Biomimetic design for remanufacture in the context of design for assembly

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Abstract: In this paper, a biomimetic design method is applied to a specific problem in design for remanufacture. First summarized is remanufacture as an option to disposal at product end of life, and how products may be designed for ease of remanufacture. Next identified is a contradiction between a design-for-remanufacture strategy and design-for-assembly preferences. Specifically, making failure-prone features into separate parts facilitates remanufacture but results in additional parts to assemble. An example involving snap fits as a method of fastening and joining is used to illustrate the contradiction. To obtain ideas on how to address this contradiction, a biomimetic search method was used to find biological phenomena that are analogous to remanufacture. One such phenomenon is described and used to develop a concept that satisfies both design-for-remanufacture and design-for-assembly preferences.

Keywords: biomimetic design, remanufacture, design for assembly

1 BACKGROUND FOR REMANUFACTURE

1.1 Remanufacture and other product end-of-life options

Product design for end of life is prompted by existing and anticipated legislation that assigns to manufacturers the responsibility for their products at the end of life. Alternatives to landfill or incineration include recycling for scrap material, remanufacture and maintenance. Maintenance extends product life through individual upkeep or repair of specific failures. Remanufacture is a production-batch process of disassembly, cleaning, refurbishment and replacement of parts in worn, defective or obsolete products. Scrap-material recycling involves separating a product into its constituent materials and reprocessing the materials.

1.2 Benefits of remanufacture

Remanufacturing is recycling at the parts level as opposed to the scrap-material level. Recycling at the higher level of components avoids resource consumption for possibly unnecessary reprocessing of material while preserving the value-added nature of components. Remanufacturing also postpones the eventual degradation of the raw material through contamination and molecular breakdown, which is frequently characteristic of scrap-material recycling. In addition, remanufacture can divert parts made from unrecyclable materials from landfill. The production-batch nature of the remanufacturing process enables it to salvage functionally failed but repairable products that are discarded due to high labour costs associated with individual repair.

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1.3 Design to facilitate remanufacture

While product design that facilitates any of the steps involved in remanufacture, namely disassembly, sorting, cleaning, refurbishment, reassembly and testing, will facilitate remanufacture, the essential goal in remanufacture is part reuse. If a part cannot be reused as is or after refurbishment, the ease of disassembly, cleaning or reassembly will not matter.

Examples of part refurbishment include application of mechanical force to reverse plastic deformation such as warps and creases, closing and filling cracks through mechanical pressure or welding, and rebuilding worn surfaces using metal spraying and welding. These refurbishment processes can be labour and equipment intensive. Also, refurbishment processes that further consume a part, such as reboring a worn cylinder to fit an oversized piston, can be performed only a limited number of times. The reliability of a reworked part may also be compromised.