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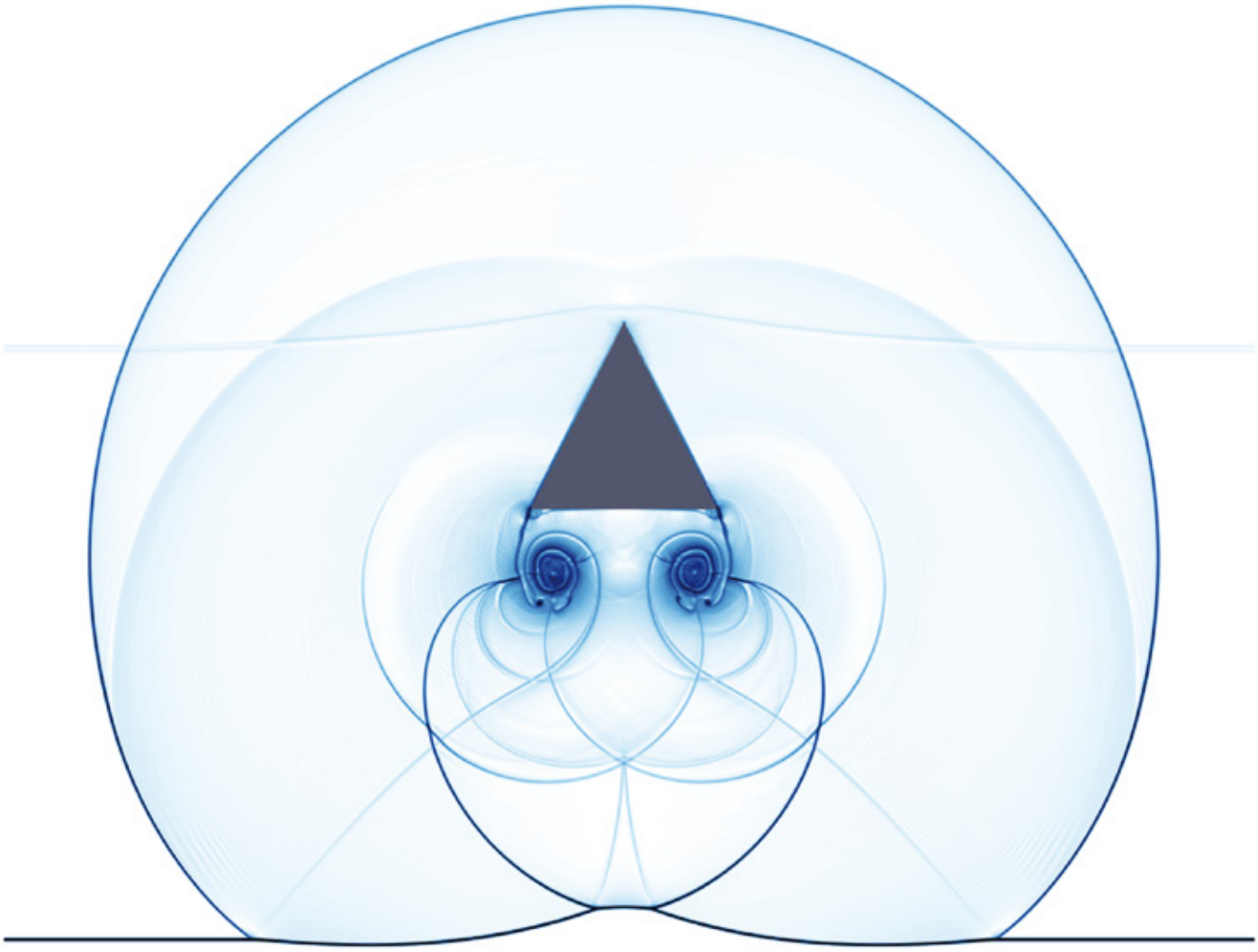
NEWSLETTER DEL DIPARTIMENTO DI INGEGNERIA INDUSTRIALE DELL'UNIVERSITÀ DEGLI STUDI DI PADOVA

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE



COPERTINA

Schlieren numerica della diffrazione di un'onda d'urto attorno ad un cono a Mach 1.3

PAGINA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Life Cycle Assessment and End of Waste to support innovation process

The circular economy approach, adopted by European Union in last years, provides for the reintegration of products at the end of life within the production cycles. This allows a double benefit: reduction of waste to be disposed and saving of virgin natural resources. Accordingly, the concept of waste must be redefined: it is no longer a problem to be discarded, but it represents a resource to be recovered, that in turn allows companies an economic convenience of raw materials supply and an environmental improvement. Clearly, the reintroduction of waste in production cycles as "secondary raw materials" must be properly regulated, in order to protect health and safety of man and environment, coherently with prevention and care principles, that are fundamental in European policy. In fact, defining the minimum quality and safety standards that must be respected for materials re-use, End of Waste Regulations (EoW) represent the framework for companies that want to invest in technological and production eco-innovations. This is the case of a Venetian company leader in the design, production and installation of expansion vessels for heating systems, as hydraulic components in domestic boilers (fig.1). Thanks to a collaborative project with our research group, this company conducted a preliminary Life Cycle Assessment (LCA) with the aim to identify the main environmental impacts associated with the life cycle of the product (fig.2). Through this preliminary LCA, the most promising opportunities for environmental improvement have been identified in the end of life phase of expansion vessel, going to enhance the EoW. Therefore, possible solutions for recovery of product at the end of life have been elaborated, including the return of replaced vessels to the company and the reintegration of materials and components within the production process to create new products. The solutions identified for recovery of materials at the end of life involves various innovations in the company. In a technological perspective, the production process must be adapted, to allow the processing of secondary materials. In an organizational perspective, the supply chain must be redefined, to allow the return of replaced vessel at the end of life. Now, it becomes essential for the company to know both the technological opportunity of product recovery at the end of life, and the economic convenience of innovative changes derived by this innovation.

Fig.1. Expansion vessel in domestic boiler

Fig.2. Steps of product's life cycle

Research topic:
Environmental and industrial safety

DII research group

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The research in the field has been started thanks to a stage experience of Master Degree Course in Industrial and Civil Safety Engineering [http://is.dii.unipd.it/].

Main research topics:
- Life Cycle Assessment
- Environmental Risk Assessment
- Sustainability Management
- Circular Economy Approach

Research topic:

Energy

DII research group
CAPE-Lab

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(University of Padova)
Prof. Nilay Shah
(Imperial College London)

Main research topics:

- Carbon capture, transport, and storage
- Supply chain optimisation
- Societal risk-constrained optimisation
- Optimisation under uncertainty
- Risk management

Optimising European supply chains for carbon capture, transport, and storage

To constrain the mean global temperature rise below 2°C by 2100, a collective effort is required to keep the level of CO_2 equivalent below 550 ppm. In order to meet these stringent global environmental targets, carbon capture, transport, and storage (CCS) have been highlighted as strategic technologies. However, considering the early design stage of CCS infrastructures, analytical supply chain (SC) modelling and optimisation through mixed integer linear programming offers the opportunity for a quantitative evaluation supporting the strategic design of such a high-level SC. In particular, the following issues have been considered and tackled:

1. *CCS SC optimisation:* the objective was to minimise the total cost to install and operate a new European network capable of capturing and eventually storing up to 70% of the European emissions from large stationary sources. Results demonstrated the potential for sequestration and, simultaneously, the good computational performance of the solution approach. Costs for capture emerged as the key economic challenge of the system, being transport- and sequestration-related costs a negligible part of the overall investment.

2. *Societal risk-constrained SC optimisation:* the economic optimisation was coupled with societal risk analysis and mitigation measures on the pipeline infrastructure. It emerged that mitigation actions never represent more than 10% of total cost for installing and operating the transport network. However, the need of guaranteeing a minimum level of societal risk may limit the carbon reduction potential down to 50%.

3. *SC optimisation under uncertainty in storage capacity:* the objective was to quantify the financial risks arising from geological uncertainties in European supply chain networks, whilst also providing a tool for minimising storage risk exposure. It was shown that such risks can be minimised via careful design of the network, through distributing the investment for storage across Europe, and incorporating operational flexibility to improve network resiliency on uncertainty.

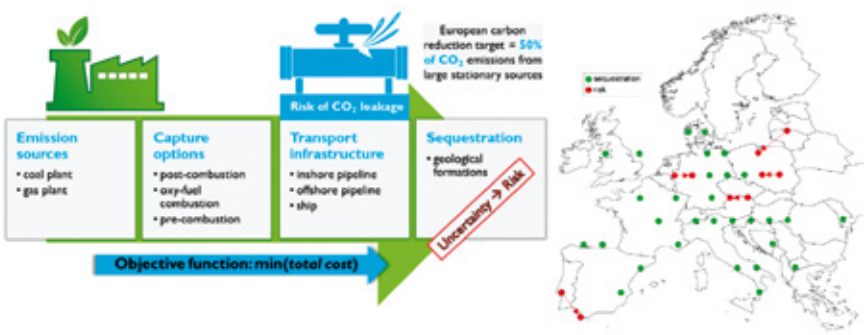

Figure 1. Example of European CCS SC design stages and structure, and resulting network.

MINLU: a complete suite for autonomous monitoring of light pollution from drones

MINLU sensor suite has been designed to measure the luminous intensity of polluting sources and their spectral power density with a wavelength resolution which allows to identify the different lamp technology used in street lighting.
Thanks to its low mass and limited envelope MINLU can operate over a dedicated area from drones or balloons, achieving a spatial resolution better than 0.1 meter and allowing monitoring of time evolution of the luminosity for many hours.
The suite is completely autonomous: the imaging subsystem, which includes three cameras with dedicated filters and a spectrometer, is controlled by a Central Data Management Unit comprising all electronic boards for sensor conditioning, data acquisition, compression and storage. Telemetry stream including under sampled acquired images, position and attitude information is transmitted on ground through a Zigbee system while high resolution images are stored on on-board memory. Power is provided by rechargeable lithium batteries allowing continuous operation up to 4 hours.
Calibration activity of suite is currently ongoing in Illumination and Photometry laboratory , while test fights with drone will be conducted in March 2019.

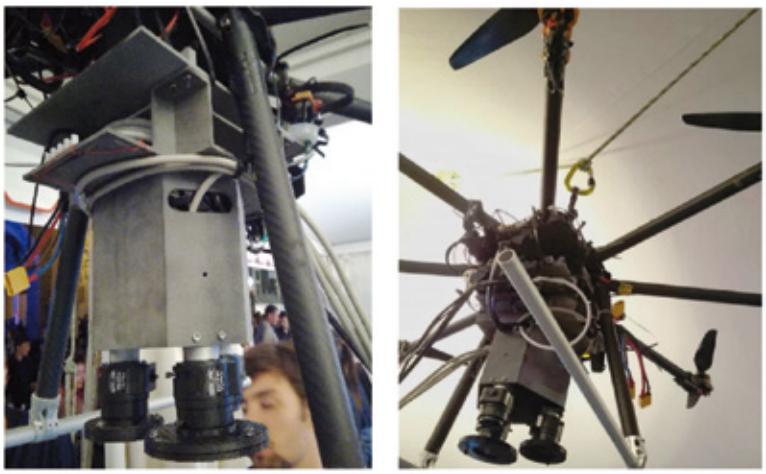

Figure 1. MINLU suite installed on octocopter drone

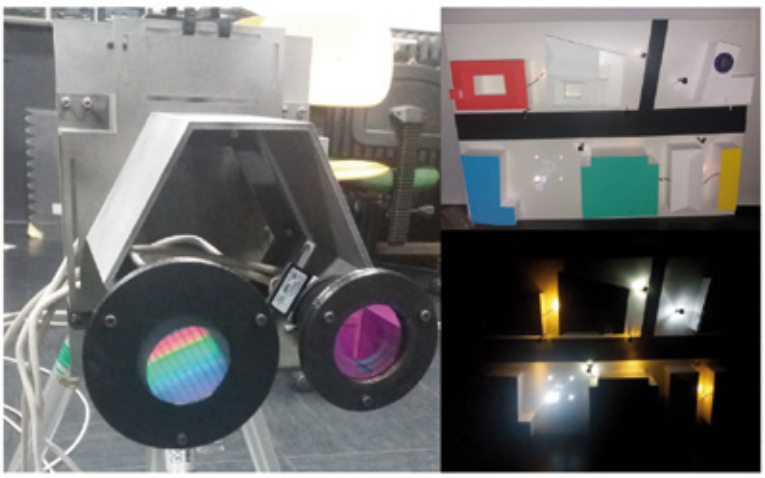

Figure 2. Calibration activity in Illumination and Photometry laboratory

Research topic:
Electrical systems engineering

DII research group

Space flight dynamics
Illumination & Photometry

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Project activities are carried out in collaboration with :

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(Center of Studies and Activities for Space "CISAS" G.Colombo)

MINLU is developed under coordination and funding by Department of Industrial Engineering as part of the Twinning research program of the University of Padova.

Main research topics:

- light pollution
- artificial lighting & urban monitoring
- remote sensing
- photometry & spectral analysis

Research topic:

Materials

DII research group

CHEMTEC

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The research in this field was initially financed by a company working on conversion of vegetable oils. Currently, it is part of Egle Rosson's Ph.D. program, in collaboration with a company which provides the waste animal fats.
Acknowledgements: Dr. Keti Vezzu, Ph.D, for the ICP measurements, ABC lab for LHV analyses, and Prof. Monica Giomo for viscosity measurements.

Main research topics:

- Waste up-cycling.
- Physico-chemical characterization of different waste animal fats and related bioliquids.
- Design of conversion processes which are able to preserve the original physico-chemical properties and the triglyceride structures of the treated waste animal fats.
- Design of green physico-chemical treatments, optimizing the boundary conditions in order to increase the conversion efficiency and reduce as much as possible the mass loss and the formation of waste residues.
- Direct application of waste animal fats as bioliquids.

Production of bioliquids from waste animal fats

The search of alternative fuel resources is a hot topic nowadays, looking for employing 20% of the total energy from renewable resources by 2020 in Europe. The Directive 2009/28/EC subsidizes the use of biomass, including vegetable oils and animal fats, for this purpose. Moreover, a sustainable waste management is fundamental to implement a circular economic approach in which the up-cycling of waste materials is useful to reduce the impacts associated to the related disposal (Directive 2008/98/EC).

Different waste animal fats have been considered in the study. They could be directly used as bioliquids if their physico-chemical properties comply with the quality standards, according with the regulation (EC) n. 1069/2009. The designed conversion process aims to reduce the intrinsic acidity with the esterification of FFAs, using different alcohols and catalysts in comparison, and a final neutralization with bases. The refining is achieved with activated carbons and other physical treatments in order to remove the remaining suspended particles and the particulate matter formed during the conversion process. The conversion efficiency amounts to 80-85%.

The bioliquids obtained from the bone, the chicken and the tallow fats comply with the quality limit values suggested by the standard UNI 6579: 2009 for the application in civil and industrial power plants (Tables 1) [1]. In particular, the bone fat bioliquid belongs to class B, as classified by the standard UNI/TS 11163: 2009, while the tallow fat can be directly used as bioliquid without any treatment, belonging to class C.

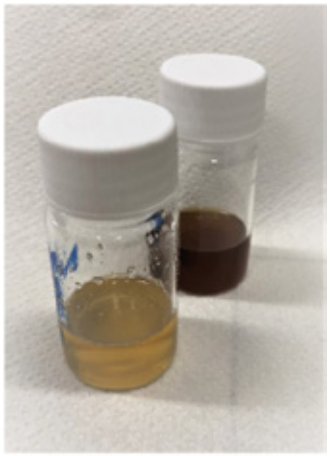

Table 1. Properties of the bioliquids obtained with the designed conversion process

Property	Unit	Bone fat biol.	Tallow fat biol.
Density (40 °C)	kg/m³	900 0.0211	903 0.0052
Viscosity (40 °C)	mm²/s	28 0.0009	22.1 0.0042
Acid value	mg KOH/g	0.496 0.0738	0.435 0.0431
Moisture content	% w/w	0.058 0.0014	0.096 0.0025
Total contamination	% w/w	N.A.	0.284 0.1353
Ash content	% w/w	N.A.	0.004 0.004
Peroxide value	meqO_2/kg	12.9 1.403	N.A.
Iodine value	g/100g	50.5 1.06	28.6 0.2516
Group I metals (Na+K)	mg/kg	17.7	172
Group II metals (Ca+Mg)	mg/kg	38.8	49.5
Phosphorous content	mg/kg	44	290
Sulfur content	mg/kg	175	1826

[1] E. Rosson, P. Sgarbossa, F. Pedrielli, M. Mozzon, R. Bertani - Waste Management, submitted.

Valuable secondary raw material by chemical recycling of polyisocyanurate foams

Polyurethane rigid foams (PUR) are widely employed materials for flooring and roofing applications in sustainable building and infrastructure projects for lower energy costs.
However, due to the growing concern about flammability of foamed materials, which has led to strict building regulations, the use of polyisocyanurate (PIR) foams is steadily growing due to their higher thermal stability and fire resistance than PUR. In this context the rapid rise in the consumption of such materials poses a serious issue for their recycling in terms of economic and environmental perspectives.
One of the most popular method for the recycling of polyurethanes (PU) reusable wastes is glycolysis, a transesterification process capable to produce oligomers in the PUs production (Figure 1).

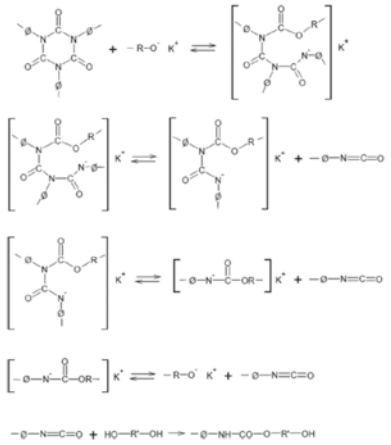

Figure 1. Reaction of isocyanurate and related compounds during glycolysis

In this work we explored the feasibility and optimization of such method, never been applied before for the recycling of PIR foams. The results showed that a glycolysis process in presence of dipropylene glycol, as glycolysis agent, and potassium acetate, as catalyst, can be successfully carried out even with PIR foams with extremely high isocyanate index. Under proper conditions, the highly cross-linked structure of the polymer can be converted into a liquid, single phase, mixture of highly branched oligomers which was suitable to be used in the synthesis of new rigid foams. Due to the high functionality of the glycolysis products and their compatibility with isocyanates, the mechanical properties of specimens based even on high amounts (up to 75%) of glycolysis polyols turned out to be higher or either very close to those of standard specimens based on virgin polyol only (Figure 2).

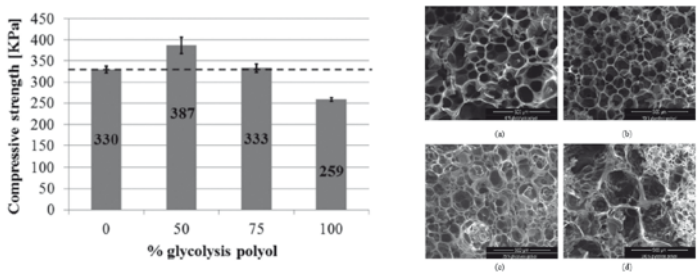

Figure 2. Compressive strength performance and microstructure of PIR foams containing different percentages of glycolysis-derived polyols

Research topic:

Industrial processes and products

DII research group

Polymer Engineering Group (PEG)

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The present work has received funding from the Veneto POR FESR 2014-2020 under the research project entitled «Chemical recycling of polyurethanes systems in the perspective of Circular Economy»

Polymer Engineering Group

Main research topics:

- Nanostructured membranes based on nanofibers via electrospinning
- High performance polymeric nanocomposites
- Thermal stability and fire behavior of polymeric materials
- Design and processing of polymeric materials
- Physical and chemical recycling of plastic materials

Energy Modelling Of Historical Buildings

Research topic:

Energy

DII research group

BETA_Lab: Building Energy Technology Assessment

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The research activity was supported by Padua University and is ongoing and carried out in collaboration with:

Francesca Da Porto,
Geoscience Department of Padua University.

Antonio Galgaro,
Geoscience Department of Padua University.

Roberto Zecchin, Padua University.

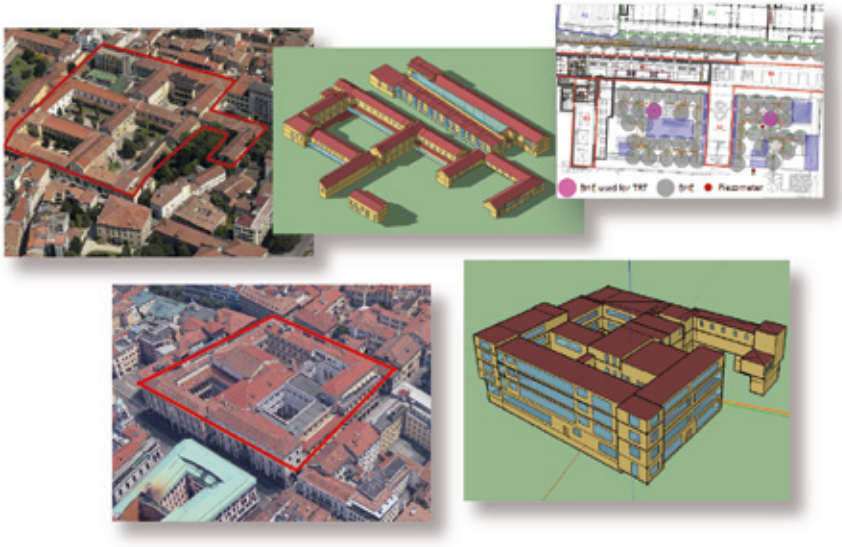
Main research topics

- Modeling and Field Measurements of Radiant Systems
- Ground Source Heat Pumps
- Solar Systems Design for Heating and Cooling
- Double Skin Facades
- Energy Analysis and Temperature Distributions in Large Spaces
- Simulations and Measurements in Buildings
- Energy Efficiency of Building Plant System
- Nearly Zero Energy Buildings (nZEB)
- Low Exergy Systems in Buildings
- Thermally Activated Building Systems
- District Heating and Cooling Networks
- Thermal Comfort
- Modelling and Development

The existing buildings are responsible of about the 40% of the primary energy demand in Europe. As widely known and discussed in literature, the energy efficiency improvement, especially in building sector is one of the most important actions for the reduction of the greenhouse gases emissions in the atmosphere. In Italy, the total amount of heritage monuments is about 4,000,000 of 5,367,000 present in the worldwide. Many buildings have been built before the 1919 and today are used as residential buildings or for public services. From the UNESCO World Heritage List, Italy has 4.7% of the world architectural heritage that occupies 46% about of the entire country.

This work presents two case studies. The first one is the retrofitting of a historical building of the University of Padua, equipped with a hybrid heat pump system, which uses as heat source/sink the ground and ambient air. The building is located in Padua and it is a historical complex of the late 1800, previously used as a geriatric hospital, in which a retrofit process is occurring in order to build the new humanistic campus of the Padua University reaching the highest energy efficiency. The refurbishment is in progress and regards both the building envelope and the plant-system. The building is equipped with two types of heat pumps: the first one is coupled to the ground with borehole heat exchangers and the second is a common air-to-water heat pump. The entire building plant system has been investigated through integrated computer simulations making use of EnergyPlus Software. A new control strategy in order to manage the two types of the heat pumps has been developed in order to increase the energy efficiency. The results outline the potential of the computer simulations in order to control the hybrid heat pump system. In fact, a suitable switch temperature was found in order to move from ground to air source/sink for the heat pumps. In addition, this strategy allows the control of the thermal drift of the ground temperature throughout the years.

The second case study is Palazzo Bo, one of the oldest University buildings sited in the central area of the city, developing specific retrofit solutions according to national regulations and constraints for the protection of historical-cultural architecture heritage. This work is part of a project on energy sustainability supported by the University of Padua. Energy simulations have been implemented and the thermal behavior of the building has been investigated considering the peculiarities of the envelope and real weather data. The developed model can be used to improve the management of the plants and / or to design energy efficiency measures, even though, for a building subject to historical protection, it is very complex to work on the envelope.



Optimization of industrial robotic systems

The Robotics and Automation research group mainly focuses its research activity in improving the performance of industrial robotic systems, with particular attention on modelling and optimization of robotic manipulators and flexible work-cells.

One of the research topics is focused on the trajectory optimization of task-redundant manipulators (figure 1) performing tasks characterized by high vibrations and forces, such as deburring. The irregularities of the burr induce vibrations in the robot leading to a phenomenon called "chatter", which brings bad finishing of the workpiece. Since the resonance frequency of the structure is configuration-dependent and the robot is task-redundant, it is possible to plan a robot's trajectory in a way that minimizes chatter*. In addition, when more than one finishing operation is required on the same workpiece, the motion sequence can be optimized to minimize cycle time, while automatically generating via-points at the same time, to avoid interference between the robot and the piece.

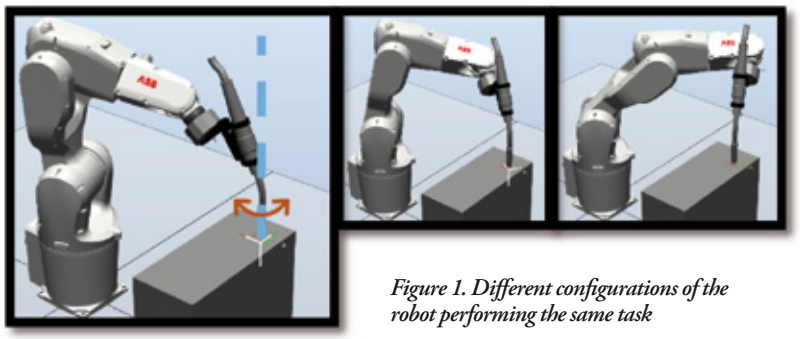


Figure 1. Different configurations of the robot performing the same task

Another hot topic in robotics is flexibility. We are currently studying new flexible feeders with drastically reduced retooling time, thus improving the productivity of the assembly line.
In particular, the vibratory behavior of a cylindrical object on an inclined vibratory plane has been modeled and tested (figure 2). The prototype of a full feeding system, including an industrial vision system and hoppers, is being developed, with the aim of optimizing the feed of common objects, such as screws.

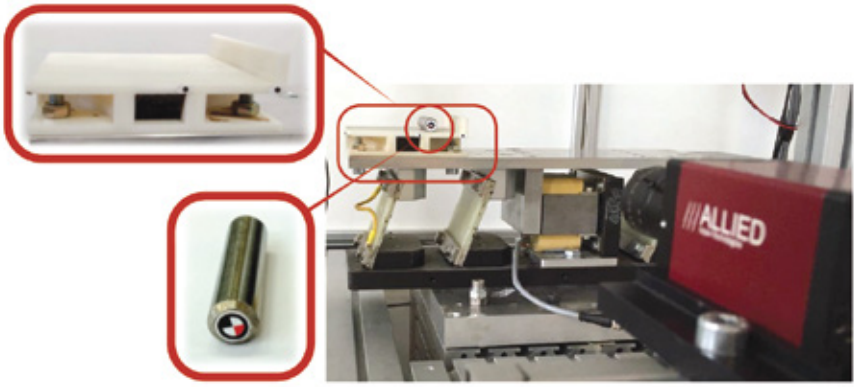


Figure 2. Experimental setup to study the behavior of a cylindrical part on a vibratory plane

** This research is carried out jointly with Alberto Doria, Matteo Massaro and Silvio Cocuzza.*

Research topic:

Mechanical systems engineering

DII research group
Robotics and Automation

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Main research topics:

- Industrial manipulators
- Flexible robotic assembly
- Kinematic optimization
- Flexible part feeding
- Robot guidance
- Vision inspection
- Industry 4.0
- Collaborative robots

Research topic:

Electrical systems engineering

DII research group

Power System Group

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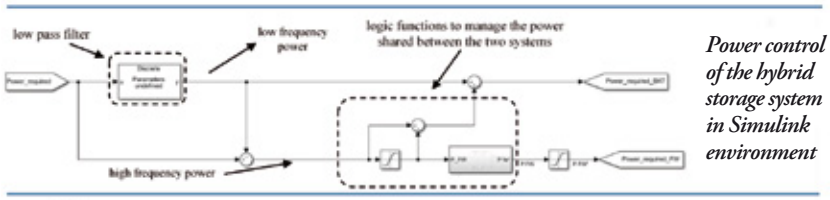
This work was financially supported by the Department of Industrial Engineering-University of Padova under the project entitled "Flywheels and Li-ion Batteries for Stationary Hybrid Energy Storage Systems".

Main research topics

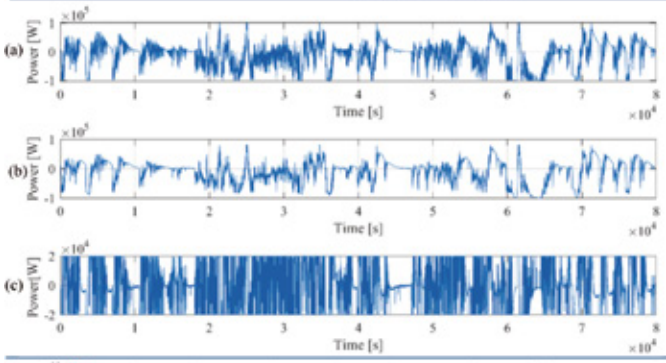
- Large-scale energy storage in the network;
- EHV/HV dc and ac innovative transmission lines e.g. insulated cables and gas insulated lines;
- Synergy between railway and highway infrastructures and insulated cables;
- Multiconductor cell analysis (MCA) of asymmetric systems by means of self-implemented matrix procedures (insulated cables with screens and armours, gas insulated lines with enclosures, overhead lines with one or more earth wires);
- Availability assessment of whole HVDC-VSC links
- Sinergy between insulated cable power transmission systems and transport infrastructures;
- Smart grids: the operation and control of active networks;
- Voltage regulation in the distribution network with high penetration of distributed generation.

Hybrid Storage Systems to Counter the Battery Aging During the Grid Services

The massive introduction of photovoltaic or wind farms in the electrical networks involves several crucial issues for the safe and reliable operation of transmission and distribution grids. Foremost among these are the non-programmability of renewable energy sources, which involves traditional power plant manage difficulties and congestions in the power transmission lines, and the decrease of the network regulating energy, which leads to network instability. The installation of energy storage systems in a high voltage network could be one of the key elements to effectively help in solving these problems, postponing or avoiding the grid reinforcement .This solution seems to be very effective, but recent studies demonstrated that battery aging during a grid frequency regulation operation could be higher than expected and difficult to foresee, especially for some battery technologies. In this research, starting from experimental measurements, a hybrid energy storage system consisting of flywheels and batteries with a Lithium-manganese oxide (LMO) cathode has been modelled and analysed in Simulink environment. The simulation results suggest that a suitable control of the power shared between the batteries and the flywheels could effectively help in countering Li-ion battery accelerated aging due to the grid frequency regulation service. In particular, by means of a low-pass filter, the low frequency components of the required power are supplied by the batteries whereas the high frequency ones are supplied by the flywheel.



Power control of the hybrid storage system in Simulink environment

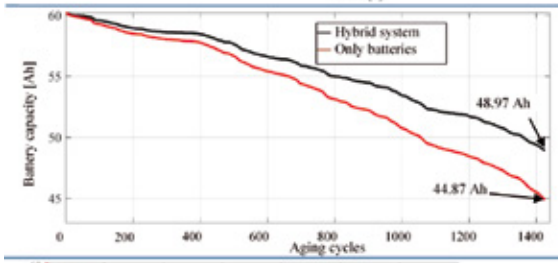


Hybrid system aging test simulation:

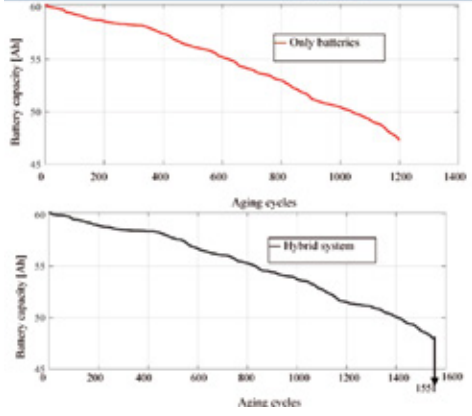
(a) Total required power

(b) battery power

(c) flywheel power



Comparison between the battery residual capacity after 1424 aging cycles for the two systems.



Maximum number of cycles that the batteries can tolerate before their capacity decreases by 20%

QuartoDiLitro torna dalla Spagna con il Best Industrial Project ed il secondo posto assoluto alla MotoStudent 2018

Ritorno trionfale dalla V edizione della competizione ingegneristica MotoStudent (3-7 Ottobre 2019) per il Team QuartodiLitro dell'Università degli Studi di Padova: 15 studenti, sotto la supervisione del Prof. Massaro, hanno sfidato 45 team in un'intensa settimana di prove sul circuito FIM di MotorLand Aragon. Il suolo spagnolo ha sorriso al team di studenti padovani che si aggiudicano il titolo di Miglior Progetto Industriale studentesco al mondo!

Dopo le verifiche tecniche e di sicurezza del mercoledì, la competizione entra nel vivo con la presentazione del saggio tecnico, frutto di due anni di lavoro, che viene illustrato in due presentazioni (giovedì e venerdì) di fronte ad una giuria di esperti del settore automotive. La prima, riassume le scelte progettuali che gli studenti hanno effettuato durante la realizzazione del prototipo, accompagnata da una proposta d'innovazione. La seconda, consiste nell'esposizione del progetto d'industrializzazione: si simula la produzione di massa del prototipo realmente costruito con la verifica della sostenibilità economica e la redazione di un business plan. Il venerdì si chiude la prima fase della competizione, quella ingegneristica, chiamata MS1. Con la giornata di sabato si entra nella seconda fase delle competizione (MS2), dove la protagonista è il prototipo Vittorina impegnata nei test dinamici di frenata, gymkhana e accelerazione. La bontà del lavoro degli studenti, e le qualità del pilota Francesco Reale, emergono dai risultati in pista: primo posto al test di frenata, settimo posto nella gymkhana e quarto posto nella prova di accelerazione. Molto buona anche la manualità degli studenti che, smontando e rimontando carene e ruota anteriore in 34.2s, regalano al team il terzo posto nel mechanical test. La somma dei punteggi delle prove intermedie garantisce al team QuartodiLitro di presentarsi alle qualifiche di domenica mattina con il primo posto virtuale MS2.

Domenica mattina i prototipi tornano a solcare l'asfalto per le prove libere, dove però si assegnano ulteriori punti per la massima velocità ottenuta. Con 176kph, il team QuartoDiLitro si aggiudica il quarto posto nella classifica "top speed".

Ore 14:30: si spengono i semafori e partono i prototipi. Il pilota Francesco Reale dopo le prime due curve raggiunge la seconda posizione ed inizia a battagliare contro il prototipo del Politecnico di Milano. Da metà gara la lotta è solitaria, anche a causa della rottura dell'Università di Brescia, che fino ad allora aveva battagliato per le prime posizioni. Ad un giro e mezzo dal traguardo, in piena bagarre, il destino ha deciso per il team: cedimento del motore e gara finita per QuartoDiLitro, che per la cronaca porta a casa anche il miglior tempo sul giro in gara.

La settimana spagnola si conclude con il primo posto in MS1, l'ottavo posto in MS2 (nonostante la rottura del motore in gara) e il secondo posto assoluto mondiale 2018.

Achievements

DII research group

Dinamica del Veicolo
Meccanica Applicata

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Università degli Studi di Padova

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Cover story

La tecnica Schlieren è una tecnica ottica in grado di evidenziare le variazioni di densità all'interno di un mezzo trasparente. Viene ampiamente utilizzata in tutti i campi della fluidodinamica comprimibile. L'immagine mostra una ricostruzione numerica di una Schlieren applicata al campo di densità attorno ad un triangolo investito da un'onda d'urto a Mach 1.3. A livello numerico la tecnica viene replicata filtrando il modulo del gradiente di densità con un filtro esponenziale tarato sul valore del gradiente massimo. Ne consegue che, ove il gradiente risulti piccolo rispetto al livello di riferimento, l'immagine viene colorata con toni chiari, viceversa, per le porzioni di campo ove il gradiente approccia il valore di riferimento prevalgono i toni scuri. Il risultato finale mette in risalto non solo le strutture di shock, strutture a cavallo delle quali il gradiente di densità approccia il valore massimo, ma anche tutte le strutture vorticose che vengono a formarsi sul retro del triangolo.

Ing. Francesco De Vanna

Nato a Venezia il 27/03/1992, Francesco De Vanna è dottorando iscritto al terzo anno del Corso di Dottorato in Ingegneria Industriale dell'Università di Padova. Diplomatosi presso il Liceo Classico M. Foscarini di Venezia nel 2011, prosegue i propri studi dapprima con la laurea Magistrale Ingegneria Meccanica e in seguito con il dottorato di ricerca. Appassionato di modellistica numerica applicata ai fluidi e ai sistemi propulsivi, i temi di ricerca di Francesco De Vanna riguardano principalmente la fluidodinamica computazionale con particolare riferimento all'aerodinamica ad alta risoluzione di flussi comprimibili attorno a geometrie complesse. Durante il dottorato, ha sviluppato URANOS (Unsteady Robust All-around Navier-StOkes Solver), un solutore Navier-Stokes "fully compressible DNS».

www.dii.unipd.it

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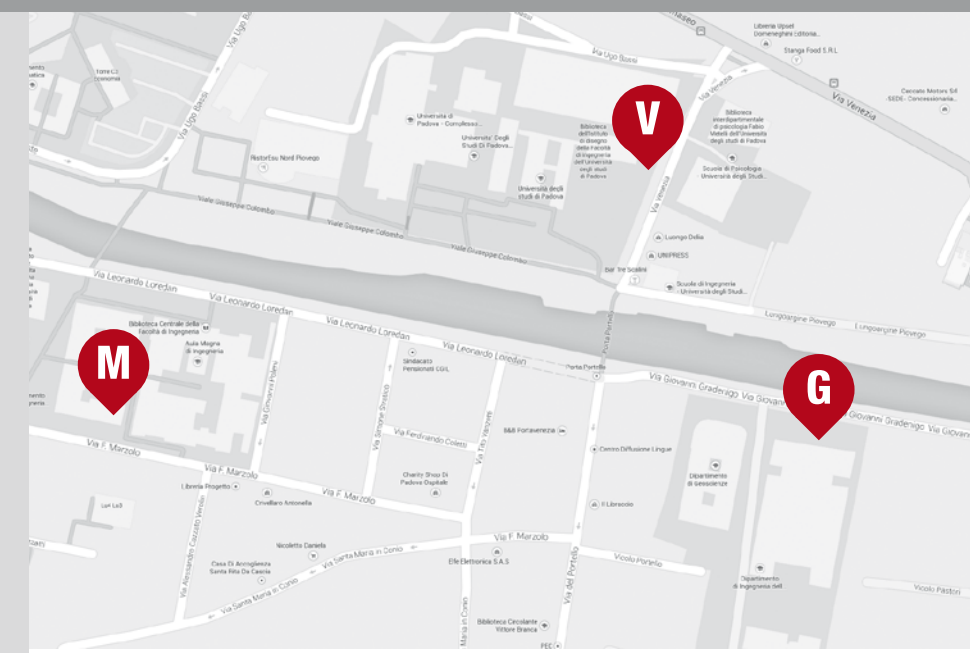
SEDI



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