natural rubber (NR) with thermoplastic polyurethane blends and kenaf fibers as filler has given the opportunities to develop these new engine rubber mounting composite. Experimental works have been done and all three material is able to be blend together. But in this particular studies, it is focused on the conceptual design of the rubber composites of the engine rubber mounting. There is four (4) design has been prepared and the best design will be selected using TRIZ principle solution for the early stage. Then a morphological chart will be involved in this study and then use the ANP as the final decision of selecting the design. Fig. 2 shows the working framework of the conceptual design studies.

3.1. Defining the design intents and identifying the improving and worsening parameters of the engineering system

In the early paragraph had mentioned and identify the general problem regarding the engine rubber mount. Based on that problem statement, an engineering solution through TRIZ method is applied. The first step is to identify the engineering worsening problem and improvement parameter using contradiction matrix method of TRIZ. The with the contradiction matrix, the 40 principle invention of TRIZ to be filled in Table 1.

The table of contradiction matrix is then simplified to identify the items that need to improve in the worsening features as shown in Table 2. The next step is to identify the suitable TRIZ solution principle to suit the conceptual design of engine rubber composite mount.

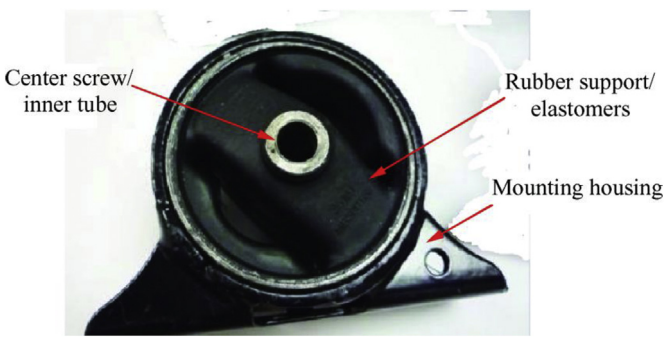

Fig. 1. Engine rubber mount parts.

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