



PhD in INGEGNERIA DEI MATERIALI / MATERIALS ENGINEERING - 39th cycle

**PNRR 117 Research Field: ADVANCED CHARACTERIZATION OF CRITICAL POLYMERIC
COMPONENTS USED IN FOOD PACKAGING EQUIPMENT**

Monthly net income of PhDscholarship (max 36 months)

€ 1400.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

**Motivation and objectives of the research
in this field**

The packaging industry is currently facing many challenges: the continuous research of an optimal balance between quality and performance on one side, and productivity and cost-efficiency on the other, has recently been increasingly affected by a greater awareness about safety, environmental and sustainability issues. Within this context, the engineering of polymeric components in packaging systems or in their production equipment suffers from a lack of well-established, scientifically sound and easy to implement design tools able to rapidly adapt existing and new solution to a continuously changing database of available materials. The goal of this research project is to acquire a deeper fundamental understanding of several physical phenomena which eventually determine the degree of success of these polymeric components, such as deformation, yield, fracture, friction, adhesion, wear and possibly more. The identification of the key aspects which influence the component performance will allow the development of robust testing methods (to obtain relevant material properties) and reliable models (analytical and/or numerical) to support the design and improvement of new and existing solutions. To delimit a research area for which successful results can be obtained in the timeframe of a PhD project, specific components will be selected to develop what will become a general methodology. These will be polymeric components used within packaging equipment, essential for the success of filling and sealing operations. During



	<p>their use they come in contact with packaging materials under a set of challenging conditions which may include high contact pressures, sliding speeds, temperature as well as aggressive chemical environment. The selection of the best material for a given application cannot be made on the basis of the technical datasheet provided by the supplier: standard properties may not adequately describe the actual performance of the final product. Moreover, variability originating from the production process needs to be carefully addressed by specifying the acceptable range of key functional properties.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The research will be focused on three main areas:</p> <ol style="list-style-type: none"> 1. Mechanical and thermal testing to obtain reliable data of elastomeric compounds properties, to be used for virtual simulations of related components. Specific tests will be carried out to measure the main material properties needed for the definition of the virtual material model, considering the characteristics of actual components. These tests will include both standard and non-standard methods, which will consist of ad-hoc defined testing protocols. This approach requires a validation step which can be carried out by performing measurements on the final components. The experimental activity will contribute to enlarge the available material property database which has been until continuous development during the past years. 2. Fracture behaviour of Thermoplastic and Thermoset elastomers Tests to evaluate the fracture properties of the materials will be carried out, using approaches which enable to predict the actual components response, considering their real geometry and stress state. The effect of strain rate on the measured properties needs to be carefully considered in view of the high-speed loading of the application in the filling machine; this objective can be achieved by performing the tests at the relevant speed, if feasible, or by correctly modelling the strain-rate dependence and



	<p>extrapolating (after a suitable validation) the experimental data to the correct range. Based on results obtained, the fracture behaviour characterization may be extended to include fatigue resistance of said material/components. The opportunity of addressing this issue will be evaluated following the analysis of the quasi-static fracture characterization.</p> <p>3. Study on correlation between polymer mechanical properties and surface wear against packaging material. The development of ad-hoc testing rigs can be instrumental in bridging the gap between the mechanical and long-term tribological performance: a dedicated test platform allows better control of key parameters including contact pressure, sliding speed, temperature, environment, counterpart characteristics. Additionally, surface treatments and functionalization will be considered to further enhance the performance of the components in the industrial application.</p>
Educational objectives	<p>The PhD candidate will become familiar with state-of-the-art mechanical testing protocols and analysis, using existing models and developing new ones to correlate the fracture resistance of rubbers with their tribological properties.</p>
Job opportunities	<p>The PhD candidate will develop an in-depth knowledge of mechanical testing methods, together with a variety of advanced analysis techniques used in the polymer field. This will make her/him a valuable asset to any company working with polymers, not limited to the packaging sector.</p>
Composition of the research group	<p>1 Full Professors 3 Associated Professors 3 Assistant Professors 7 PhD Students</p>
Name of the research directors	<p>Prof. L. Andena, Prof.ssa C. Marano</p>



Contacts

Prof. Luca Andena

Prof.ssa Claudia Marano

<https://www.cmic.polimi.it/ricerca/elenco-gruppi-di-ricerca/polyenglab/>

Additional support - Financial aid per PhD student per year (gross amount)

Housing - Foreign Students

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Housing - Out-of-town residents
(more than 80Km out of Milano)

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Scholarship Increase for a period abroad

Amount monthly

700.0 €

By number of months

6

National Operational Program for Research and Innovation

Company where the candidate will attend
the stage (name and brief description)

Tetra Pak Packaging Solutions S.p.A. Via Antonio Delfini no. 1,
Modena <https://www.tetrapak.com/>

By number of months at the company

6

Institution or company where the
candidate will spend the period abroad
(name and brief description)

to be defined

By number of months abroad

6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Confidentiality (Agreement with company): since this is a thematic scholarship, the management of Confidential Information, Results and their publication is subordinate to the restrictions agreed upon with the funding company. Upon acceptance of the scholarship, the beneficiary must sign a specific commitment.

Individual budget for research (5.700 euro): 1st year: 1.900 euro; 2nd year: 1.900 euro; 3rd year: 1.900 euro

Teaching assistantship (availability of funding in recognition of supporting teaching activities by the PhD student): there are various forms of financial for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities within the limits allowed by the regulation.