

DA CONSEGNARE AL COORDINATORE DEL CORSO PER LA PRESENTAZIONE DEL DOTTORANDO AL GIUDIZIO DEL COLLEGIO DEI DOCENTI IN VISTA DELL'ESAME FINALE

SCHEMA INFORMATIVA SULLE ATTIVITA' DEL TRIENNIO

- Cognome e Nome: **Nithin Amirth Jayasree**
- Titolo di studio posseduto:
Masters in Manufacturing and Management conseguito in data **16/12/2011** from the **l'Università di Nottingham**
- Dottorato di Ricerca in: **Mechanical Engineering**
- Ciclo: **XXX** Anni accademici di riferimento: **2014 - 2017**
- Dipartimento: **DIMEAS Department of Mechanical and Aerospace Engineering**
- Coordinatore: **Prof. Luigi Garibaldi**
- Tutore: **Prof. Massimiliana Carello**
- Titolo della Tesi di Ricerca (in Italiano e/o in Inglese): **Modelling and testing of thermoplastic composite parts integrating process simulation**

A. DESCRIZIONE DELL'ARGOMENTO DELLA TESI (massimo 20 righe)

Traditionally, product design involves a detailed conceptual and embodiment design followed by detailed prototype manufacture and testing. This trial and procedure gives an acceptable product but is repetitive, expensive and time consuming with additional labour costs, machine time and also material scraps. To minimise these product development costs and to save time exponentially a robust modelling protocol with a dependable FEA tool needs to be employed at its early design phase.

These predictive capabilities for thermoplastic composite industry is examined in this thesis.

This thesis aims to establish an accurate predictive model on a rational basis and an innovative methodology for the structural analysis of thermoplastic composite components for general lightweight automotive components. This is done by the Finite Element Analysis (FEA) and then by the process simulations, considering the composite material as an elastic anisotropic woven fabric to study the deformations undergone during the manufacturing process. The proposed methodology for creating the predictive model is fairly accurate, and it is a novel method which can be easily integrated and adapted into a components initial design phase. This optimisation technique can replace the expensive and traditional trial and error procedures during the design and prototyping phase, and it significantly decreases the time to build the final component.

B. ATTIVITA' DI RICERCA SVOLTA NEL TRIENNIO

B.1 descrizione complessiva e sintetica dell'attività di ricerca

During the research period, I have successfully completed a range of task directly related to my PhD thesis, which are:

- Characterised continuous fibre and short fibre composite material for creating material cards for FEA analysis.
- Detailed study on different composite failure criterion.
- Structural FEA analysis and comparison with experimental results on a continuous fibre laminate part and an over-molded composite part.
- Study and simulation of deformation behaviour of reinforced thermoplastic composite during its forming process.
- Characterised and simulated the composite material for process simulation focussing on tensile, intra ply shear, tool-ply friction, ply-ply friction and bending mechanisms for creating FE material card.
- The results from the process simulation was successfully mapped on the FEA model to create an all-inclusive model delivering accurate results.

B.2 argomenti di ricerca specifici affrontati

The specific research topics that I addressed during my PhD thesis are:

- Characterisation of thermoplastic materials and creation of FE material cards.
- Thermoplastic composite parts design, modelling and structural analysis
- FE Process Simulation of thermoplastic components.
- Characterisation of composite fabric and composite laminate at forming temperature.
- Mapping process simulation data to a crash model.

B.3 risultati più rilevanti ottenuti nel triennio

During the three years of PhD I found several results that is new and relevant in the field of composite materials modelling and FE analysis. I was able to focus my research on innovative methodologies that is relevant to the lightweight automotive industry investing on thermoplastic composite materials for creating various lightweight automotive components. Specifically, I have devoted myself for the creation of methodology valid for creation and development of modelling strategies for thermoplastic components.

I validated the results of the FEM virtual model simulations thank to experimental results Further, I was able to understand the reasons for the possible variation in the results between FE and experiment; and explored process simulation FE to accurately model the deformations that may occur during the forming of thermoplastic components. A methodology for integrating the process simulation results on to the crash model was researched on, called mapping. At the end of my research, a good confidence for creating an FE model integrating process simulation for structural simulation was achieved and the methodology was validated using a different and more complex component.

B.4 collaborazioni di ricerca avute con Università, Centri di ricerca ed Industrie nazionali ed internazionali (specificare il quadro entro cui sono avvenute: contratti di ricerca, periodi di formazione, ecc.)

During the three years I worked actively inside the IEHV research group (Innovative Electric and Hybrid Vehicles).

Some of the specialised experiments on composite materials were conducted in Proplast Research Center (Strada Comunale Savonesa, 9, 15057, Cascina Rivalta Scrivia, AL).

B.5 ulteriori attività di ricerca (progetti e contratti di ricerca nazionali ed internazionali)

None

B. 6 brevetti conseguenti l'attività di ricerca

None

B. 7 altre attività che si ritengono degne di menzione

None

C. ATTIVITA' DI FORMAZIONE

C.1 partecipazione ad attività interne di supporto alla didattica (specificare su quali corsi, e se eventualmente il dottorando sia stato nominato cultore della materia)

None

C.2 corsi e seminari più significativi seguiti (interni, esterni, ecc. - indicare solo il tipo ed il numero)

- Internal:
 - 8 Hard skill courses
 - 6 Soft skill courses
- External: 3 Seminars

C.3 periodi di formazione esterni al Politecnico (tipo di formazione, luogo e durata)

All the extra activities that I have done during the time of my PhD are listed below:

- 2nd International Composites Congress (ICC) Dusseldorf (Germany) (28th - 29th November 2016) 2 days
- Processing of Thermoplastic Composites: Thermoplastic Composite Research Centre (TPRC), Palatijn 15, Enschede, Netherlands (1st to 3rd December 2015) 3 days
- Advanced Methods for Material Testing: PhD summer school, AIAS, Università di Ferrara, Italy (22nd to 25th June 2015) 4 days

- French-Italian-Swiss PhD Workshop: (European Scientific Institute), Archamps Technopole in France (15th to 16th Sep 2016). 2 days
- LSDyna Composite forming, Kaizanet, Bangalore, India. (2nd to 9th May 06/2017). 5 Days
- LSDyna Composites, Torino, Italy. (29th to 31st May 2017), 3 Days.
- Corso Altair HyperWorks Pre-Post Mod1, c/o Altair Engineering Srl, (26th to 27th Jan 2015), 2 Days.
- Corso Altair Optistruct Dynamic Analysis, c/o Altair Engineering Srl (26th to 27th Mar 2015), 2 Days.
- Corso Altair Optistruct Compositi, c/o Altair Engineering Srl (16th to 17th Jul 2015), 2 Days.
- Corso Altair Radioss Explicit, c/o Altair Engineering Srl (30th to 31st Jul 2015), 2 Days.
- Corso Hyperworks Radioss Compositi, c/o Altair Engineering Srl (24th to 26th Sep 2015), 3 Days.

D. PUBBLICAZIONI FATTE E IN CORSO (indicare il numero e il tipo: riviste nazionali ed internazionali, congressi, capitoli libri ecc.)

International journal: 2 papers

- Carello, M., Amirth, N., Airale, A.G. M. Monti A. Romeo. Building Block Approach' for Structural Analysis of Thermoplastic Composite Components for Automotive Applications *Appl Compos Mater* (2017). 1-12
- N. Amirth Jayasree, A.G. Airale, A. Ferraris, A. Messina, L. Sisca, M. Carello. (2017). Process analysis for structural optimisation of thermoplastic composite component using the building block approach. *Composites Part B: Engineering*. 126, 119-132.

Conference Papers: one paper

- Carello, M.; Airale, A.G.; Ferraris, A.; Messina, A.; Amirth Jayasree, N. (2017) *From thermosetting to thermoplastic composite materials: automotive applications in structural components*. In: Automotive Engineering Congress, Norimberga (Germany), 30-31 May 2017.

Torino, 06/10/2017

(firma del dottorando)