Proceedings of DETC'02
ASME 2002 Design Engineering Technical Conferences and Computers and Information in Engineering Conference
Montreal, Canada, September 29-October 2, 2002

DETC2002/DFM-34177

BIOMIMETIC CONCEPT GENERATION APPLIED TO DESIGN FOR REMANUFACTURE

E. Hacco, L.H. Shu*
Life-Cycle Design Laboratory
Dept. of Mechanical & Industrial Engineering
University of Toronto
5 King's College Road, Toronto, Ontario, Canada M5S 3G8

*Contact author: T: 416 946 3028, F: 416 978 7753, E: shu@mie.utoronto.ca

ABSTRACT

This paper applies a biomimetic design method to generate concepts for design that facilitates remanufacture. Biomimetic design fully or partially imitates or evokes some biological phenomenon. A method for identifying and using biological analogies for engineering problems was introduced in an earlier paper. This initial method was tested on an example in design for remanufacture. Here, the method is further developed and used to find more biomimetic solutions for the same problem in design for remanufacture. While the example problem is in remanufacture, the method can be used to develop biomimetic concepts for engineering design in general.

The paper first summarizes previous efforts in developing and testing the biomimetic concept generation technique. Next described are the differences in the method that are used for this paper, including the increased importance of strategies to help identify promising analogies. Results of applying the modified method to design for remanufacture are documented.

Keywords: biomimicry, analogy, function, remanufacture

NOMENCLATURE

Biomimetic design: Design that, fully or partially, imitates or evokes some biological phenomenon.

Biological phenomenon: Any natural phenomenon pertaining to the biological sciences including all levels of biological organization shown in Table 1.

INTRODUCTION

The context for biomimetic design includes the use of analogies, as well as related and unrelated stimuli in concept generation. Analogies range from those available in a related product or application, to abstract phenomena whose relation to the problem is not immediately obvious. The use of unrelated stimuli includes relating the problem at hand to a random subject, with the goal of generating novel solutions during this process. Biological analogies lie somewhere between related and unrelated stimuli. The analogies are sought based on functional similarities, and are thus related, but analogies found at different levels of the biological organization shown in Table 1 may be quite abstract, the use of which may encourage different perspectives on the problem.

Biological phenomena hold a vast amount of ideas that could be useful to engineers during design concept generation. Advantages of biological systems are discussed by Paturi (1976), Galbraith *et al*. (1989), Benyus (1997), Affholter and Arnold (1999), and David (1999). While many cases of biomimicry exist, several started with an interesting biological phenomenon that was developed into a useful concept. Therefore, little insight is offered on how to find appropriate biological analogies given an engineering problem as the starting point. Several other instances of biomimicry copy fairly obvious examples, e.g., a fish for underwater robotic movement or a bat or bird for a flapping wing ornithopter. It is likely that the ability to locate biological analogies beyond the obvious would help generate novel engineering concepts. We believe that a systematic search for analogies at multiple levels of biological organization shown in Table 1, i.e., from the molecular to the ecological level, would encourage different perspectives on problems and thus lead to novel solutions.

An earlier paper (Vakili and Shu, 2001) introduced a biomimetic concept generation method to address the above shortcomings of existing biomimicry. The preliminary method was tested on a problem in design for remanufacture.

In this paper, we further develop the method and apply it to the same problem in design for remanufacture so that the results can be compared with those obtained previously.

The main components of the paper include:

1. Summary of our previous efforts towards generalizing biomimetic concept generation.
2. Description of our subsequent progress, resulting benefits and additional challenges.
3. Documentation of applying the developed method to the continued example in design for remanufacture.