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Design Of Quick Release Mechanism For Disassembly : A Sustainable Approach

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Abstract— Sustainability is an increasingly important requirement for human activity, making sustainable development a key objective in human development. At its core, sustainable development is the view that social, economic and environmental concerns should be addressed simultaneously and holistically in the development process. Sustainable development is the view that social, economic and environmental concerns should be addressed simultaneously and holistically in the development process *"Tsai C. Kuo[9]"*. Sustainability can be incorporated into design, during all phases of the design process, and many tools to support such endeavors have been developed and applied (Fig. 2). One of these is described in this section, namely, Design for Disassembly (DFD). Design for Disassembly involves the incorporation of sustainability objectives in design activities.

Index Terms— Design For Disassembly (DFD), Fastener, Life Cycle Assessment (LCA), Metaklett, Quick Release Mechanism, Sustainability, Velcro.

1 Introduction

DFD vastly reduces waste in the manufacturing and recovery processes and allows for greater flexibility during product development, shorter development time scales and reduced development costs at the end of life and with lower cost even prolongs the life of product by allowing for changes.

Design for Disassembly targets for EcoDesign (Fig. 1):

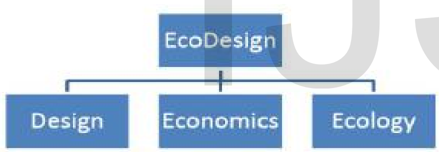

Fig. 1

Design for Disassembly (DFD) is a process by which a product and its parts can be easily: Reused, Re-manufactured and Replaced. Design for Disassembly a type of green manufacturing is the term used to describe environmentally sound practices of producing products, or producing environmentally sound products.

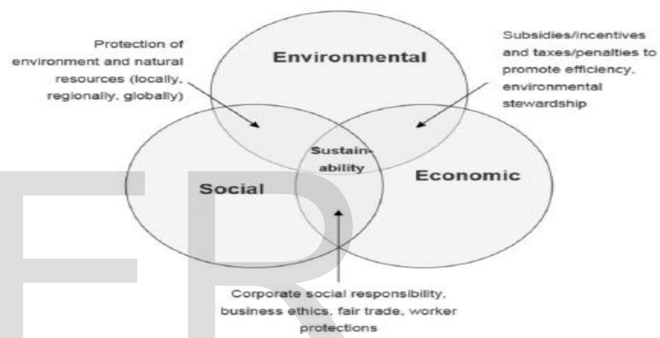

Fig. 2

When the product is originally designed to be taken apart, so that they can be used in later generations of products, DFD is the first step in designing a product for reuse, remanufacturing, and replacing to meet our growing organization demands for better products. This study led to the development of Life Cycle Assessment (LCA).

LCA is a tool for improving the environmental performance of processes and systems, and is often used in sustainability work.

In LCA, the environmental impacts of a product or service are analyzed through all phases of its life, with the objective of reducing environmental damage, in part by enhancing resources conservation and efficiency. All these factors and observations directly point out to the initial stage of a product or part development , where if DFD concept is followed, the outcomes might result into better durability , better utility and less environmental damage in the upcoming years.

Design for Disassembly is a technique design the product to be disassembled for easier maintenance, repair, recovery and reuse of component and material reduce the environmental impact and increase the value of end-of-life products and enabled to recent advances technologies and is needed to support current organization needs for faster innovation product development cycles combined with products.

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1.1 Problem Definition

"1. The typical concept lacks a comprehensive framework to integrate design for disassembly with product design process while considering corporate sustainability strategy *"Robert Bogue[8]"*. 2. Product designers' options are limited due to the limited number of existing active joints; and there is no specific design method to assist with design and invention of active joint".

Therefore, it could be concluded that the overall objectives are to bridge these identified gaps, and to this end, the following solution is stated:

"Product life-cycle can be improved by incorporating design for disassembly in product design process. A framework equipped with methods and tools is essential to achieve this goal. showing means of active joints for easier disassembly of a product putting forward the concept of reusability and replacing."

1.2 Objectives

The objectives are:

To improve sustainability by improving the product design that helps corporate introduce sustainable product to the market. Also to increase the product life in terms of durability.

We are also targeting on introducing a new innovative active joint and active fastener that can be used directly by product designers; to design quick release mechanism for easier assembly and disassembly thus reducing the time required for disassembly.

2 Methodology

2.1 Background

Typically the start to end of a material / product flow is like:

Fig. 3

This typical process does not consider any environmental problems; neither has it taken into account of the economic losses linking up with the product.

The above process has some loopholes and if modified to the below structure, the flow becomes more efficient and ready to use for the upcoming years.

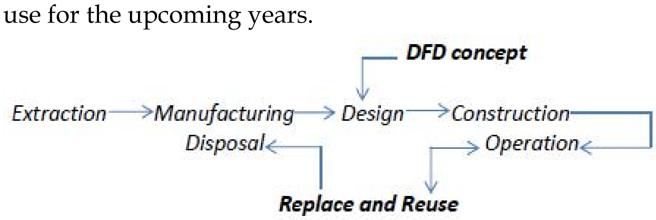

Fig. 4

In the above process after introducing two internal changes namely DFD concept and Replace Reuse Concept, the process becomes more efficient in terms of usage and economy.

The internal changes are majorly focused at the tail end of the process, at points: Design, Operation, Disposal thus introducing concept of Design for Disassembly (DFD) and therefore allowing the criteria of replacing the defected parts and then again reusing the product.

2.2 Scope

The increasing individualization of products assigns manufacturing companies to new tasks like manufacturing various products in a more efficient way.

This progression in the market leads on the one hand to a new product design and on the other hand to an improved production process. Both are necessary to reduce assembly, service and recycling costs. Hence the joining technology is and will become more and more important.

The following conventional joining technologies:

1.Welding,

2.Bonding,

3.Bolting or

4.Clamping

These have their own disadvantages especially in the field of flexibility.

In order to reduce the effort for assembling and disassembling by retaining the requirements of the connection a new innovative joining technology is needed.

In this study a new joining technology is introduced to become faster and more flexible in assembling and disassembling. The basic idea of this manufacturing technology comes from a "metal hook and loop fastener" or METAKLETT. A hook and loop fastener consisting of metal has a lot of advantages for the fields of industrial assembly, service and recycling.

Similar to the synthetic hook and loop fastener or Velcro, a metallic hook and loop fastener is characterized by easy closing and opening without special tools.

In comparison to the synthetic hook and loop fastener or Velcro the transmissible forces are very high. An additional benefit can be gained for instance in shock absorbing or resistance against chemical and thermal influence.

The following support for high transmissible and shear strength shows that Metaklett has comparatively more strength than Velcro (Table 1 & Table 2) *"Hölzel Stanz- und Feinwerktechnik GmbH & Co. KG[4]"*:

Table 1 - Velcro

Material	Width (mm)	Attachment strength (N/m2)				
		Shear		Lateral shear		Peel
attachment overlap (mm) x (Fig. 1)		20	72	10	30	72
A—standard	20	35	87	32	—	4·6
A—standard	30	35	98	30	—	4·8
B—elasticated	30	25	36	22	—	2·0
A—standard	50	74	195	48	72	5·0
B—elasticated	50	40	60	21	54	3·4
C—"Kric Krac"	50	>365*	>335*	284	>390*	4·8

*Tearing of material rather than pulling apart of attachment

Table 2 - Metaklett

Clamp	N/cm²						
	23 °C	50 °C	100 °C	200 °C	400 °C	600 °C	800 °C
Pull-out strenght	7	7	7	8	-	-	-
Shear strength 0°	35	29	28	33	49	32	16
Shear strength 30°	12	8	8	9	-	-	-
Shear strength 45°	11	8	8	9	-	-	-
Shear strength 60°	10	8	7	8	-	-	-
Peel strength	3	3	3	3	-	-	-

2.3 Material and Design

While designing, the product designer must consider that the design enables the product and its parts to be easily reused, re manufactured or disassembled and reduced environmental impact at end of life product. There are two important factors which must be considered here:

1. Material Selection
2. Product Structure & Component design

1. <u>Material Selection:</u>

The selection of materials should in no way compromise the structural requirements of the design the properties of a specific material meet the requirements for the design better than other.

For manual separation, large masses of a single material are important. For mechanical separation, reducing the total number of different materials in the assembly is more important and maximizes the recovery, recycling, and re manufacturing throughout the product life cycle.

The following points were taking into consideration while selecting the appropriate material for the hook and loop (Metaklett) fastener:

1. Minimize the different type of material in each part.
2. Minimize the number of different material in product.
3. Enabling the disassembly material to be easily recycle whenever possible.
4. Enabling the disassembly parts for re manufacturing or reuse.
5. Select compatible material.
6. Reduced overall material diversity.
7. Use all material optimally.
8. Avoid contaminant material.
9. Less cracking at high temperatures.
10. Preventing undesired reaction with the environment (eg. Rusting).

The following properties are considered while selecting the proper desired material:

1. Chemical Resistance at high temperature - minimum Chromium 18%
2. Structural Stability- minimum Nickel 9%
3. High Creep Strength (allowing to use at high temperatures) - Austenitic Steel used (*Martensitic and Precipitation Steels are not used since they soften at high temperatures*).

After considering the previous constraints to material selection for metal hook and loop fasteners , according to the European Standards EN 10088-1:2005, the most suitable material will be X10CrNi18-8 (DIN 1.4310) where DIN is abbreviated from Deutsche Institute of Normag or The German Institute of Standardisation*"The European Standard[2]"*.

2. <u>Product Structure & Component design:</u>

Product Structure & Component design are useful for component which is easy to disassemble for servicing will usually be easy to disassembly for recycling designer should enable product rapid and economically disassembly.

The following points are considered:

1. Reduced the number of assembly operation ensure that the product service life is appropriate.
2. Design modular product to enable modules to be disassembly for service or reuse reduced the number of parts used in an assembly standardization of component assembly material priority reduced the different types of material in an assembly.

The design of a metallic hook and loop originates from the conventional hook and loop mechanism, popularly known as the Velcro (Fig. 5). A Velcro strip consists of multiple loops on one strip and multiple hooks on the other.

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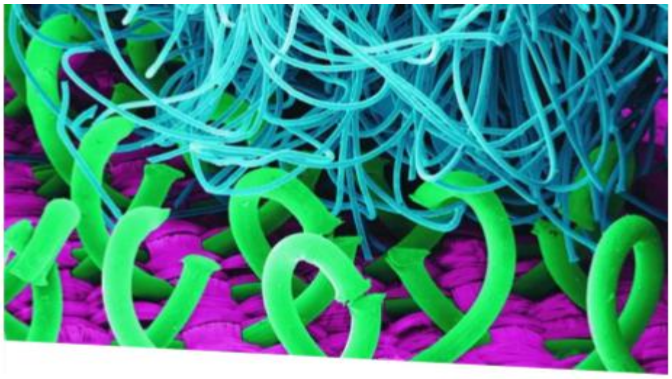

Fig. 5 - Conventional Hook and Loop Fastener (Velcro)

The Design consists of two parts:
1. Hook
2. Loop

HOOK:

The designed hook is shown below:

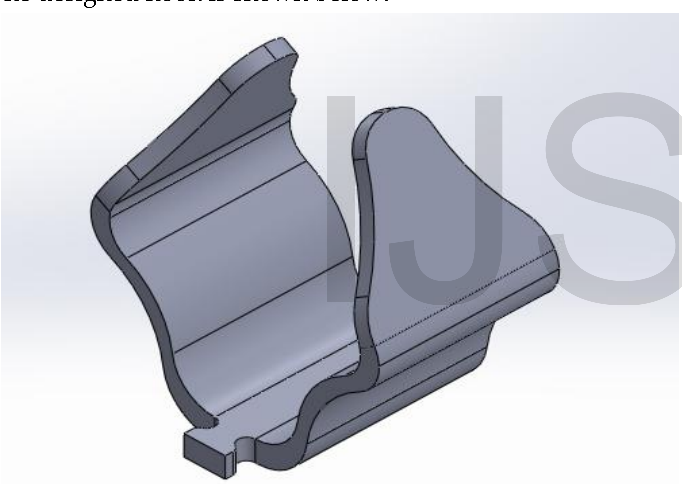

Fig. 6

Table 3

Material	X10CrNi18-8
Dimensions	Wide = 1mm Length = 1mm Thickness = 1mm = 1mm - 1.15mm (at neck portion)
Tolerance	± 0.05mm

The Hook (Figure 1) represents the male part of the system. It has two protruding parts similar to a conventional hook for holding and clinging to an object. The edges of the hook are rounded off in order to remove the hook easily without damaging the other part of the system. The neck or the portion containing the bend , has been comparatively given more thickness than rest of the hook body part. It is because while engaging and disengaging the components , more stresses are liable to be produced at the bend portion of the hook. So to prevent more stresses which might result into breaking of the hook, the neck is given more thickness.

LOOP:

Table 4

Material	X10CrNi18-8
Dimensions	Outer square = 1mm x 1mm Pocket square = 0.8mm x 0.8mm Thickness of loop and sheet = 1mm
Tolerance	± 0.05mm
No. of loops	4

The designed loop is shown below:

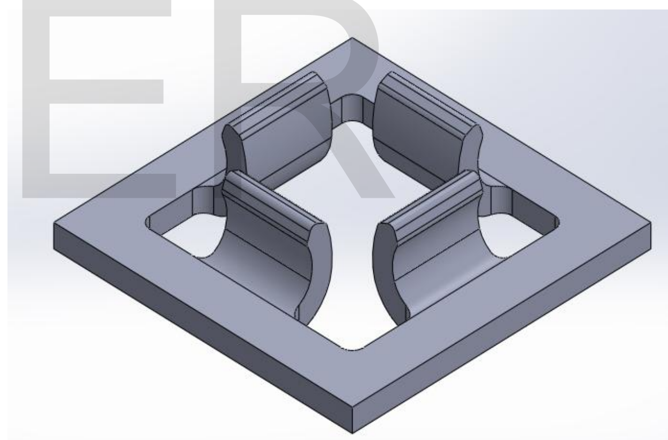

Fig. 7

The Loop (Figure 2) represents the female part of the system. Here it consists of four protruding parts which will have the function to hold the hook. Like the hook, the loop has rounded edges for disengaging without damaging the hook.

HOOK AND LOOP:

METAKLETT is a multiply mountable and dismountable metallic hook and loop fastener that can be applied in environments where synthetic materials lose their practicality. A metallic hook and loop is a mechanism which holds two components together. METAKLETT system consists of steel straps mounting a hook system that interlocks with an eyelet strip. These two components,the hook, HOOK and the complement LOOP are pressed together, the structures will lock with each other and become capable of transmitting forces both vertically and

horizontally. The connection can be undone by pulling the elements apart without using any tool, thus warping the material easily with less efforts.

The complete design will include two strips. Each loop will be 1mm thick,10mm wide and length of any measurement depending upon the specific requirement of the product. These strips will house 4 hooks and loops in a row. So if the strip length is 50mm, total hook and loop interlocks will be 20(5x4). A minimum of four hooks have to be used for the joint.

3 Conclusion

Through qualitative research disassembly would be a feasible alternative to direct disposal after usage. Thus it facilitates the idea of sustainable manufacturing by reusing and replacing the part. The intention is to contribute to a product's reusability and recyclability.

Results can be considered very positive: problems related to both the assembly and disassembly of the mechanical system is expected to be improved not only at product level but also at component level. Product remanufacturing is environmentally preferable in comparison to new product manufacturing. Design for disassembly aspect should be integrated into manufacturing companies to reduce the environmental impacts arising from their products after use.

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