Proceedings of IDETC/CIE 2006
ASME 2006 International Design Engineering Technical Conferences &
Computers and Information in Engineering Conference
September 10-13, 2006, Philadelphia, Pennsylvania, USA

DETC2006-99398

CASE STUDY IN BIOMIMETIC DESIGN: HANDLING AND ASSEMBLY OF MICROPARTS

L.H. Shu
Dept. of Mechanical & Industrial Engineering
University of Toronto

H.N. Hansen
Dept. of Manufacturing Eng. & Management
Technical University of Denmark

A. Gegeckaite
Dept. of Manufacturing Engineering & Management
Technical Univ. of Denmark

J. Moon
Dept. of Mechanical & Industrial Engineering
University of Toronto

C. Chan
Dept. of Mechanical & Industrial Engineering
University of Toronto

ABSTRACT

This paper describes the application of the biomimetic design process to the development of automated gripping devices for microparts.

Handling and assembly of micromechanical parts is complicated by size effects that occur when part dimensions are scaled down. A common complication involves sticking between the gripping device and the micropart, which hinders the automation of picking and releasing operations. This paper presents the identification and use of biological analogies to solve the problem of sticking during microassembly. Selected release techniques based on DNA transcription and the abscission process in plants inspired concepts of new automated handling devices for microobjects.

The design, development and testing of a gripping device, based on biological principles, for the automated handling and assembly of a microscrew is presented.

1 INTRODUCTION

This paper describes the application of the biomimetic design process to the development of automated gripping devices for microparts. Biomimetic design involves the identification and use of biological analogies to solve problems in engineering. First, a summary of related and previous work on biomimetic design will be provided. Next, difficulties which arise in the handling of parts at the micro level that do not arise at the macro level, will be described. A search for biological analogies that may be used to solve these difficulties resulted in several relevant biological phenomena, two of which will be summarized here. The strategies from these phenomena will be highlighted, and the physical implementation and experimental validation of one strategy will conclude this paper.

2 RELATED AND PAST WORK

Biomimetic design uses biological phenomena as analogies to help solve engineering problems. One well-known example of biomimetic design is the development of Velcro after observing that cockleburs attach to clothing and fur. First presented in this section will be related work in analogical reasoning and design by analogy. Next described is how biomimetic design fits into the technique of synectics and how TRIZ is relevant to biomimetic design. Finally, past work in biomimetic design is summarized.

2.1 Analogical Reasoning

Analogical reasoning involves the transfer of information from a source to a target domain. Within-domain analogies are used between the same or at least conceptually close, source and target domains, e.g., from one type of electromechanical product to another. Between-domain analogies are used between different source and target domains, e.g., from biological phenomena to electro-mechanical products.

Benami and Jin (2002) developed a Cognitive Model of Creative Conceptual Design that captures the relationship between the properties that stimulate cognitive processes and the design operations that facilitate cognitive processes. One conclusion of the study was that ambiguous entities stimulated more ideas than non-ambiguous entities, which tend to be fixating. Also noted is that analogies from conceptually different domains result in more creative, original ideas.