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APPLICATIONS OF COMPOSITE MATERIALS IN THE CONSTRUCTION OF A ROBOT ARM

BY

GEORGETA CIOBĂNAŞU* and CĂTĂLIN GABRIEL DUMITRAŞ*

“Gheorghe Asachi” Technical University of Iaşi,
Faculty of Civil Engineering and Building Services and
Faculty of Machine Manufacturing and Industrial Management

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Abstract. The performance of a robot is highly dependand on the its weight, since big inertia translates into a decrease of the robot's positional precision and in an increase of the vibration level, aspects which play an important role in most application fields of robotics. As a response to this problem, we consider the construction of a robot arm using composite materials. Composite materials represent an ensemble of chemically distinct materials which displays superior qualities in comparison to each constitutive material considered separately. The benefits of these materials, like resistance to high temperatures, mechanical stress, chemical agents, corrosion, dimensional stability mirror into the advantages of robots using composites in their structure, yeilding more performant elements.

Key words: composite materials, robot arm

*Corresponding author; *e-mail:* ciobanasu2004@yahoo.com, dumitrascata@yahoo.com

1. Introduction

The current trend in robotics is the increase of robot complexity in order to simplify their utilization. The architecture of the robot can be split in two parts: the mechanical structure and the electronic structure. While the mechanical structure determines the performance and the costs of the first generation robots, the electronic structure conditions the quality of the second generation robots.

Regardless of the robot's generation the most complex aspects to be taking into consideration at realization stage are: the mechanical volume structure, robot's weight, cost reduction, the adaptation to the mechanical structure of the electric, hydraulic and pneumatic motors and the design of mechanical arms that can grab objects of diverse forms.

The greatest benefit of the modern composite materials is the fact that they are at the same time light and resilient. By selecting a suitable combination of matrix and reinforcement, a new material can be created in order to fulfill the requirements of a specific application. In addition, composites offer design flexibility since most of them can be modeled in complex shapes. The downside is in the majority of cases the cost. Even though the resulting product is more efficient, the raw materials are usually expensive.

We propose the realization of a robot arm, starting from a Fanuc m-410 robot, by selecting from the light technical materials category several composite materials to construct it from. The long term purpose is conducting a future work consisting of a comparison study of the technical performance and of the mechanical characteristics of a classic robot and of the same robot equipped with composite materials components.

2. Intelligent Materials

The so-called "smart" materials represent a complex concept based on contemporary materials as well as informatics. These materials are artificially created and possess several functions, like sensor, processor, actuator and feedback. The purpose of this research field is to obtain intelligent structures with superior performance, which manifest recognition, reaction and adaption potential.

Intelligent materials are used in fields like: medicine, polymers, metals, semi-conductors, ceramics, mechanical engineering, electronics, and many other.

2.1. Characteristics of Intelligent Materials

These materials can be organic, inorganic and composite and they present the following characteristics: properties, structural composition, functions requested by the environment or by the working conditions. The current stage of technology permits the study of materials on the atomic and molecular scale. Thus there exist possibilities of creation of new materials through the use of software programs. Fig. 1 depicts the connection between structural, functional and smart materials (Poteraşu, 2000).

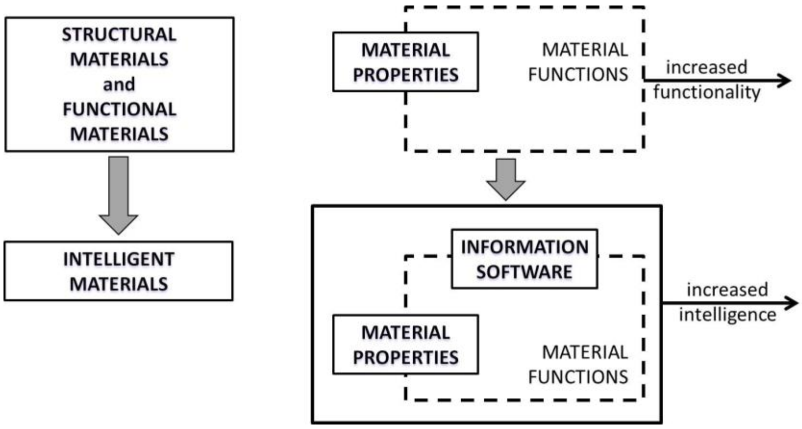

Fig. 1 – Intelligent materials

Materials in general can be classified in three major groups:

- Alive – which dissipate energy continuously and need a corresponding energy source
- Instinctive or reactive – react to diverse stimuli by modifying their physical, chemical and electromagnetic properties
- Inert – structural or decorative materials which are designed to exhibit a minimal reaction to the external stimuli.

Composite materials are part of the latter group and they are detailed in the following subchapter.

2.1. Composite Materials

Composite materials represent an ensemble of chemically distinct materials which displays superior qualities in comparison to each constitutive material considered separately. Even though the constituent materials maintain their individual identity on a macroscopic level in the composite, their association generates different characteristics for the blend as a whole (Cerbu, 2006).

The structure of the composite materials is composed of two elements: the matrix, as the continuous phase and the reinforcement, known as the discontinuous phase, distributed evenly on the entire volume of the matrix. Fig. 2

shows the structure of composite materials, highlighting the different types of matrices and reinforcements (Ciobanu, 2011, Mallick, 1997).

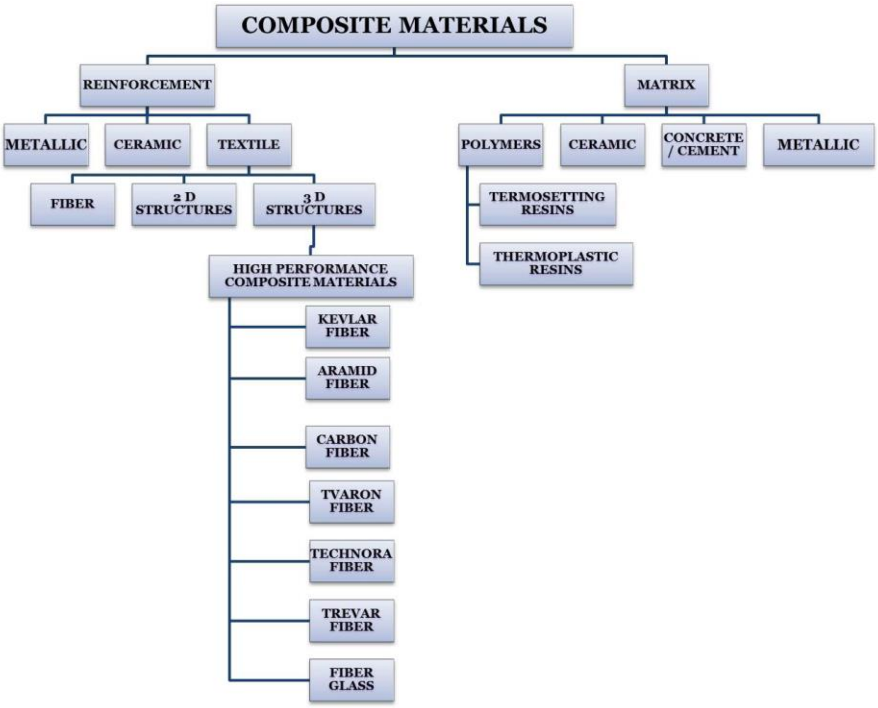

Fig. 2 – Classification of composite materials

The main advantages of composites are (Roylance, 2000):

- high mechanical resilience
- low density (small weight)
- high resilience to chemical agents influence
- corrosion resistance
- high temperature resistance
- wear resistance
- tensile strength
- dimensional stability

The advantages of composite materials translate into the advantages of the industrial robots equipped with such materials. Thus these robots demonstrate a higher positional precision, a higher resilience to stress, smaller energy consumption and so on (Maurer *et al.*, 2012, Wood, 2003).

3. Application: Composite Materials in Robot Arm

We consider an element from the structure of a Fanuc m-410 robot. For the realization of the 3D model of the robot's arm the sketch showed in Fig.3 is used.

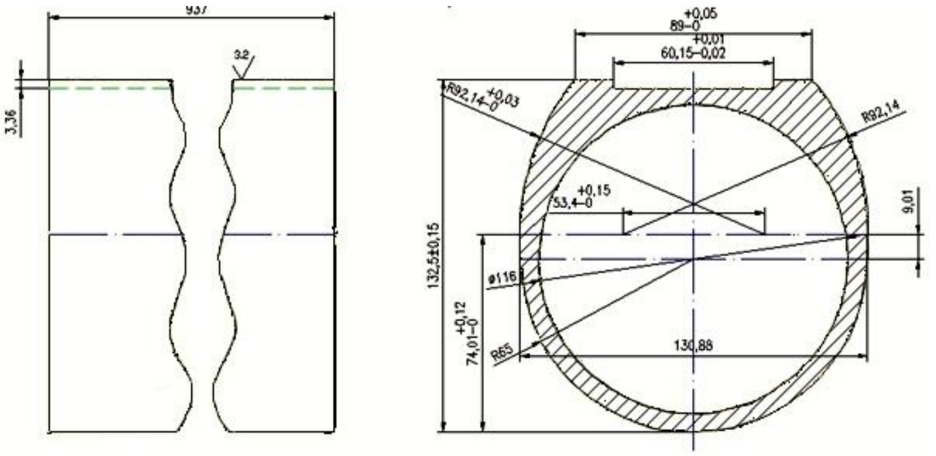

Fig. 3 – 2D model of the robot's arm

Based on the 2D model the robot's arm is built, see Fig. 4.

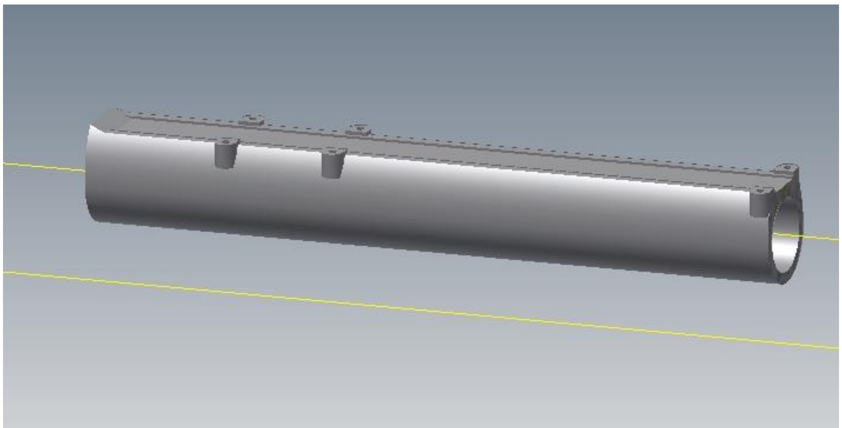

Fig. 4 – 3D model of the robot's arm

Using the 3D model, a profile of expanded polystyrene is constructed, on a scale of 1:2, as it can be seen in Fig.5.

Fig. 5 – Constructed profile based on 3D model

These 3D templates shall be utilized for creating the robot's arm using composite materials. The following steps are applied:

- the template is placed on a lathe; the lathe allows the rotation of the template at a small speed
- the fiber of composite material is wrapped around the template, as shown in Fig.6; in order to achieve this a device that maintains constant the thread tension; the fiber is laid on the template in two layers, thus the matrix is completed, a thermoplastic resins polymer; the reinforcement is of type textile, fiber glass

Fig. 6 – Composite material wrapped around the template

Thus we obtain a final structure which is embedded in the initial OLC 45 robot's arm, used for future experiments, Fig.7.

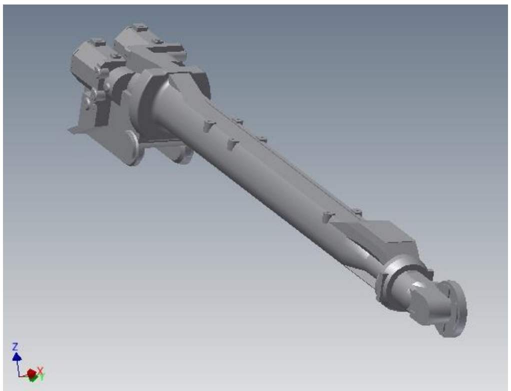

Fig. 7 – Robot arm

4. Conclusions and Future Work

Studies have shown that the high weight of robots represents the main mechanical characteristic that influences their performance, since large mass leads to big inertia, which in result contributes to the decrease of robot's positional precision, e.g. stopping at a fixed point and to the increase of vibration level, all of which constitute important aspects in many application fields like surgery robotics, manipulation of micro-components and others.

Taking into consideration the many benefits of the composite materials, like resilience to high temperatures, mechanical stress, chemical agents, corrosion, dimensional stability, we constructed a robot's arm using these intelligent materials.

As future work, we propose the realization of a comparison study of the technical performance and of the mechanical characteristics of a robot, first by selecting from the light technical materials category several composite materials to construct the robot's components from and then by considering the same robot equipped with classic common materials.

REFERENCES

Cerbu C., *Materialele compozite și mediul agresiv*. Editura Universităţii Transilvania Brașov, 2006, ISBN (10) 973-635-861-5;ISBN (13) 978-973-635-861-6 .

Ciobanu L., *Development of 3D Knitted Fabrics for Advanced Composite Materials*, Advances in Composite Materials - Ecodesign and Analysis, ISBN 978-953-307-150-3, 2011.

Mallick, P. *Composites Engineering Handbook*, Marcel Dekker, USA, 1997.

Maurer A., Deodorico W., Huber R., Laffont T., *Aerospace Composite Testing Solutions using Industrial Robots*, 18th World Conference on Nondestructive Testing, 16-20 April 2012, Durban, South Africa

Poterașu V.F., *Structuri și materiale inteligente adaptative vol.I Materiale, dinamică, control.* Editura CERMI Iași 2000, ISBN: 973-8000-49-1.

Roylance D., *INTRODUCTION TO COMPOSITE MATERIALS*, Cambridge, MA 02139, 2000.

Wood R. J., *Microrobotics Using Composite Materials: The Micromechanical Flying Insect Thorax*, Robotics and Automation, Proceedings. ICRA '03. IEEE International Conference on Volume 2, 2003, p. 1842 – 1849

APLICAŢII ALE MATERIALELOR COMPOZITE ÎN CONSTRUCŢIA UNUI BRAŢ DE ROBOT

(Rezumat)

Este cunoscut faptul că greutatea mare a roboților reprezintă principala caracteristică mecanică ce influențează performanțele robotului, deoarece aceasta implică mase mari, respectiv inerție mare, ceea ce determină scăderea preciziei poziționale a robotului, de exemplu oprirea la punct fix, creșterea nivelului de vibrații, constituind aspecte importante în unele domenii de aplicație, cum ar fi roboții chirurgicali, roboții ce manipulează micro-componente, etc..

Ne-am propus alegerea din categoria materialelor tehnice ușoare, a unui material compozit ca material de execuție a unui element din structura unui robot Fanuc m-410, realizat la scara 1:2.

Cel mai mare avantaj al materialelor compozite moderne aste faptul că sunt ușoare și în același timp rezistente. Prin alegerea unei combinaţii adecvate de matrice şi armătură, un nou material poate fi realizat astfel încât să indeplinească cerinţele specifice unei aplicaţii.

Pe un șablon de polistiren expandat se înfășoară fibra de material compozit de tip textil (fibră de sticlă), în 2 straturi după care se definitivează matricea, care este un polimer thermoplastic (rășină). Soluţia constructivă propusă şi implicit realizarea fizică a elementului de robot considerat a necesitat crearea unui dispozitiv care menţine constantă tensiunea în fir. S-a pregătit astfel o structură care a fost înglobată într-un braţ de robot.

Se conturează direcţii de cercetare viitoare prin realizarea unor studii comparative al performanţelor tehnice şi al caracteristicilor mecanice ale acestui robot față de același robot construit cu materiale clasice pentru a evidenţia faptul că avantajele materialelor compozite se oglindesc și în avantajele roboților industriali ce le conțin, în ceea ce privește o mai bună precizie pozițională, o rezistență mai mare la solicitări, consum mic de energie, ș.a.