STUDENTS' ANNUAL ACTIVITY REPORT
CYCLE 34 YEAR 2020

- Name and Surname **Mahmoud ASKARI**
- Dottorato in **INGEGNERIA MECCANICA**
- Department **Mechanical and Aerospace Engineering**
- Coordinator **Prof. Luca GOGLIO**
- Tutor **Prof. Cristiana DELPRETE, Prof. Eugenio BRUSA**
- Macroarea

  Application of smart structures in vibration control and energy harvesting technology
- Short description of research activity

Recently, an increasing attention has been paid on piezoelectric energy harvesting technology for the development of autonomous sensors and low-power electronics, as they are currently used in a wide range of industrial applications. Designing autonomous sensor nodes for condition monitoring of industrial systems, such as rotors, rolling mills and other is a significant issue of the current research activity in this field. According to the Industry 4.0 strategy, a key feature consists in remotely connecting operators to working machinery, for a suitable action of monitoring, diagnosis and prognosis. This project is focused on the design of autonomous sensor node that could be easily applied to a working machinery, to retrieve information for data mining, and thus to predict residual life and plan the maintenance activity in service. The physical node will contain a three-axes accelerometer for vibration monitoring, a small communication device for transferring data, a vibration energy harvester for power feeding the device, and in some cases even a temperature sensor.

As a primary step, a set of disc-like configurations composed of smart piezoelectric cantilevers are proposed to be used as the vibration energy harvesting system (VEHS) to be applied to the above-mentioned autonomous sensor node. Current sensor nodes available on market use batteries as their power source, thus having limited lifetime. In some cases, battery-powered sensors cannot even be applied to the machine, due to their harsh working conditions. Thus, the use of energy scavengers could be a promising solution to overcome the issues just mentioned. However, for the development of this project, the finite element method can be exploited to perform a set of analyses, including modal, electric charge, stress and strain analyses to predict the performance of the system of interest (SOI). A suitable validation of numerical models is foreseen.

Moreover, the literature demonstrates that most of the available research works in this field are based on some numerical methods, while analytical solutions have been often limited to relatively simple cases. However, the analytical modelling of smart piezoelectric structures is significant to investigate the nature and the features of the electromechanical coupling. Therefore, in this project, a set of analytical models have been also developed, to examine the electromechanical behaviour of smart structures made of piezoelectric and graded materials containing porosity. In this sense, several problems, including energy harvesting, free vibration, wave propagation, buckling and dynamic analyses of coupled piezoelectric plate structures, with different mechanical and electrical boundary conditions, have been investigated. The state space approach, the Navier's method and some other efficient techniques have been employed to solve the governing equations associated with the systems of interest.

- Training activities carried out during the year (courses, seminars, etc.); for each activity specify the nature, duration, and location

  The courses that I passed during second year are as follows:

Course	Skill type	Duration (hrs)	Location
Time management	Soft Skill	2	PoliTo
Entrepreneurial Finance	Soft Skill	5	PoliTo
Tutorial course on TEX/LATEX	Soft Skill	4	PoliTo
Modelli Shell 3D per strutture in composito	Hard Skill	15	PoliTo
Aspetti avanzati del metodo degli elementi finiti	Hard Skill	20	PoliTo
Total (within year 1 & 2)	Hard Skill	105	
Total (within year 1 & 2)	Soft Skill	47	

- Possible participation in further research activities during the year (research projects and agreements)

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- Possible participation in internal activities to support teaching during the year (specify on which courses, named as "subject expert")

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- Stays at other research institutions during the year

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- Collaborations with companies during the year

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- List of accepted papers

1. Askari, M., Brusa, E., & Delprete, C. (**2020**). On the vibration analysis of coupled transverse and shear piezoelectric functionally graded porous beams with higher-order theories. In: *The Journal of Strain Analysis for Engineering Design*, 0309324720922085. Click Here.
2. Askari, M., Brusa, E., & Delprete, C. (**2020**). Electromechanical vibration characteristics of porous bimorph and unimorph doubly curved panels. In: *Actuators* (Vol. 9, No. 1, p. 7). Multidisciplinary Digital Publishing Institute. Click Here.
3. Askari, M., Brusa, E., & Delprete, C. (4-6 September **2019**). Vibration analysis of porous bimorph doubly curved shells for energy harvesting applications. In: *8th International Conference on Mechanics and Materials in Design (M2D2019)*, Bologna, Italy. Click Here.

Date, September 18th 2020.

Cristiana Delprete   Eugenio Brusa

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Signature of Tutors

Askari

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Signature of the Phd student

The Coordinator

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