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Fabrication Methods of Compliant Mechanisms

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Abstract

This paper will present specific procedures and processing methods of compliant mechanisms. Will mention a few unconventional and conventional processing methods for compliant mechanisms. Also, will present, detailed, three obtaining methods of these mechanisms, authors participating at production process, such as: milling method, 3D printing method and shaped by moulding method. These methods will demonstrate experimentally some effective ways of achieving the compliant mechanisms each with their advantages and disadvantages, presented in paper. At the end of this paper will present the results and the conclusions of the three studied methods.

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Keywords: compliant mechanism; unconventional and conventional processing methods; milling method; 3D printing method and shaped by moulding method.

1. Introduction

Compliant mechanisms have an increasing importance in industrial field, replacing a big part of the traditional mechanical mechanisms, which offers the opportunity to study them. This is a new type of mechanism which uses the elastic deformation on the material to transmit motion or convert movement, force or energy [1]. Compared with conventional rigid mechanism, the compliant one has no or reduces largely the backlash, friction and abrasion in mechanism [2]. Also reduced noise, maintenance is easier and has a better accuracy [3]. At present, compliant mechanisms become the focus of mechanisms research and they have been developed rapidly in recent years due to

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their advantages as required in modern machinery [4]. Therefore, the applications of compliant mechanisms has become increasingly prevalent in medical instruments and mechanical devices [5].

To realize a compliant mechanism, in their design must take into account the material, mechanism topology and realizations methods of these [6], [7].

Specific procedures and processing methods of compliant mechanism are selected so as to be fully compliant, to be in one piece and do not suppose assembly operations. Unconventional and conventional processing methods proved to be effective and suitable for achieving compliant mechanism in monolithic structure [8].

2. Production methods of compliant mechanisms

Unconventional processing methods which are effective when we talk about compliant mechanisms are: electro erosion machining, chemical and electrochemical machining by erosion, laser beam processing, electron beam, with plasma or waterjet.

For specific dimensions, mini and micro mechanisms, successfully apply the so-called micro-technologies. These micro-technologies involve processing operations of the substrates, for the preparation of thin films, for configuration of thin films and realization of micro-structures. The most commonly used materials from which are executes the elements of a compliant micro-mechanisms are: mono and polycrystalline silicon, silicon nitride, nickel, copper, gold, epoxy resins, silicone and acrylic, polymethylmethacrylate, etc. Thin films are realized by chemical vapor deposition, thermal oxidation, spraying, ion implantation, thermal evaporation in vacuum, autocatalytic deposition and plasma polymerization. Technological procedures to configure thin films are: wet chemical erosion, dry etching and lithography, in its different variants (photolithography, electronic lithography, nanolithography) or Roentgen lithography. The micro mechanisms can actually be achieved by sacrificial layers technique, by micro processing based on anisotropy and selectivity or LIGA process. Compliant mechanism is appropriate when very fine motion is required such as micro actuators and good for MEMS process since it does not required any assembly process [9].

The processes studied in this paper to realize compliant mechanisms are: the milling method, 3D printing method and shaped by moulding method. These three methods have been used as realization methods because good results can be obtained with accuracy and desired values in an optimal timeframe [8]. Movement accuracy depend of the elastic coupling geometry and also by midpoint stiffness, which result from designing step [10].

3. Research methodology and results

In continuation of this paper it will present compliant mechanisms, the authors participated to their realization for this study, by three methods presented above.

First study is the achievement of a compliant mechanism by milling method.

The material used was plexiglass. We determined the material properties using the INSTRON machinery, an extensometer for measuring deformation of parts under tension, and three identical specimens of polycarbonate. The graph of part deformation during testing, the stretch resistance up to the maximum tensile load, can be seen in Figure 1 (the values of the Poisson's ratio, 0.39, and the Young's modulus, 1.92 GPa) [11].

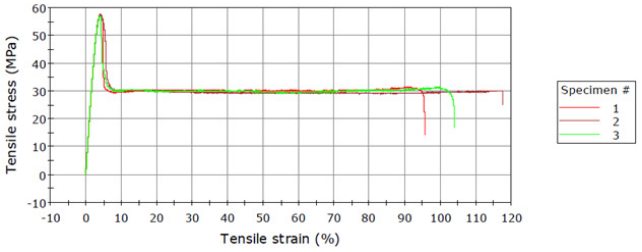

Fig. 1. The graph of specimens deformations.