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NUMERICAL MODELS FOR THE DESIGN OF VARIABLE ANGLE TOW PIEZO-COMPOSITE STRUCTURES

Enrico Zappino*, Erasmo Carrera*, Andrea Viglietti*, Matteo Filippi*

*Mul^2 Team, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy
enrico.zappino@polito.it, erasmo.carrera@polito.it, andrea.viglietti@polito.it, matteo.filippi@polito.it

Summary: The use of active materials, such as piezo-electric material, makes it possible to develop smart structures that can find application in different fields such as structural morphing, MEMS, sensor/actuator or energy harvesting. The performances of these devices are strictly related to the dynamic response of the structure, that is, advanced materials can be used to increase the harvesting capability of the device. The present work explores the possibility to use variable angle tow composite, VAT, materials for the design of efficient active structures. Refined computational models have been considered to include the electro-mechanical coupling as well as the variable angle tow lay-up. The models have been assessed and the VAT materials have been used to improve the the performances of the devices considered.

ABSTRACT

In the recent years the development of advanced materials, such as the piezo-electric material, has lead to the design of small devices able to exploit the electro-mechanical coupling to actuate, monitoring, extract energy or control structures of different nature. These devices can be used to produce small quantities of energy but large enough to supply wireless sensors, monitoring systems etc [1]. The design of such structures requires to predict complex phenomena such as: electro-mechanical coupling, stress concentrations at the interface between the active material and the substrate layers, complex boundary conditions, etc. A large number of advanced models, able to deal with such complex problems, have been proposed over the last decades [2]. The performances of the smart structures may be enhanced by an accurate design of the dynamic response of the structure, for this reason, variable angle tow, VAT, composite materials appears to be promising for this application. VAT materials consider a continuous variation of the lamination angle along one or more directions of a structure. This approach can produce unconventional mechanical couplings and increase the number of the parameters that can be changed in the design of the structure, leading to optimized solutions. The present paper proposes to use refine numerical models [3] to exploit the capabilities of the variable angle tow to enhance the performances of smart devices such as piezo-actuators or energy harvester.

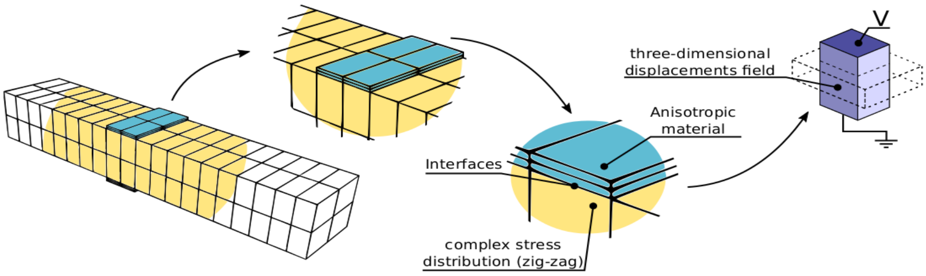

Figure 1: Example of a piezo-layered structure.

The numerical models used in the present work is derived in the frameworks of the Carrera Unified Formulation, CUF. This approach has been widely used in the analysis of smart structures [3] and here is extended to the analysis of energy harvester including VAT materials. The use of three-dimensional displacement fields and of the node-dependent kinematic formulation [4] makes these models able to deal with complex phenomena, such as those shown in Fig. 1, with a reasonable computational cost.

The results show that the present approach can provide accurate results in the analysis of piezo-composite devices including VAT lamination. The introduction of VAT materials has allowed different tailoring solutions to be considered and compared. In conclusion has been demonstrated the reliability of the present models also in the energy harvester design. The accuracy and computational efficiency of CUF based models make them suitable for further application in this field such as non-linear analysis or the optimization.

References

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