



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

**KES Series of conferences
in Sustainable Design and Manufacturing**

KES-SDM 2017

26-27-28 April 2017, Bologna, Italia

University of Bologna

Agenda & Book of Abstract

KESInternational

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Conference Organisation's Welcome

Ladies and Gentlemen, Dear Colleagues,

We are pleased to welcome all delegates and speakers to the fourth International Conference on Sustainable Design and Manufacturing (SDM17), organized jointly by the University of Bologna and KES International. Welcome to the Laboratories of the Department of Arts of the University of Bologna that will host us for this three-day meeting.

We are proud to announce that more than 25 countries all around the world are here represented through their scientists and academics involved in the issue of **Sustainability**. The conference programme is looking very exciting with over 90 oral presentations of scientific and industrial papers to be presented across 15 parallel sessions: 4 Track Sessions and 11 Invited Sessions.

We are privileged to have three keynote speakers and an honoured guest speaker: Prof. Dr.-Ing. Guenther Seliger, Chair of the Global Conference on Sustainable Manufacturing at the Technische Universitaet Berlin; Prof I. S. Jawahir, Director of the Institute for Sustainable Manufacturing (ISM) at the Kentucky University; Prof. Shahin Rahimifard, Director of the Centre for Sustainable Manufacturing and Reuse/Recycling Technologies (SMART) at the Loughborough University and Dr. Marino Golinelli, founder and honorary President at the Marino Golinelli Foundation and the Opificio Golinelli.

We would like to thank Prof. Giuseppina La Face, Director of the Department of Arts, for their availability, assistance and help in the organisation of our international meeting and for giving us the possibility to be here in this beautiful place in the centre of Bologna.

We hope that the conference schedule will be worthwhile for you, and we hope that you will have a pleasant stay in beautiful Bologna.

the KES-SDM 2017 international conference Organisation

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Conference Organisation

Honorary Chairs:

Rossi Setchi, Cardiff University, UK

Guenther Seliger, Technische Universitaet Berlin

General Chair:

Giampaolo Campana, Bologna University, Italy

Executive Chair:

Robert J. Howlett, Bournemouth University, UK

General Track Chairs:

Track 1: Dr. Pinar Bilge & Dr. Jeremy Boinvoisin, Technische Universitaet Berlin, Germany

Track 2: Dr. Peter Ball, University of York, UK

Track 3: Dr. Daniel Eyers, Cardiff University, UK

Track 4: Dr. Elliot Woolley, Loughborough University, UK; **Prof. Dzung Viet Dao**, Griffith University, Australia

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Stefano De Miranda, Department of Construction Eng., University of Bologna, Italy

Alfredo Liverani, Department of Industrial Engineering (DIN), University of Bologna, Italy

Luca Tomesani, Department of Industrial Engineering (DIN), University of Bologna, Italy

Emilio Ferrari, Department of Industrial Engineering (DIN), University of Bologna, Italy

Promotion and Publicity Chair:

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KES International Executive Chair: R. J. Howlett, Bournemouth University, U.K.

KES Founder: L. C. Jain, University of South Australia

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International Program Committee

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Dr. Jian JIN	Beijing Normal University, China
Prof. Stefan Junk	University of Applied Sciences Offenburg, Germany
Prof. Mohammad Arif Kamal	Architecture Section Aligarh Muslim University, Aligarh, India
Dr. Olivier Kerbrat	ENS Rennes, France
Prof. Hideki Kobayashi	Department of Mechanical Engineering, Osaka University, Japan
Dr. Edwin Koh	National University of Singapore, Singapore
Prof. Kari Koskinen	Tampere University of Technology, Finland
Dr. Gul E. Okudan Kremer	Pennsylvania State University, USA
Prof. Chee-Peng Lim	Deakin University, Australia
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Prof. Johan Van Niekerk	Programme leader of the Industrial Design Department, Cape Peninsula University of Technology
Prof. Gilberto Osorio-Gomez	EAFIT University, Medellín Colombia

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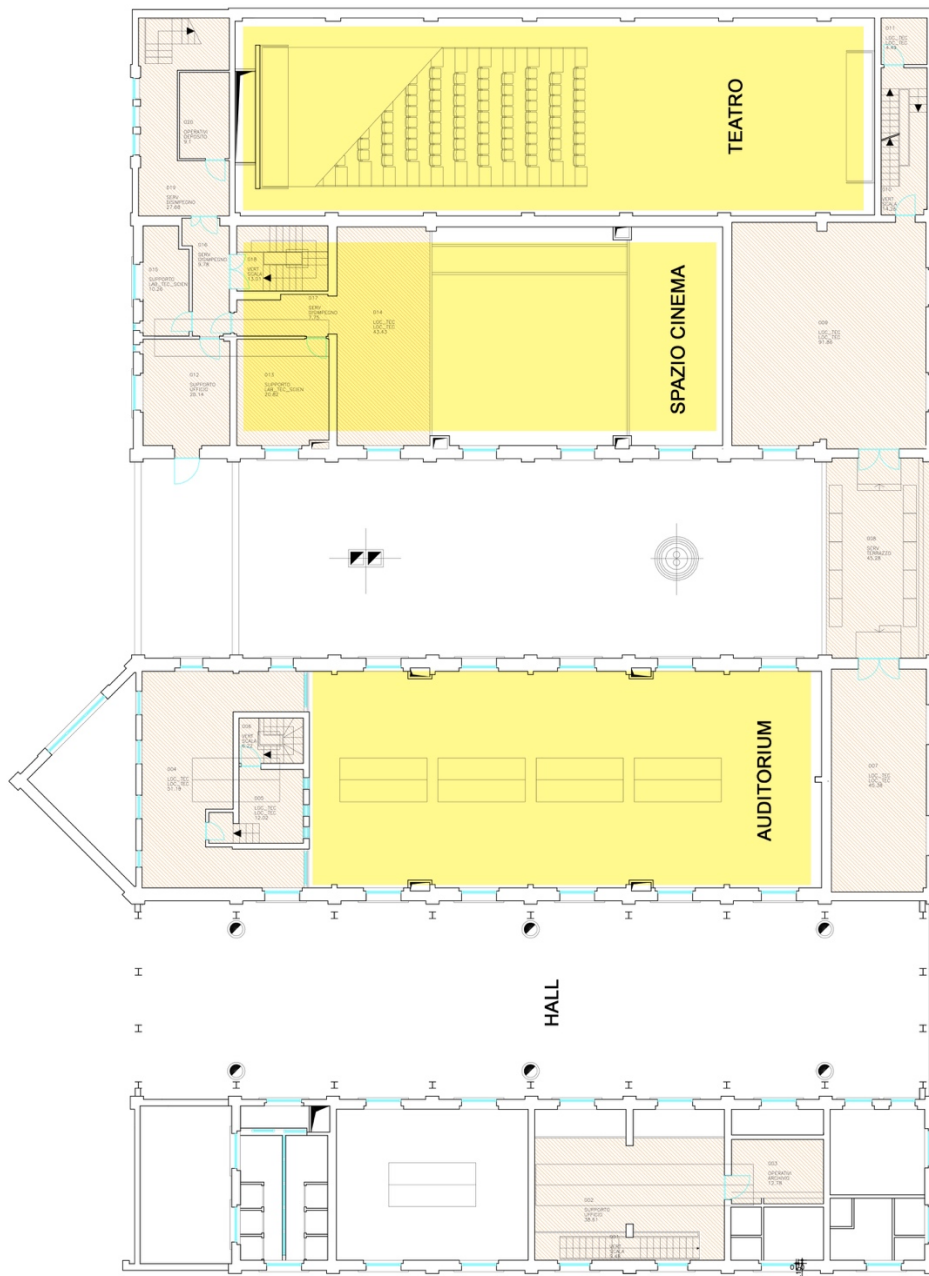
Dr. Jae-Hwan Park	Middlesex University, UK
Dr. Paolo C. Priarone	Polytechnic of Torino and AITeM, Italy
Eng. Paul Prickett	Cardiff University, United Kingdom
Dr. Laura Purvis	Cardiff Business School, Cardiff University, UK
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Prof. Davide Russo	The University of Bergamo, Italy
Dr. Michael Ryan	Cardiff University, UK,
Dr. Konstantinos Salonitis	Cranfield University, UK
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Prof. Zhongde Shan	China Academy of Machinery Science and Technology (CAM), China
Dr. Leila Sheldrick	Imperial College, Faculty of Engineering, Dyson School of Design Engineering, UK
Prof. Alessandro Simeone	Loughborough University, UK
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Prof. Tien-Lung Sun	Yuan Ze University, Taiwan
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Dr. Parag Vichare	University of the West of Scotland, UK
Prof. Dr. Dzuraidah Abd Wahab	Universiti Kebangsaan Malaysia, Malaysia
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Dr. Qing Wang	Durham University, UK
Prof. Peter Wells	Cardiff Business School, Cardiff University, UK
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Dr. Imene Yahyaoui	Federal University of Espiritu Santo, Brazil
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The conference venue at Laboratories of Arts

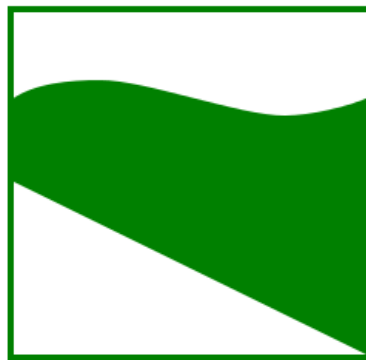
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Laboratories of Arts of the University of Bologna are located in
Piazzetta P.P. Pasolini 5/b, 40122 - Bologna – Italia



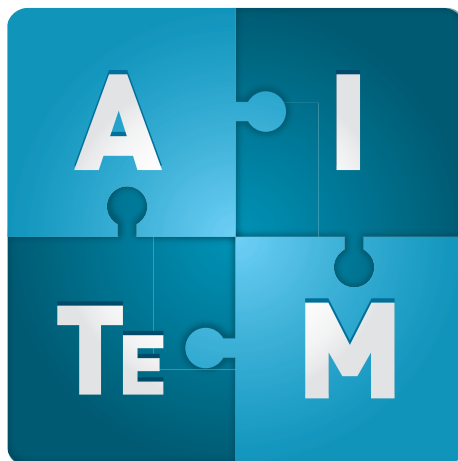
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Honorary Guest Speaker

Dr. Marino Golinelli, Fondazione Marino Golinelli

Keynote Speakers

Prof. Guenther Seliger, Technische Universitaet Berlin

Prof. I.S. Jawahir, Kentucky University

Prof. Shahin Rahimifard, Loughborough University

List of Track Sessions

G01: Sustainable Design, Innovation and Services

G02: Sustainable Manufacturing Processes and Technology

G03: Sustainable Manufacturing Systems and Enterprises

G04: Decision Support for Sustainability

List of Invited Sessions

IS02: The Learning Supply Chain

IS04: Sustainable Materials: Renewable and Eco Materials, Bio-Polymers, Composites with Natural Fibres

IS05: Business model innovation for sustainable design and manufacturing

IS06: Resource and Energy Efficiency for Sustainability Advances in Process Industries

IS08: Sustainability in industrial plant design & management: applications & experiences from practice

IS09: Sustainability of 3D Printing and Additive Manufacturing

IS10: Sustainable mobility, solar vehicles and alternative solutions

IS11: Eco Designed through Systematic Innovation

Piano concert

Maestro Stefano Malferrari

FRANZ SCHUBERT (1797-1828)

Impromptu in E_b major, op. 90, no. 2

Impromptu in G_b major, op. 90, no. 3

FRÉDÉRIC CHOPIN (1810-1849)

Valse in A_b major, op. 34, no. 1

Polonaise in A_b major, op. 53

GIOACHINO ROSSINI (1792-1868)

Ouf! les petits pois

Petit caprice (style Offenbach)

FRANZ LISZT (1811-1886)

Rigoletto: Paraphrase de concert

Notes about the piano concert by Prof. Giuseppina La Face

In 1827, a year before his death, a 30-year-old Franz Schubert (1797-1828) wrote eight piano “Impromptus”, op. 90 and 142. The impromptu is a composition that has an extemporaneous quality: the idea of putting into written shape a sudden inspiration fascinated musicians throughout the 19th and 20th century. The form of the op. 90 Impromptus is simple, although their outline might elude an untrained ear. Number two is the most plastic example. The first part is an acrobatic twirl, a *perpetuum mobile* of small notes flitting about; the second part, a marked waltz step, is openly Romantic in expression. After repeating the opening whirl, the short coda features a last, partial reprise of the waltz. Number three slowly spins a cantabile melody, sweet and measured, like a golden thread woven into the arabesque of the arpeggios, over a carpet of deep chords in the left hand. Everything flows, each phrase links to the next seamlessly; the piano’s singing flows calmly towards distant regions.

Waltz op. 34 no. 1 and Polonaise op. 53 by Frédéric Chopin (1810-1849), the great Polish composer and pianist who became a naturalized French citizen, were composed when he was respectively 25 and 32. The waltz and the polonaise were popular dances in the European 19th-century salons. The waltz, a sensual partner dance from the Austrian-German world, became the favourite dance of the European upper-middle class. The Polonaise, originally a popular dance, gradually raised to the status of a solemn ceremonial dance, a musical emblem of the highest Polish and Russian aristocracy. Chopin’s compositions, however, were not written to be danced – they abstract the dance’s features and, although retaining their rhythm and phrasing, are meant to be listened to in a recital. Among the waltzes, op. 34 no. 1 is one of the most complex. After a blaring opening comes a succession of several adjacent sections characterized by unbridled melodic invention, and enriched by short decorative scales and light flights of notes, quite hard to perform, or by quick rhythmic swerves. In the Polonaise op. 53, Chopin turns the dance into a sumptuous *mise-en-scène* of heroic valour; indeed, as musicologist Charles Rosen

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suggests, his aim seems to depict a cavalry charge. Fraught with octaves, *sforzati* and *fortissimi*, this piece maintains a grandiose, magniloquent tone throughout, and requires of the performer consummate bravura and an aggressive technique.

We are now going to listen to two late piano pieces by Gioachino Rossini (1792-1868), the foremost Italian composer in the first half of the 19th century. The pieces are drawn from the so-called *Péchés de vieillesse*: these ‘Sins of Old Age’ belong in fact to the very last years of his long life, ca. 1857-1868. The composer had abandoned opera theatre some 30 years earlier. He wrote these pieces for his own amusement, to liven up the evenings he held at his place on Saturdays for the Parisian *beau monde*. The first piece bears a puzzling title, *Ouf! les petits pois* (Oof! The green peas), which has stirred the imagination of critics. The guests sit down at the table: there is a side dish of green peas. If eaten with a fork, they are impossible to spear, they just roll away, and the table mate loses his temper. The relaxed pace of the opening apparently evokes the dinner atmosphere; the trills in the central part describe the annoying rolling of the beans, and the ensuing irritation. Finally, peace is restored. According to an alternative interpretation, the scene takes place on the kitchen table: peas are shelled to be cooked, and away they roll... The *Petit Caprice* (style Offenbach) has also generated quite a few interpretations. The most accredited version suggests that Rossini drew inspiration from a caricature of Jacques Offenbach, the author of so many satirical Parisian operettas. A friend of Rossini’s, the French-German composer was thought to be a jinx. *The Petit Caprice* is a jaunty, mocking can-can that parodies Offenbach’s own euphoric can-cans. Rossini, however, prescribes a rather peculiar fingering: the opening motif should be played with the fifth and second finger of the right hand – those used to form the sign of the horns to ward off the evil eye... Rossini then supposedly wrote a sort of prankster joke addressed to Offenbach, but with a good-luck gesture attached to it, along with a sly but benevolent laugh.

The evening closes with a brief foray into the world of Italian opera, again seen through the lens of salon music. In the 19th century it was common for the most

acclaimed operas to be paraphrased in piano ‘fantasies’, which evoked in recitals the melodies heard at the theater. Franz Liszt (1811-1886) composed his paraphrase from Rigoletto towards 1860 (Giuseppe Verdi had written his opera in 1851). The part being echoed and transformed is the famous “quartet” from the third act. Rigoletto and his daughter Gilda, hiding outside the tavern of the bandit, Sparafucile, watch the latter’s sister, Maddalena, as she is shamelessly courted by the Duke of Mantua (the seducer of the naive Gilda, who is hopelessly infatuated with him). Liszt opens the scene with Maddalena’s motif («Ah! ah! rido ben di core»), then, after some scales and breakneck flights of notes, introduces the bold motif of the Duke («Bella figlia dell’amore, | schiavo son de’ vezzi tuoi»). Liszt’s piece hardly pays attention to Gilda and Rigoletto: more than a quartet, this is a duet, but one that sends off sparks. The pianist must tackle transcendental difficulties of performance, flying up and down the keyboard, from low to high register, in an acrobatic frenzy that alternates with moments of longing: in sounds and gestures, the piece describes the erotic interaction between the Duke and Maddalena. Enjoy the music!

Biographical notes about Maestro Stefano Malferrari

Stefano Malferrari studied at the conservatoire "G. B. Martini" of Bologna and got his diploma (with honours) at the conservatoire "G. Rossini" of Pesaro under the guide of Franco Scala. After that, he continued his studies with the pianists Jörg Demus and Gyorgy Sandor. He was among the founders of the Associations "Incontri col Maestro" (Imola, now Academy).

Classified among the winners of a few international competitions (Enna, Senigallia), he gave concerts: recitals and soloist with orchestra (Warsaw Symphony Orchestra, Recife Symphony Orchestra, Accademia Bizantina), chamber music groups, and ensembles of contemporary music for celebrated Italian associations and concert halls, such as Sala Verdi (Milan), Philharmonic Academy (Rome), Teatro Comunale (Florence), and Teatro Comunale (Bologna). Other concerts have been given in Europe (Switzerland, France, Germany, Sweden, Croatia, Iceland, Norway, Russia and Great Britain), middle and south America (Mexico, Peru, Colombia, Brazil, Chile, Argentina and Ecuador), and Asia (Kazakstan, Thailand).

He played in several international festivals: "Rossini Opera Festival" (Pesaro), "Festival dei Due Mondi" (Spoleto), "Maggio Musicale Fiorentino (Florence)", "MilanoMusica" (Milan), "Settembre Musica" (Turin), "Biennale Musica" (Venice), "Cité de la musique" (Strasbourg) and "International Bergen Festival" (Bergen, Norway), Ravenna Festival.

Very committed to chamber music and Lieder repertoire, he played with many renowned musicians, e.g., the flautists Andrea Griminelli, Giorgio Zagnoni, the pianist Jörg Demus, the violinist Domenico Nordio, the sopranos Dimitra Theodossiu, Irina Lungu and Lorna Windsor and the mezzo Monica Bacelli. He has devoted particular attention to the contemporary repertoire by collaborating with the violinist Enzo Porta, the flautist Annamaria Morini, and the pianist Mauro

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Castellano; on many occasions he presented works in first absolute execution, by collaborating with composers such as Sylvano Bussotti, Jonathan Harvey, Tristan Murail, Adriano Guarnieri, Paolo Aralla, Cristina Landuzzi, and Chiara Benati. He has taken part in many contemporary music ensembles, e.g. Octandre (Bologna), FontanaMIX (Bologna), European Music Project (Ulm, Sweden) and Zephir Ensemble (Palermo).

In October 2008 he played in the 1° world performing of “Concerto per l’Infanzia” for piano, soprano and orchestra of Marco Biscarini, at the Theater Santa Isabel of Recife, with Recife Symphonic Orchestra.

Some performances of his were broadcasted by RAI (Italian Television), foreign radios, and private networks. He recorded some CDs for NUOVA CARISCH, NLM, NUOVA ERA, AGENDA, TACTUS, VERMEER and EMAVINCI.

Besides teaching at the conservatoire "G. B. Martini" of Bologna, he held courses and conference- concerts for several Italian musical institutions. Moreover, he is director (with Lorenzo Bianconi and Giorgio Pagannone) of the book series “Chiavi d’ascolto” [Listening Keys] (Albisani Editions).

He was appointed as a jury-member in some national and international piano and chamber music competitions. He collaborated as director or artistic consultant for both private and institutional cultural and musical associations. He was also involved in the establishment of the contemporary musica ensemble FontanaMIX.

AITeM-AIAS joint Award

The joint AITeM-AIAS Award to Olmes Ognibene has to be conferred during the Social Dinner at the Savoia Hotel in Bologna for his relevant contribution to the development of the mechanical industry and for his attention to the sustainability issue.

Olmes Ognibene funded in 1953 the OGNIBENE company that has become a multinational corporation under the management of Claudio Ognibene, President and CEO since 1975.

Olmes Ognibene is an innovator with a solid knowledge and large competences in the mechanical field. He is author of a number of patents and inventions.

Ognibene is a multinational family-owned company that has been operational on the market for more than sixty years. It is the only company worldwide that produces complete steering systems.

Great attention has also been given to environmental sustainability, with actions aimed at energy conservation and minimal impact on the natural environment.

Ognibene has been pursuing a policy of energy conservation and environmental sustainability for many years. Today the company's commitment to energy efficiency has been further enhanced through the installation of a photovoltaic system in the productive plant in Italy. This power generating system has a capacity of 0.6 MW and so far has produced nearly 2 million kWh, the equivalent of the annual consumption of 620 houses in terms of renewable energy. Moreover, regarding heating, the current installation of condensing boilers ensures energy savings up to 30%.

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KES-SDM 2017**

Conference Timetable

<p><i>KES-SDM 2017</i> <i>Laboratories of Arts, Piazzetta P.P. Pasolini, 5/b, University of Bologna, Bologna</i></p>	
<p><i>Preliminary Meetings, 26 April 2017</i></p>	
14:00	Visits to enterprises in the Bologna Industrial District
18:00	Registration, Reception, Common Area
18:30	Maestro Stefano Malferrari's piano concert, Auditorium Room
19:30	Sustainable Welcome Buffett-Dinner, Common Area
<p><i>The 1st conference day, 27 April 2017</i></p>	
8:00	Registration, Reception, Common Area
9:00	1st Plenary Session, Auditorium Room Greeting from the Institution. A welcome by the General Chair
9:30	<i>Honoured Guest Speech by Dr. Marino Golinelli. Introduced by Emilio Ferrari</i>
9:45	<i>Keynote Speech by Prof. Guenther Seliger. Introduced by Luca Tomesani</i>
10:30	1st Parallel Session G01: Sustainable Design, Innovation and Services, Auditorium Room G02: Sustainable Manufacturing Processes and Technology, Theatre Room G04: Decision Support for Sustainability, Cinema Room
11:10	Coffee Break, Common Area
11:40	2nd Parallel Session G01: Sustainable Design, Innovation and Services, Auditorium Room G02: Sustainable Manufacturing Processes and Technology, Theatre Room G04: Decision Support for Sustainability, Cinema Room
13:00	Lunch, Common Area

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14:00	2nd Plenary Session, Auditorium Room <i>Keynote Speech by Shahin Rahimifard. Introduced by Rossi Setchi</i>
15:00	3rd Parallel Session G03: Sustainable Manufacturing Systems and Enterprises, Auditorium Room G02: Sustainable Manufacturing Processes and Technology, Theatre Room IS04: Sustainable Materials: Renewable and Eco Materials, Bio-Polymers, Composites with Natural Fibres, Cinema Room
17:00	Coffee Break, Common Area
17:30	4th Parallel Session IS11: Eco Designed through Systematic Innovation, Auditorium Room IS10: Sustainable mobility, solar vehicles and alternative solutions, Theatre Room IS08: Sustainability in industrial plant design & management: applications & experiences from practice, Cinema Room
19:30	Closing of the sessions of the first conference day and leaving the venue - Private buses to the Social Dinner place (Savoia Hotel)
20:00	<i>Social Dinner (Savoia Hotel)</i> <i>AITeM-ALAS joint Award Assignment to Olmes Ognibene.</i>
23:30	Leaving the Savoia Hotel - Private buses to the Conference venue
<i>The 2nd conference day, 28 April 2017</i>	
8:00	Registration, Reception, Common Area
9:00	3rd Plenary Session, Auditorium Room Opening: presentation about KES-SDM series of conferences given by Rossi Setchi. Introduced by Robert Howlett
9:30	<i>Keynote Speech by I. S. Jawahir. Introduced by Dario Croccolo</i>
10:30	5th Parallel Session G01: Sustainable Design, Innovation and Services Auditorium Room IS09: Sustainability of 3D Printing and Additive Manufacturing, Theatre Room IS06: Resource and Energy Efficiency for Sustainability Advances in Process Industries, Cinema Room
11:30	Coffee Break, Common Area
12:00	6th Parallel Session G01: Sustainable Design, Innovation and Services Auditorium Room

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	IS09: Sustainability of 3D Printing and Additive Manufacturing, Theatre Room IS06: Resource and Energy Efficiency for Sustainability Advances in Process Industries, Cinema Room
13:00	Lunch, Common Area
14:00	7th Parallel Session IS05: Business model innovation for sustainable design and manufacturing, Auditorium Room IS09: Sustainability of 3D Printing and Additive Manufacturing, Theatre Room IS02: The Learning Supply Chain, Cinema Room
16:00	Coffee Break, Common Area
16:30	4th Plenary Session, Auditorium Room Robert Howlett by KES presents the Awards Assignment: Best presentation and Best paper assignment
17:00	Closing and Farewell

Agenda and Book of Abstract

***Preliminary Meetings
Wednesday, 26 April 2017***

- 14:00 Meeting at the Laboratories of Arts of the University of Bologna.
Visits to enterprises in the Bologna Industrial District.
We will leave the conference venue by private buses. We will be back after the visit with the same private buses.
- 18:00 Registration, Reception, Common Area
- 18:30 Maestro Stefano Malferrari's piano concert, **Auditorium Room**
The piano concert is offered by the Department of Industrial Engineering and the Department of Arts of the University of Bologna
- 19:30 Sustainable Welcome Buffett-Dinner, Common Area
Food and beverages have been prepared by *Azienda Agrituristica Tizzano* (www.agritizzano.it).
The Welcome Buffett-Dinner is offered by the sponsors and the Department of Industrial Engineering.

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1st conference day *Thursday, 27 April 2017*

8:00 Registration, Reception, Common Area

9:00 1st Plenary Session, Auditorium Room

Greeting from the Institution. A welcome by the General Chair

9:30 *Honoured Guest Speech by Dr. Marino Golinelli. Introduced by Emilio Ferrari*

9:45 *Keynote Speech by Prof. Guenther Seliger. Introduced by Luca Tomesani*

Honoured Guest Speaker

Dr. Marino Golinelli

Imprenditore, pioniere, filantropo, visionario | Entrepreneur, pioneer, philanthropy, visionary

Fondatore e Presidente Onorario di Fondazione Golinelli | Founder and Honorary President of Fondazione Golinelli

Nota biografica: Marino Golinelli nasce a San Felice sul Panaro (Modena) l'11 ottobre 1920. Nel 1943 si laurea in Farmacia all'Università di Bologna. Il 24 gennaio 1948 rileva un piccolo laboratorio a Bologna e intraprende un'attività indipendente per la produzione di farmaci. Fonda Biochimici A.L.F.A., poi Alfa Wasserman, colosso dell'industria farmaceutica; nel 2015 si fonde con il ramo italiano di Sigma-Tau, dando vita ad **Alfasigma**.

Nel 1988 fonda la **Fondazione Marino Golinelli**, con l'obiettivo di promuovere l'educazione e la formazione, di diffondere la cultura, di favorire la crescita intellettuale, responsabile ed etica dei giovani, i cittadini del futuro in un mondo globale. Oggi Fondazione Golinelli è l'unico esempio italiano di fondazione privata ispirata al modello delle grandi fondazioni filantropiche americane. Dopo aver già investito nella Fondazione 51 milioni di euro, Marino Golinelli ha messo a disposizione altri 30 milioni di euro per sviluppare e sostenere nei prossimi anni il Progetto Opus 2065. Col tale progetto intende rafforzare la missione etica di Fondazione Golinelli. Golinelli è oggi Presidente onorario di Fondazione Golinelli.

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Nel 2015 realizza l'**Opificio Golinelli**, con un importante intervento di riqualificazione urbana. Si tratta di una cittadella per la conoscenza e la cultura dove si svolge ampia parte delle attività formative, didattiche e culturali che fanno capo alle sei aree progettuali della Fondazione.

Biographical notes: Marino Golinelli was born 11 October 1920 in San Felice sul Panaro (Modena). In 1943 he achieved his Master Degree in Pharmacy at the University of Bologna. In January 1948 he acquired a small independent shop and began producing medicine. He founded Biochimici A.L.F.A., named after Alfa Wasserman, which has grown into a major pharmaceutical company. In 2015, Alfa Wasserman joined the Italian Brand of Sigma-Tau: **Alfasigma** was born.

In 1998, he founded the **Marino Golinelli Foundation** with the aim of promoting Education and Training, spreading scientific culture and supporting the intellectual, responsible and ethical growth of young people, who will be the citizens of the future globalised world. Today, the Marino Golinelli Foundation is one of the few Italian foundations greatly inspired by the large philanthropist-supported American foundations. After an initial investment of 51 Million Euro, Marino Golinelli delivered a further 30 Million Euro with the aim of developing and supporting Project Opus 2065 over the coming years. This project furthers the ethical mission of the Marino Golinelli Foundation. Golinelli is, today, honorary President of the Marino Golinelli Foundation.

In 2015, he realised the **Opificio Golinelli**, a project dedicated to revamping and revitalising urban areas. This is the place where the didactical and cultural activities of the Golinelli Foundation, which are mainly related to six areas, are developed.

Title of Talk: La Cultura del Design per costruire un Mondo Sostenibile | Design Culture for building a Sustainable World

Abstract: not available.

Keynote Speech

Prof. Dr.-Ing. Guenther Seliger

Chair of the GCSM (Global Conference on Sustainable Manufacturing)
TU Berlin - Department Assembly Technology and Factory Management

Biographical notes: Prof. Dr.-Ing. Guenther Seliger studied industrial engineering at the Technical University of Berlin and received his doctorate's degree from Prof. Guenter Spur at the Institute for Machine Tools and Factory Management in 1983. After holding different positions at the Institute for Machine Tools and Factory Management as well as the Institute for Production Systems and Design Technology of the Fraunhofer Society, he became professor and chair of the Department of the Assembly Technology and Factory Management at the Technical University of Berlin in 1988. He was speaker of the Collaborative Research Centre (CRC) 281 "Disassembly Factories for the recovery of Resources in Product and Material Cycles" from 1995 to 2006 as

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well as of CRC 1026 “Sustainable Manufacturing - Shaping Global Value Creation” from 2012 to 2015, both funded by the German National Science Foundation (DFG).

Title of Talk: Leverage of education for sustainable manufacturing

Abstract: There is a lack of capabilities in engineering for emerging sustainable manufacturing needs in practice. Perspectives for proper understanding of industrial engineering as a tool in research, education, training and professional implementation for sustainable value creation by innovative manufacturing are needed. Based on a review of value creation architecture, potentials of industrial engineering are identified in order to contribute to sustainable manufacturing. Industrial engineering education is analyzed and transformed for leveraging sustainable manufacturing. The new framework for industrial engineering education is demonstrated within a case study between an early developed and emerging country.

10:30-11:10 1st Parallel Session

G01: Sustainable Design, Innovation and Services, Auditorium Room

Chairs: Pinar Bilge, Jeremy Bonvoisin

- 1.1 Optimization of Electrical Discharge Machining parameters of Co-Cr-Mo Using Central Composite Design
Soudeh Iranmanesh, Alireza Esmailzadeh, Abbas Razavykia (sdm17-006)

The optimization of electrical discharge machining (EDM) parameters of Cobalt Chromium Molybdenum (Co-Cr-Mo) is performed using central composite design to improve the process efficiency in terms of increasing material removal rate and electrode utilization time. The effects of pulse on time, pulse off time, voltage and current on electrode wear rate (EWR) and material removal rate (MRR) have been examined. The experimental results indicate that higher pulse on time, lower pulse off time, 100 v to 110 v for voltage and current at the range of 8 to 9 A are the adequate selection to achieve higher MRR and lower EWR.

- 1.2 Latent Semantic Indexing for capitalizing experience in inventive design
Pei Zhang, Cecilia Zanni-Merk, Denis Cavallucci (sdm17-005)

The growing complexity of the design activity in an innovation and sustainable context requires experience reuse as a means to limit unsustainable investments. It is a crucial task for both academic and industrial communities to find ways to efficiently capture and reuse past experience. Case-based reasoning (CBR) is a research paradigm that stores experience as a knowledge unit to solve a new problem from the previous design experience. A well-established method for inventive design is IDM (the Inventive Design Methodology). Its most widely used tool to solve a problem is the “Contradiction Matrix” associated with forty inventive principles. The correct use of these tools needs the mapping from freely expressed text (Specific Parameters or SPs) into a well-established set of Generic Engineering Parameters (or GEPs). This mapping requires expertise and may, if inappropriately used, lead to weak results. This paper introduces the Latent Semantic Indexing (LSI) algorithm to discover the implied semantic relations between SPs and GEPs coming from past experience. A semantic space based on the LSI results is built for guiding retrieval in case-based reasoning.

**G02: Sustainable Manufacturing Processes and Technology, Theatre Room
Chair: Peter Ball**

- 2.1 Improvement of Sustainability through the Application of Topology Optimization in the Additive Manufacturing of a Brake Mount
Stefan Junk, Claus Fleig, Björn Fink (sdm17-004)

In recent years, the additive manufacturing processes have rapidly developed. The additive manufacturing processes currently present a high-performance alternative to conventional manufacturing methods. In particular, they offer the opportunity of previously hardly imaginable design freedom, i.e. the implementation of complex forms and geometries. This capability can, for example, be applied in the development of especially light but still loadable components in automotive engineering. In addition, waste material is seldom produced in additive manufacturing which benefits a sustainable production of building components. Until now, this design freedom was barely used in the construction of technical components and products because, in doing so, both specific design guidelines for additive manufacturing and complex strength calculations must be simultaneously observed. Yet in order to fully take advantage of the additive manufacturing potential, the method of topology optimization, based on FEM simulation, suggests itself. It is with this method that components that are precisely matched and are especially light, thereby also resource-saving, can be produced. Current literature research indicates that this method is used in automotive manufacturing for reducing weight and improving the stability of both individual parts and assembly units. This contribution will study how this development method can be applied in the example of a brake mount from an experimental vehicle. In this, the conventional design is improved by means of a simulation tool for topology optimization in various steps. In an additional processing step, the smoothing of the thus developed component occurs. Finally, the component is generatively manufactured by means of selective laser melting technology. Models are manufactured using binder jetting for the demonstration of the process. It will also be determined how this weight reduction affects the CO₂ emissions of a vehicle in use.

- 2.2 A tool to promote sustainability in casting processes: development highlights
Emanuele Pagone, Mark Jolly, Konstantinos Salonitis (sdm17-055)

The validity of traditional manufacturing decision variables (i.e. cost, quality, flexibility and time) is questioned by some important challenges of our time: the scarcity of natural resources and environmental pollution. Increasing energy cost to extract and process natural resources, alongside regulatory pressures against pollution, pushes very mature and competitive processes like casting towards a holistic approach where sustainability contributes to strategic decisions together with the mentioned traditional manufacturing variables. As a contribution to this industrial necessity, a modular tool able to analyse material and energy flows in casting processes is under development. In particular, the ability to represent automatically Sankey diagrams of the flows recently implemented is described and validated.

**G04: Decision Support for Sustainability, Cinema Room
Chair: Elliot Woolley**

- 4.1 Sustainable Design: an Integrated Approach for Lightweighting Components in the Automotive Sector
Dattilo C. A., Zanchi L., Del Pero F, Delogu M. (sdm17-021)

In past years the European Union (EU) set targets to reduce emissions in order to encourage and develop a more sustainable society. As a consequence of this carmakers began to study new materials and innovative technologies in order to lightweight their vehicles, thus reducing use stage fuel consumption and environmental impact. A promising

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strategy for this is replacing steel with composites although the adoption of these materials often involves negative effects on production and End-of-Life (EoL) stages. For this reason, a comprehensive assessment of the entire component Life Cycle (LC) is needed, not only in terms of environmental issues but also economic and social ones. This paper presents a sustainable design approach based on TOPSIS methodology functional to compare different design solutions in the automotive sector; the approach is also validated by an application to a real case study.

- 4.2 A Monitoring and Data Analysis System to Achieve Zero- Defects Manufacturing in Highly Regulated Industries
Theocharis Alexopoulos, Michael Packianather (sdm17-022)

In order to become more competitive, manufacturing companies exploit new technologies and practices that can improve their production efficiency, and reduce the number of rejected products. This work is about a Monitoring and Data Analysis System (MDAS), a software system that combines data mining, neural networks modelling and graphical data analysis to assist the company in identifying patterns, trends or problems that increase the risk of rejected products. A pilot version of the proposed system is tested on two production lines of a pharmaceutical company and has identified previously unknown patterns and trends that were hindering the quality of the end product. Since the operation of the proposed system does not affect the production it is suitable for industries bound by strict regulation. In general, the proposed system could be adopted for other products and industries.

11:10 Coffee Break, Common Area

11:40-13:00 2nd Parallel Session

G01: Sustainable Design, Innovation and Services, Auditorium Room

Chairs: Pinar Bilge, Jeremy Bonvoisin

- 1.3 Sustainable Data Collection Framework: Real-Time, Online Data Visualization
Tien-Lung Sun, Gustavo Adolfo Miranda Salgado (sdm17-010)

This paper presents a comprehensive data collection framework focused on retrieving data from an inertial sensor using a smartphone device. The aim of this study is to present a low-cost and sustainable data collection framework solution based on previous data framework model developed. The proposed framework will allow the users (doctors, physicians, patients, family members, etc.) to visualize online the real-time performance results, as the patient carries out its physical therapy. The data collection framework utilizes an in-house developed smartphone app and open source software for the server/client interaction. The data collection framework has been tested by collecting information from different exercise machines and free movement exercises. The tests show that the real-time data collection framework proposed is reliable in capturing, recording and displaying the data obtained during a training exercise session, aiming toward the tracking people's quality of life.

- 1.4 Performance Analysis on Fitness Equipment: Application of an Inertial Sensor toward Quality of Life
Gustavo Adolfo Miranda Salgado, Tien-Lung Sun (sdm17-011)

Exercise is important for people's quality of life, and nowadays, motion assessment has been a significant part to monitor and evaluate physical factors of people on daily basis, such as activity trackers and fit bands. Some of the issues while performing motion assessment are the use of bulky sensors, data collection restrictions, limited access to data, inability to perform further analysis of the data, etc. To address some of these problems, a data collection framework was developed with the use of a low-cost inertial sensor, and tested on three different fitness equipment. The collected data was analyzed by associated to the signal to a series of performance metrics with the aid of visual

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interpretation. Based on the benchmark findings, the proposed approach has proven to be a viable way to analyze the data with the deployed tools, concise with the user's exercise performance while using the different fitness equipment.

- 1.5 Design Principles for Do-It-Yourself Production
Jérémy Bonvoisin, Jahnavi Krishna Galla, Sharon Prendeville (sdm17-012)

The increasing access of people to fabrication capabilities has stimulated the emergence of personal fabrication settings and inspired post-industrial production scenarios. One strategy to support personal production is to increase technology literacy and access for citizens to means of production. Yet, so far, the deliberate design of products so they can be realized by individuals, an activity termed here as “design for do-it-yourself (DIY) production”, has been under-explored in academia. The present article aims to formalize the know-how gained by practitioners who designed products for production in do-it-yourself settings. It provides an original definition of DIY and the formulation of 14 design principles for DIY production to support practice.

- 1.6 Establishment of Engineering Metrics for Upgradable Design of Brake Caliper
Nurhasyimah Abd Aziz, Dzuraidah Abd Wahab, Rizauddin Ramli (sdm17-018)

Design for upgradability is one of the strategies in a remanufacturing process that can help to improve the features of a product in terms of performance and functions. This paper presents a study on the performance evaluation of a product at the engineering metric level for upgrade purpose. A brake caliper was used as a case example in which brake test was conducted to measure the brake pedal force. The brake pedal force values are used to measure the brake torque which represents the performance of the brake caliper. The upgradability of the brake caliper is then evaluated in view of improving the current design. This paper also proposed and discussed future work on the upgradability of the automotive component.

G02: Sustainable Manufacturing Processes and Technology, Theatre Room

Chair: Peter Ball

- 2.3 Sustainability of die-assisted quenching technology and comparison with traditional processes
Giampaolo Campana, Fabio Lenzi, Francesco Melosi, Andrea Zanotti (sdm17-053)

The open tank oil quenching process is a traditional heat treatment that gives the final microstructures and performance to high quality mechanical parts, typically made by alloyed steels. Due to the microstructure transformations that occur during a heat treatment, the heat treated mechanical part is subjected to shape modifications and distortions. In order to match design tolerances, a machining allowance must be planned and re-machining operations must be realised. The die-assisted oil quenching process utilises a hydraulic press in order to apply a high pressure through a die to the mechanical part during the cooling stage of the heat treatment. The force exerted by the die on the part determines a reduction of distortions along with the control of the shape and of certain dimensions depending on the part geometry and the die design. In the present paper, the technical sustainability of the die-assisted oil quenching process is discussed and compared with the traditional heat treatment in terms of distortion control and reduction of machining operations.

- 2.4 Supply Chain Major Disruptions and Sustainability metrics: A case study
Luisa Huaccho Huatuco, Guljana Shakir Ullah, Thomas F. Burgess (sdm17-060)

Major Disruptions and Sustainability metrics in supply chains (SCs) are presented by means of a case study involving a large manufacturing organisation. The main findings point to four main strategies which organisations could use in the face of disruptions, namely: maintaining stock, sharing information, disaster management planning, and pursuing

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initiatives with suppliers (e.g. dual sourcing, outsourcing, SC visibility and risk modelling). The sustainability metrics indicate that being successful at managing disruptions in SCs does not preclude manufacturing organisations from also being successful in the sustainability dimensions of the triple bottom line.

- 2.5 Multi-Layer Stream Mapping: Application to an injection moulding production system
M. N. Gomes, A. J. Baptista, A. P. Guedes, I. Ribeiro, E. J. Lourenço, P. Peças (sdm17-061)

The Multi-Layer Stream Mapping (MSM) methodology addresses current challenges regarding the applicability of Lean Thinking concepts in the domain of sustainability assessment tools. Therefore, MSM aims to assess the overall performance of a production system, while evaluating the productivity and efficiency of resource utilization as well as evaluate the costs related to missuses and inefficiencies and other process and domains variables. This paper highlights the benefits arising from the application of the MSM methodology in a real industrial case regarding the injection moulding process, namely fostering the quantification of the efficiency of different resources streams, for its improvement, for the several production processes involved. So, it is explained how MSM can contribute for a more sustainable production system with a continuously increasing productivity.

- 2.6 Sustainability of Micro Electrochemical Machining: Discussion
Mina Mortazavi, Atanas Ivanov (sdm17-065)

Micro electrochemical machining is one of the promising non-conventional machining methods which has created new horizon in Micro and Nano product technologies including MEMS, defense, medical and automobile industries. An existing challenge in manufacturing has been known as the lack of identified methodology and measurement science to evaluate the sustainability of the process performance. This challenge would be more critical when it comes to Micro and Nano manufacturing process. This paper presents a review on challenges encountered in micro electrochemical machining considering it as a sustainable manufacturing process.

G04: Decision Support for Sustainability, Cinema Room

Chair: Elliot Woolley

- 4.3 A multi-criteria decision-making model to evaluate sustainable product designs based on the principles of Design for Sustainability and Fuzzy Analytic Hierarchy Process
Chanjief Chandrakumar, Asela K. Kulatunga, Senthana Mathavan (sdm17-103)

The exponential and adverse increase in global conditions like climate change, ocean acidification and aerosol loading stresses the urgency to achieve sustainable development in all global activities, including manufacturing. Despite the attempts of developing disparate approaches and concepts at different scales of economies, the global issues are still worsening. As a consequence, United Nations Environment Programme (UNEP) has introduced the concept of Design for Sustainability (DfS) to evaluate the sustainability aspects of product designs, acknowledging the importance of developing sustainable products (and services). Even though the DfS approach has been recognised as an appropriate base to establish a sustainable global economy, the scope of the assessment still requires further research, specifically with the social impacts assessment. Hence, in this study, we propose a multi-criteria decision support system based on the DfS principles, including an exhaustive set of criteria referred in the Social Life Cycle Assessment framework for the purpose of evaluating three chosen sanitation system designs. We applied the Fuzzy Analytic Hierarchy Process to solve the proposed model. Additionally, a sensitivity analysis was performed to understand the effects of the chosen priority weights. The analysis shows that the sanitation system design choice is heavily influenced depending on whether the high importance the packaging and logistics phase or the usage phase, emphasising the need for a comprehensive life-cycle analysis. The research reported in this paper is a step toward realising the targets of DfS at a practice level by simultaneously building on the original proposals and using them to solve real word design selection problems.

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- 4.4 Assessing sustainability within organizations: The Sustainability Measurement and Management Lab (SuMM)
Mariolina Longo, Matteo Mura (sdm17-072)

Sustainability measurement represents a key element if companies aim to translate sustainability from compliance with standards to core organizational asset. This paper presents the development of a structured dataset of European companies – named as Sustainability Measurement and Management (SuMM) Lab– that aims to assess company’s performance accordingly to sustainability metrics. Data have been collected on a pilot sample of 400 Italian companies and the results provide insights on how SuMM Lab could be exploited to assess the diffusion of sustainability practices in organizations.

- 4.5 Eco-Intelligent Factories: Timescales for Environmental Decision Support
Elliot Woolley, Alessandro Simeone, Shahin Rahimifard (sdm17-051)

Manufacturing decisions are currently made based on considerations of cost, time and quality. However, there is increasing pressure to also routinely incorporate environmental considerations into the decision making processes. Despite the existence of a number of tools for environmental analysis of manufacturing activities, there does not appear to be a structured approach for generating relevant environmental information that can be fed into manufacturing decision making. This research proposes an overarching structure that leads to three approaches, pertaining to different timescales that enable the generation of environmental information, suitable for consideration during decision making. The approaches are demonstrated through three industrial case studies.

- 4.6 A Combination of Life Cycle Assessment and Knowledge Based Engineering to evaluate the Sustainability of Industrial Products
Giampaolo Campana, Mattia Mele, Barbara Cimatti (sdm17-030)

The Life Cycle Thinking and the Knowledge Based Engineering approaches can be integrated in order to allow a preliminary-rough but effective Life Cycle Assessment, since the first phases of the design of an industrial product. In the present paper, we propose a general framework considering a number of different aspects, mainly concerning the manufacturing choices, but also related to the design of the product. The aim is to overcome the eco design paradox and to provide a tool supporting designer during the product concept to increase its sustainability.

13:00 Lunch, Common Area

14:00-15:00 2nd Plenary Session, Auditorium Room

Keynote Speech by Shahin Rahimifard. Introduced by Rossi Setchi

Prof. Shahin Rahimifard

Professor of Sustainable Engineering, BSc MSc PhD CEng FIMechE FHEA
Centre for Sustainable Manufacturing and Reuse/Recycling Technologies (SMART)

Biographical notes: Shahin Rahimifard is a Professor of Sustainable Engineering (since April 2009) at Loughborough University and the Founder and Director of the Centre for “Sustainable Manufacturing and Recycling Technologies (SMART)” [www.lboro.ac.uk/smart], which was established in 2004. His research work is focused on sustainability issues throughout a ‘Product Lifecycle’, including projects on sustainable product design, resource efficient manufacturing, sustainable business models, and reuse and recycling

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technologies. These projects have benefited from involvement of a number of high profile global manufacturers and retailers, which include Rolls-Royce, Jaguar Land Rover, GM, Nike, Clarks, Next, Unilever, PepsiCo, Marks and Spencer, and Tesco.

Professor Rahimifard is currently the Deputy Director of a UK National Centre for 'Innovative Food Manufacturing' in which he is leading a wide range of research ranging from 'resource efficient localised production of food products' and 'valorisation of food waste for human nutrition' to 'embedding resilience within global food supply chain'.

Professor Rahimifard is the Editor-in-Chief of the 'International Journal of Sustainable Engineering [www.tandf.co.uk/journals/tsue]', the inaugural issue of which was published by Taylor and Francis in January 2008.

Title of Talk: Forging new frontiers in sustainable food manufacturing

Abstract: One of the most prominent challenges commonly acknowledged by modern manufacturing industries is 'how to do more with less?' Nowhere is this more true than in the food sector due to the well documented concerns regarding the long term availability and security of food resources. The loss of arable land linked to climate change, the rapidly increasing global population, and changes in demand and dietary behaviours both within developed and developing countries urgently demands a need to change the way we grow, manufacture and consume our food products. The unique attributes of food products such as the need for fresh perishable ingredients, health risks associated with inappropriate production environment, stringent storage and distributions requirements together with relatively short post-production shelf-life makes them considerably different to other manufactured goods. This paper discusses a number of key research challenges facing modern food manufacturers, including improved productivity using fewer resources, valorisation of food waste, improving the resilience of food supply chains, localisation of food production, and utilisation of new sustainable sources of nutrition for provision of customised food products.

15:00-17:00 3rd Parallel Session

G03: Sustainable Manufacturing Systems and Enterprises, Auditorium Room

Chair: Daniel Eyers

- 3.1 Sustainable Manufacturing for Thai Firms: A Case Study of Remanufactured Photocopiers
Jirapan Chaowanapong, Juthathip Jongwanich

(sdm17-007)

Remanufacturing represents a significant mean encouraging sustainability. This paper aims to investigate the critical factors influencing the decisions of firms to engage in remanufacturing through conducting a case study of Thai remanufactured photocopiers employing qualitative and quantitative approaches. The results show that business feasibility is the prominent determinant driving firms' decisions, followed by firm's strategic factors, and policy factors. Totally derived from the area of business feasibility, as the top four individual factors, financial aspects is ranked first as the most critical factor influencing remanufacturing, followed by availability of skilled workers, product maturity, and technical aspects. Firm-level characteristics matter significantly in ranking the factors. Concrete support by

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government towards implementing comprehensive policies is needed to strengthen remanufacturing development in Thailand.

3.2 Steps in organisational environmental change: similarities across manufacturing sectors

Peter Ball

(sdm17-039)

With increasing expectations on manufacturers to show leadership in reducing the negative environmental and social consequences of their operations, there are many examples of successful journeys towards sustainability. Potentially there are common steps in how organizations change and these could be common across different sectors. This research seeks to uncover what companies do to instigate and create momentum in their organization and what commonality exists. Seven steps were identified through analyzing case data across companies operating in different sectors. The steps of vision, leadership, education, simplicity, pilot, momentum and broadcast are presented and the implications for further research assessed.

3.3 From the Treatment of Olive Mills Wastewater to its Valorisation: Towards a Bio-Economic Industrial Symbiosis, Y. Mouzakitīs, R. Aminalragia-Giamini, E. D. Adamides

(sdm17-040)

Although there is a significant progress in treatment technologies, Olive Mills Wastewater (OMWW) remains a source of environmental degradation to olive-oil producing regions. In this paper, the management of OMWW is examined as a trigger for a bio-economic industrial symbiosis, based on the valorisation of OMWW for bi-polymers and bioenergy production. In addition, the valorisation of OMWW is considered in an eco-industrial context, as a node of a wider network of material, energy and information exchanges. The aim of the paper is to discuss the benefits and the feasibility of such a venture from a technical, economic, as well as social perspective using the context of a specific prefecture in Greece as a reference implementation environment.

3.4 A Case Study of Sustainable Manufacturing Practice: End-of-Life Photovoltaic Recycling

Jun-Ki Choi

(sdm17-070)

The usage of valuable resources and the potential for waste generation at the end of the life cycle of photovoltaic (PV) technologies necessitate a proactive planning for a PV recycling infrastructure. To ensure the sustainability of PV in large scales of deployment, it is vital to develop and institute low-cost recycling technologies and infrastructure for the emerging PV industry in parallel with the rapid commercialization of these new technologies. There are various issues involved in the economics of PV recycling and this research examine those at macro and micro levels, developing a holistic interpretation of the economic viability of the PV recycling systems. This study will present mathematical models developed to analyze the profitability of recycling technologies and to guide tactical decisions for allocating optimal location of PV take-back centers (PVTBC), necessary for the collection of end of life products. The economic decision is usually based on the level of the marginal capital cost of each PVTBC, cost of reverse logistics, distance traveled, and the amount of PV waste collected from various locations. Results illustrated that the reverse logistics costs comprise a major portion of the cost of PVTBC; PV recycling centers can be constructed in the optimally selected locations to minimize the total reverse logistics cost for transporting the PV wastes from various collection facilities to the recycling center. In the micro- process level, automated recycling processes should be developed to handle the large amount of growing PV wastes economically. The market price of the reclaimed materials are important factors for deciding the profitability of the recycling process and this illustrates the importance of the recovering the glass and expensive metals from PV modules.

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- 3.5 Supply Chain Risk Management for Sustainable Additive Manufacturing
Daniel R Eyers (sdm17-083)

Additive Manufacturing technologies are becoming increasingly prevalent in commercial practice, and as a result attention is gradually being devoted to their implications for sustainability and supply chain management. One pertinent topic for these technologies remaining largely unexplored is that of Supply Chain Risk Management. This paper serves to provide an initial contribution in the form of a conceptual framework to identify risk sources, consequences, responses and controls from a sustainability perspective, and provides directions for future research on this topic.

- 3.6 Implementation of an advanced automated management system for the optimization of energy and power terms in a Water Purification Plant (WPP) with a photovoltaic plant (PP)
J. Chazarra Zapata, I. Yahyaoui, J. Castellote Martínez, J. M. Molina-Martínez, M. Estrems Amestoy, A. Ruiz Canales (sdm17-100)

Currently, the use of software systems for optimizing the sustainable use of water and energy resources has been implemented in a wide range of productive sectors. In the sector of Water Purification Plants (WPP) the sustainable control of water and energy consumption is carried out by means of advanced Supervisory Control And Data Acquisition (SCADA) systems. The main objective of these SCADA systems is controlling the consumption of these resources in real time. In the majority of the occasions, optimization systems for the sustainability consumption of these resources are not integrated in the SCADA system. With the integration of systems for optimization, the determination in real time of the most viable option for the sustainable management of resources is expected. In this paper, a case study in the Southeast Spain of an advanced automated management system for the optimization of energy and power terms in a WPP with renewable energy based in a Photovoltaic Power Plant (PVPP) is presented. Firstly, the introduction and some additional details for the entire problem are presented. Moreover, the main parts of the software integrated in the SCADA system of the WPP will be detailed.

G02: Sustainable Manufacturing Processes and Technology, Theatre Room

Chair: Michele Dassisti

- 2.7 Application of Design for Environment principles combined with LCA methodology on automotive product process development: the case study of a crossmember
S. Maltese, M. Delogu, L. Zanchi, A. Bonoli (sdm17-081)

The existing Community regulation pushes the carmakers to design eco-sustainability of the vehicle over its life cycle to limit the consequences of the current state and the expected growth of the sector. In this sense, one of the primary aim is reducing raw materials consumption and emissions through the adoption of innovative materials and technologies. This implies the need for the carmakers to integrate Design for Environment (DfE) principles at the early Research and Development (R&D) stage. The article presents a concrete example of integration of DfE and LCA methodology application in the R&D process of a vehicle component produced by Magneti Marelli. The study allowed drawing a balance between the advantages of a lightweight solution with respect to the standard one both from performance and environmental point of view.

- 2.8 A Conceptual Framework to support Decision-Making in Remanufacturing Engineering Processes
Awn Alghamdi, Paul Prickett, Rossitza Setchi (sdm17-093)

Remanufacturing is a promising industrial activity where products and materials are upgraded and considered for at least another life cycle. In addition to being an environmentally conscious action, remanufacturing has the potential to support circular economy within which significant profit opportunities exist. However, high levels of uncertainty can

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be experienced during, before and after remanufacturing. This makes its planning stochastic and hard to control. As each component or product is different, with for example high levels of geometrical variation; they may require a unique strategy and process planning. To aid this process, a conceptual decision making framework to support process planning of remanufacturing engineering processes (REP) is proposed. Quality Function Deployment (QFD) method is employed to support the proposed framework (hereafter referred to as REP-QFD). The application of the QFD based methods rely heavily on inputs from experts, in the form of their experience and knowledge. The paper considers how the proposed framework can be engineered with the aim to substantially reduce this reliance on experts and their expertise. The term “Engineering” here reflects the study’s focus on technical decisions at the reconditioning stage. To further support the framework a taxonomy of metal manufacturing/remanufacturing processes is also developed.

- 2.9 Optimized production process of a supporting plate as an improvement of the product sustainability
G. Bertuzzi, S. Di Rosa, G. Scarpa (sdm17-101)

The main goal of the described activity is the verification of an innovative production process of a steel supporting plate by using numerical simulation. The normal production process consists of different phases and processes: the laser cutting of blanks, welding, stress relieving, heat treatment and machining. The studied alternative is a sand casting process in order to directly obtain the final supporting plate. Numerical simulations were used to investigate the impact behavior of complex products in order to define the best production solution. The new design chain represents an important simplification in order to reach a simpler, less expensive and more sustainable manufacturing process and these aspects were confirmed performing a Life Cycle Assessment.

- 2.10 Cross-Functional Mapping to link Lean Manufacturing and Life Cycle Assessment in Environmental Impact Reduction
Jun T. Leong, Wai M. Cheung (sdm17-003)

In industry, carbon emissions are mainly produced from the amount of energy used in the manufacturing processes due to the burning of fossil fuels, material of products and transportation. The aim of this paper is to report the synergy of integrating life cycle assessment (LCA) and Lean manufacturing to reduce the negative environmental impacts of a plastic injection moulded product. A cross-functional mapping method is used because a number of functional areas such as Lean manufacturing and LCA are involved. This work demonstrated that the adaptation of lean thinking and LCA could minimise negative environmental impacts of a product significantly.

- 2.11 Combining Process Based Monitoring with Multi-Layer Stream Mapping
D. Fisseler, A. Schneider, E. J. Lourenço, A. J. Baptista (sdm17-033)

For a company it is important to improve resource and eco-efficiency in order to save money, the environment and to improve the company's image. We present a new approach combining Multi-layer Stream Mapping (MSM) and a Business Process Based Monitoring and Control Framework to monitor relevant process variables and use the values as an input for MSM to reduce waste and costs. This combination supports the decision making process and allows to identify major inefficiencies and provides means for more sustainability.

- 2.12 Cryogenic delamination and sustainability: analysis of an innovative recycling process for photovoltaic crystalline modules
M. Dassisti, G. Florio, F. Maddalena (sdm17-014)

The increasing rate of production and diffusion of photovoltaic (PV) technologies for industrial and domestic applications urges improvement of the sustainability of their demanufacturing processes in order to reduce the amount of electronic wastes. Sustainability of demanufacturing processes concerns the reduction of energy consumption, the reduction of polluting substances as well as the reduction of the effort spent in recovery of the components. No optimal process exists so far, provided a number of different approaches have been devised. A promising choice relies

on the use of thermo-mechanical treatments for inducing a delamination process where interfacial bonding between layers are weakened and, finally, broken inducing separation of the layers. In this view, in this paper we present a preliminary industrialization study, based on Finite Element (FE) Analysis, to prove the validity of the new sustainable demanufacturing process endeavouring the delamination process. The analysis is performed searching the optimal thermally induced cycles at cryogenic temperatures. We finally show that it is possible to induce the delamination according to specific operating temperatures.

IS04: Sustainable Materials: Renewable and Eco Materials, Bio-Polymers, Composites with Natural Fibres, Cinema Room

Chair: Mario Domingo Monzón Verona

- 8.1 Developing fiber and mineral based composite materials from paper manufacturing by-products
Cynthia Adu, Mark Jolly (sdm17-013)

Developing valuable materials from the by-products of paper industry can help to address some environmental and economic issues associated with traditional synthetic composites. Particularly, the management of paper mill sludge (PMS) waste remains an economic and environmental challenge for the pulp and paper industry. 11 million tons of PMS is generated annually in Europe from the waste water treatment (WWT) process of paper mills. PMS is mostly used in low value applications. However, PMS contains fibers and minerals with physic-chemical properties that exhibit a high potential to substitute some conventional materials in other industries. The research presented in this paper aims to explore new directions for further investigation on PMS material applications by reviewing the literature on PMS materials and subsequently characterizing sludge from 6 different mills. The study shows the technical feasibility, opportunities and technological readiness of fiber and mineral based composites obtained from PMS, such as; cementitious products, polymer reinforcement and fiberboards.

- 8.2 Sustainable Carbododiimine and Triazine reagents as collagen cross-linking agents in the presence of PAMAM Dendrimers
V. Beghetto, L. Agostinis, V. Gatto, R. Sole, D. Zanette, S. Conca (sdm17-026)

This work reports a general outline on sustainable technologies for the stabilization of collagen and comparative study of 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide (EDC) versus 4-(4,6-dimethoxy[1,3,5]triazin-2-yl)-4-methyl-morpholinium chloride (DMTMM) as cross-linking agents of collagen powder. The cross-linking efficiency of these agents on collagen matrixes in the presence of different polyamidoamine dendrimers (PAMAM) has been tested in order to determine the influence of steric hindrance and aminic groups abundance.

- 8.3 Banana Fiber Processing for the Production of Technical Textiles to Reinforce Polymeric Matrices
Z. Ortega, M. Monzón, R. Paz, L. Suárez, M. Morón, M. McCourt (sdm17-043)

Banana fibers have been extracted by mechanical means from banana tree pseudostems, as a strategy to re-evaluate banana crops residues. Extracted long fibers are cut to 45 mm length and then immersed into an enzymatic bath for their refining. Conditions of enzymatic treatment have been optimized to produce a textile grade of banana fibers, which have then been characterized. This fiber has then been transformed into yarns and woven to produce a technical textile with different textile structures. Woven material was then used to produce a composite by compression molding, using polypropylene (PP) as polymeric matrix.

Once the composite was prepared, mechanical testing was carried out (tensile, flexural and impact tests). Results were compared to those obtained with parts made only of PP and with results composite made with a commercial woven product made of flax.

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- 8.4 Experimental investigation into the use of natural reinforcements for sustainable composite materials
M. Del Borrello, M. Secchi, G. Campana, M. Mele (sdm17-080)

The present work investigates the manufacturability of different composites reinforced with natural fibres that are hemp and bamboo vinyl. Feasibility of different processes were studied and mechanical properties of obtained composite materials were examined by using non-destructive analysis and tensile tests to assess the manufacturability. Hemp fibres were manufactured by using braiding technology to produce differently oriented textiles. Bamboo reinforcement were employed in form of vinyl sheets. Matrices were made of traditional or innovative polymeric materials. The composite materials were processed through Resin Transfer Moulding (RTM) or Resin Powder Moulding (RPM). Applicability onto different shapes were assessed.

The obtained material performances have been compared with both analytical and numerical models to evaluate their applicability.

Eventually, results are discussed pointing out foreseen opportunities for the industrial application of investigated materials.

- 8.5 The effects of the industrial processing on commercial polyhydroxyalkanoates
Laura Mazzocchetti, Tiziana Benelli, Emanuele Maccaferri, Loris Giorgini (sdm17-085)

In the last years polyhydroxyalkanoates (PHAs) gained increasing attention as potential sustainable replacement of current plastics from fossil sources. PHAs are biodegradable polymers which can be produced from bacteria exploiting waste as feedstock. In order to bring these polymers on the market, it is necessary to know their properties and assess the effects of industrial processing stages on the final material. For this reason, in this work different industrial PHAs were investigated. These materials were structurally characterized and their thermal properties were assessed. Furthermore, they were subjected to different thermal and thermo—mechanical treatments (various time, temperature and frequency of rotation in the extruder) in order to study the effect of the applied conditions on the properties of the final material.

- 8.6 Pyrolysis of low-density polyethylene in an innovative batch pilot plant: influence of the temperature on product distribution and gas composition
G. Zattini, C. Leonardi, L. Mazzocchetti, M. Cavazzoni, I. Montanari, C. Tosi, T. Benelli, L. Giorgini (sdm17-095)

Pyrolysis of low-density polyethylene in an innovative batch pilot plant, with a hydraulic guard ensuring a safe process, was performed. The influence of process temperature on yield, distribution and composition of products was investigated. The oil/waxes were analyzed by gas chromatography coupled mass spectrometry, while pyrolysis gas was monitored online during the process by micro-gas chromatography. Pyrolysis were carried out at 450, 500, 550 and 600 °C. Results obtained show that low temperatures yield a greater amount of oil/waxes, and a gas enriched in carbon oxides and C3+ hydrocarbons. At higher temperatures, the gas fraction, riche in methane and hydrogen, is predominant over liquid products. This process has proved to be a versatile way to recover polyethylene wastes into valuable oils (rich in aliphatic and simple aromatic hydrocarbons) or gas, to be used as petrochemical feedstock or fuel, thus providing a sustainable method for material and energy recovery of waste packaging.

17:00 Coffee Break, Common Area

17:30-18:50 4th Parallel Session

IS11: Eco Designed through Systematic Innovation, Auditorium Room

Chair: Davide Russo

Ind02 Conscious and Innovative design with solidThinking Evolve and Inspire

Adel Matar (SolidThinking, www.solidthinking.com), **Riccardo Bianco** (Weisoft, www.weisoft.it)

SOLIDTHINKING EVOLVE 2017: THE ULTIMATE HYBRID MODELING AND RENDERING SYSTEM. Evolve is a high quality 3D Hybrid Modeling and Rendering environment that enables industrial designers to evaluate, research and visualize various designs faster than ever before. Evolve runs on both Mac OS X and Windows.

EVOLVE
solidThinking



SOLIDTHINKING INSPIRE 2017.1: GAUGE OPTIMIZATION, MOTION, TOPOGRAPHY OPTIMIZATION, AND MORE! solidThinking Inspire allows design engineers, product designers and architects to investigate structurally efficient concepts quickly and easily. This can lead to reduced costs, development time, material consumption, and product weight.

SOLIDTHINKING EVOLVE 2017: THE ULTIMATE HYBRID MODELING AND RENDERING SYSTEM

solidThinking Evolve is an all-in-one industrial design tool that allows industrial designers to develop and explore forms faster than ever before. It enables users to capture an initial sketch, explore styling alternatives, and visualize products with best-in-class renderings generated in real time. Evolve provides organic surface modeling and parametric solid controls, and polygonal modeling with NURBS-based surfaces and solids and a unique ConstructionTree history feature. It frees designers from the constraints of engineering-oriented CAD tools, while allowing the export of digital models required by others in the product development process.



SOLIDTHINKING INSPIRE 2017.1: GAUGE OPTIMIZATION, MOTION, TOPOGRAPHY OPTIMIZATION, AND MORE!

solidThinking Inspire enables design engineers, product designers, and architects to create and investigate structurally efficient concepts quickly and easily. Traditional structural simulations allow engineers to check if a design will support the required loads. Inspire enhances this process by generating a new material layout within a package space using the loads as an input. The software is easy to learn and works with existing CAD tools to help design structural parts right the first time, reducing costs, development time, material consumption, and product weight.

15.1 How to build guidelines for Eco-improvement

Davide Russo, Caterina Rizzi, Christian Spreafico

(sdm17-056)

Over the last 30 years the number of methods for Eco-design increased dramatically. LCA in Eco-assessment has established itself as a reference methodology and with it some tools that reached an international resonance. On the contrary, in the Eco-improvement world, the growth of methods has not been accompanied by a method or a tool better than other ones. One of the main reasons is the different type of users; there are people skilled in problem solving and those who have no experience. In addition, in order to be universal, the methods based on guidelines often do not go into too much detail, thus limiting their effectiveness. The balance between completeness and simplicity is the key issue around which the authors have attempted in recent years.

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In such a context, this paper aims at solving this contradiction and proposes an ontological framework to build guidelines for eco-improvements. Their content has been structured into five parts, according to well-known conceptual design frame-works, such as Function-Behaviour-Structure (FBS) methods and similar. The result is a set of over than two hundred suggestions that can be comfortably used through a web portal following a recommended step-by-step methodological path.

- 15.2 QFD and TRIZ to Sustain the Design of Direct Open Moulds
G. Caligiana, A. Liverani, D. Francia, L. Frizziero, G. Donnici (sdm17-067)

Sustainable design aims at the creation of physical objects, environment and services that complies to optimize social, economic, and ecological impact. QFD is able to assess the product design by the choice and definition of parameters that can be qualitatively discussed. The purpose of design is to meet a need in new ways and in innovative ways. In this context, the QFD aims at evaluating the quality of a design process. TRIZ is a design method that aim at defining and overcome some critical issue that can affect the development of a product, by means of potential innovative solutions. In this paper QDF and TRIZ analysis have been adopted in order to validate a design method for direct open moulds, by a new strategy: hybrid manufacturing can reduce the production time, the use of material, the energy and the waste consumption, employing subtractive and additive techniques efficiently combined.

- 15.3 An industrial application of a TRIZ based Eco-design approach
Davide Russo, Caterina Rizzi, Pierre-Emmanuel Fayemi (sdm17-073)

ITree, a step by step procedure for supporting eco-assessment and eco-design is presented. The assessment phase is carried out combining life cycle assessment, for calculating the environmental impacts, with an innovative technique, called “IFR index”, for selecting the main LCA criticalities. IFR index is inspired by Ideal Final Result tool from TRIZ, the Theory of inventive problem solving. Also part of the design phase is based on the use of TRIZ: a set of Eco-guidelines, have been conceived introducing TRIZ fundamentals onto green design. An industrial case study dealing with the production of a chemical product for the agricultural market illustrates how the method has been applied.

- 15.4 An Eco-design methodology based on a-LCA and TRIZ
G. Bersano, P.-E. Fayemi, M. Schoefer, C. Spreafico (sdm17-102)

An Eco-design methodology based on two abridged Life Cycle Assessment (aLCA) tools and TRIZ Eco guidelines is presented. This method is one of the outputs of the European project REMake, which developed and tested new approaches for eco-innovation and optimization of energy and materials for 250 manufacturing SMEs in six countries. Unlike other Eco-design methods, this method couples a simplified but solid assessment phase, realized with an abridged LCA, to an advanced and structured product improvement phase (that normally consists of basic design suggestions). A set of over 300 Eco-design guidelines, coming from problem solving techniques as TRIZ and conceptual design are selectively introduced to develop design variants to the given system with the aim of providing a lower global environmental impact. The advantages and limits of the method have been evaluated versus other methods inside European project REMake, and in this article are presented two case study realized in an independent way by two research groups that have tested it in two industrial case studies.

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IS10: Sustainable mobility, solar vehicles and alternative solutions, Theatre Room

Chair: E. Betancour, C. Fragassa

- 14.1 History of solar car and its electric components advancement and its future
Hideki Jonokuchi, Satoshi Maeda (sdm17-071)

The paper introduces a brief review about the history of solar cars, focusing on electronic aspects and with slight glances at the history of such vehicle in Japan, particularly. This emergent technology, by its conceptual nature, presents as limiting factor the availability of energy prevention from sunlight, which induces challenging engineering endeavors in order to make such vehicle feasible, although the expectation around it noticeable. Hence, arising technologies have presented innovative solutions with the aim at minimizing running losses and improving energy efficiency in general. The present work explains in detail some design aspect inherent of solar vehicles, as well as the role it plays in a sustainable society.

- 14.2 A Brief Review on Determinant Aspects in Energy Efficient Solar Car Design and Manufacturing
Giangiacomo Minak, Cristiano Fragassa, Felipe Vannucchi de Camargo (sdm17-094)

In the past decades, sustainable means of transportation have become an important issue once they are potentially able to supply modern transport needs whilst not harming the environment. Accordingly, to this general interest, solar vehicles have been developed by several institutions worldwide to participate in international class races, promoting this research field. As the competitiveness increased, solar technologies evolved toward noteworthy solutions for a modern and sustainable mobility. Hence, this work intends to provide a general overview on solar vehicles, particularly regarding the main design and manufacturing features that allowed to increase energy efficiency, considering the relevance of this factor for solar cars. Due to the huge amount of information available, a limited number of aspects was selected for further analysis, mainly related to design and engineering, such as: weight reduction, aerodynamics and kinematics, mechanics and advanced materials.

- 14.3 Mg₂SiO₄: Er³⁺ Coating for Efficiency Increase of Silicon- Based Commercial Solar Cells
Rubia Young Sun Zampiva, Annelise Kopp Alves, Carlos Perez Bergmann (sdm17-086)

Efficiency record commercial silicon solar panels convert about 25% of the sunlight into energy while the vast majority of conventional panels convert between 15% and 16%. The main factors of energy loss are the loss by light reflection on the cell surface and the loss by the energy emitted in the UV and IR band which is directly transmitted and/or converted to heat without being harnessed by the cell. To reduce these losses, it is proposed the use of rare earth doped Mg₂SiO₄ films. Preliminary absorption and emission tests for up and down conversion have indicated that the use of Mg₂SiO₄:Er³⁺, as a cell coating generates the conversion of IR energy into VIS energy, allowing the solar cell to use this energy. The presented forsterite films antireflection property, together with the erbium upconversion properties, indicates the Mg₂SiO₄:Er³⁺ as promising to increase the commercial silicon-based solar cells efficiency.

- 14.4 Aerodynamic effects of manufacturing tolerances on a solar car
E. Betancour, C. Fragassa, J. Coy, S. Hincapie, G. Osorio-Gomez (sdm17-098)

In the case of solar vehicles, since the primary necessity is to optimise the energy efficiency during motion, many efforts are addressed by designers in searching the perfect aerodynamics. It means, in particular, the minimization of the drag force at cruising speeds and an elaborated vehicle's Computer-Aided Design (CAD) are the principal result of this activity. Despite, these efforts can be nullified by geometrical tolerances emerging from manufacturing. In this paper, the effects of tolerances introduced by composite manufacturing processes are investigated combining 3D

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scanning technology and Computational Fluid Dynamics (CFD). After the solar car manufacturing, a reverse engineering process is executed with the aim to scan the vehicle's body and compare it to the initial theoretical design. Geometric deviations are found and their aerodynamic consequences are evaluated in terms of aerodynamic losses.

- 14.5 Experimental Temperature Modelization for Solar Racing Vehicle
C. Rossi, M. Bertoldi, G. Fabbri, D. Pontara, G. Rizzoli

(sdm17-092)

This paper presents an experimental method to model the temperature response of the inverters of the solar car Emilia 3 which is the vehicle build by the Italian Onda Solare team for the World Solar Challenge 2013. Object of this paper is using the experimental data collected to create a thermal model of the inverters to predict dangerous situations and adding it to the energetic model of the overall vehicle powertrain to better simulate racing conditions and help the race strategy planning. The data is elaborated to identify the experimental transfer function between motor current and inverter temperature. The function is validated with the current measurements and its behaviour was found to be consistent with the real temperature data.

IS08: Sustainability in industrial plant design & management: applications & experiences from practice, Cinema Room

Chair: Emilio Ferrari

Co-Chair: Marco Bortolini, Riccardo Accorsi

Ind01 Smart Factory Competitiveness based on real time monitoring and quality predictive model applied to Multi-Stages Production Lines

Nicola Gramegna, Enginsoft, www.enginsoft.it

The Industry 4.0 is the industrial revolution based on Cyber-Physical-Systems (CPS) in the context of Factory of Future. The digital innovation is not an exclusivity of new and advanced technology and production processes. The traditional production processes and plants are evolving following this digitalization combining the long experience and the new fast methods to improve the production efficiency, to accelerate the fine-tuning and real-time adjustment of the process parameters oriented to the zero defect quality.

Manufacturing current trends show an improvement in demand for light products considering the material substitution for complex structural parts, the design and technology innovation as well as the evolution in smart production. Due to the high number of process variables involved and to the non-synchronisation of all process parameters in a unique and integrated process control unit, High Pressure Die Casting (HPDC), as well as plastic injection moulding (PIM), is one of the most “defect-generating” and “energy-consumption” processes in EU industry showing less flexibility to any changes in products and in process evolution. In both, sustainability issue imposes that the production cell are able to efficiently and ecologically support the production with higher quality, faster delivery times, and shorter times between successive generations of products.

The platform is the result of FP7- MUSIC project (funded in the frame of the Call FoF-ICT-2011.7.1 Smart Factories: Energy-aware, agile manufacturing and Customization) giving a new age to the traditional multi-stages production. The current pilot projects are oriented to Foundry 4.0. The digitalization of foundry plays a key role in competitiveness introducing new integrated platform to Monitor the process by sensors and predict the Quality and the Cost of the casting in real-time.



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- 12.1 Eco Orbit View – a way to improve environmental performance with the application of Lean Management
Katarzyna Skornowicz, Malgorzata Fialkowska-Filipekab, Remigiusz Horbala (sdm17-017)

The purpose of this paper is to present two case studies from the application of Eco Orbit View, a method that extend the mind-set of Lean Management towards environmental performance, and to discuss the potential of broader implementation in medium and small sized manufacturing companies. Eco Orbit View method was developed during Eco Lean Compass project pursued in an international consortium including institution from Poland, Germany and Turkey. It applies low-cost improvements of production processes based on Lean Management in order to bring positive impact both on business and environmental performance. We verified the method on two case studies performed in medium-sized manufacturing companies from Poland and Turkey. In both cases the method brought positive impact on selected business and environmental metrics. Regarding business metrics, implemented improvements were inexpensive or even costless, but at the same time resulted in significant financial gains for the companies. When it comes to the environment, the main achievement was the significant reduction of physical wastes, electric energy and oil consumption. In next steps of Eco Lean Compass project we want to focus on delivering the method to a broad community of companies and develop the Eco Lean Transformation Program to assure the sustainability of the improvements.

- 12.2 On Reconciling Sustainable Plants and Networks Design for By-Products Management in the Meat Industry
R. Accorsi, R. Manzini, G. Baruffaldi, M. Bortolini (sdm17-076)

Population growth and rising per capita consumption of meat is growing and is expected to further accelerate in future. The production of beef is undoubtedly a high environmental stressor due to land-use change, water and energy consumption and by-products production. This paper focuses on the distribution and transportation processes of the beef slaughtering's by-products throughout their proper valorization chains. A methodology, inspired to the LCA, and encompassing data collection, simulation, and multi-scenario analysis is proposed and illustrated. This is applied to a real-world case study from the meat industry to showcase the importance of reconciling plant and network design to address both economic and environmental sustainability.

- 12.3 3D Printing Services: A Supply Chain Configurations Framework
Helen Rogers, Norbert Baricz, Kulwant S. Pawar (sdm17-075)

This paper presents an extended framework for the classification and categorization of 3D printing services, using the findings of two previous studies (carried out by the authors) as a foundation. The work to date revealed that 3D printing services can be separated into three distinct categories based on the configuration of their design-related and manufacturing-related processes: generative, facilitative and selective services. This study examines in more detail 105 of the 558 originally identified 3D printing service providers in Germany, Austria, Switzerland and the Benelux countries, with the goal of further clarifying the main drivers, linkages, buildings blocks and modules that shape these three individual branches of services. These configurations will potentially have wide-ranging impact on the supply chain strategies, structures and operations of the future.

- 12.4 Design of an innovative plant for the wastewater recovery and purification in the food & beverage industry
M. Bortolini, M. Gamberi, F. Pilati, A. Regattieri, R. Accorsi (sdm17-077)

The food & beverage (F&B) industry is among the most water intensive sectors with thousands of litres per hour of raw water requirement. Starting from the statement of this issue, an overview of the evidences from the field and a quick survey of the existing technologies for the raw water saving through its local collection and treatment before discharge, this paper investigates the design of an innovative industrial plant for the water closed-loop recovery, purification and local reuse. Actually, a prototype of such a plant is working within a mid-size F&B company operating in the Emilia-Romagna region, Italy. The plant nominal capacity is of about 45,000 l/h of discharged wastewater. It

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integrates water ultra-filtration and reverse osmosis technologies. Details of the functional module design and of the logic of control are in the present paper. Finally, few preliminary evidences from the plant field-test are provided.

19:30 Closing of the sessions of the first conference day and leaving the venue - Private buses to the Social Dinner place (Savoia Hotel)

20:00 *Social Dinner (Savoia Hotel)*
AITeM-ALAS joint Award Assignment to Olmes Ognibene, conferred by the Department of Industrial Engineering of the University of Bologna

23:30 Leaving the Savoia Hotel - Private buses to the Conference venue

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*2nd conference day
Friday, 28 April 2017*

8:00 Registration, Reception, Common Area

9:00 3rd Plenary Session, Auditorium Room

Opening, Presentation about KES-SDM series of conferences given by Rossi Setchi.
Introduced by Robert Howlett

9:30 Keynote Speech by Prof. I. S. Jawahir. Introduced by Dario Crocco.

Prof. I. S. Jawahir

Director, Institute for Sustainable Manufacturing (ISM)

James F. Hardymon Chair in Manufacturing Systems, and Professor of Mechanical Engineering
University of Kentucky, Lexington, KY 40506 USA

Biographical notes: Dr. I.S. Jawahir is a Professor of Mechanical Engineering, James F. Hardymon Endowed Chair in Manufacturing Systems, and the Founding Director of the Institute for Sustainable Manufacturing (ISM) at the University of Kentucky (Lexington, KY, USA). He received his Ph.D. from the University of New South Wales (Sydney, Australia) in 1986. His current research interests are in sustainable manufacturing, focusing on developing predictive performance models and optimization techniques for products, processes and systems. He has produced over 350 technical research papers, including 140+ refereed journal papers, and has been awarded with 4 U.S. patents. He has supervised and directed the research of 34 PhD and 85 MS graduates. He has also served as External Examiner for over 100 PhD theses and dissertations from 27 major universities in 12 countries. He has delivered 52 keynote papers in major international conferences and over 150 invited presentations in 34 countries.

Professor Jawahir has received significant research funding from U.S. Federal Agencies and from major manufacturing companies such as IBM, General Motors, Ford, General Electric - Aviation, Toyota, Sandvik, Kennametal, Lexmark, Mazak and 3M. He is a Fellow of three major professional societies: CIRP (International Academy for Production Engineering); ASME (American Society of Mechanical Engineers); and SME (Society of Manufacturing Engineers). He is the Founding Editor-in-Chief of the International Journal of Sustainable Manufacturing, and the Technical Editor of the Journal of Machining Science and Technology. He is also

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currently serving as a Member of the ASME Board for Research and Technology Development (BRTD), and in 2005, he founded the ASME Research Committee on "Sustainable Products and Processes" and served as the Founding Chairman of this committee for the first six years (2005-11). Professor Jawahir is the Founder of the CIRP International Conference Series on Modeling of Machining Operations. He organized and hosted the first conference in this series in Atlanta, GA, USA in 1998. This series still continues with the 14th and 15th conferences were held in Torino, Italy in 2013, and in Karlstruhe, Germany in 2015, respectively, and the 16th conference will be held in Cluny, France in 2017. Professor Jawahir served as the Chairman of the CIRP's International Research Collaborative Working Group on "Surface Integrity and Functional Performance of Components" for four years (2007-11).

Professor Jawahir received the 2013 ASME Milton C. Shaw Manufacturing Research Medal for his outstanding research contributions to sustainable manufacturing, and was awarded the 2015 W. Johnson International Gold Medal for his lifelong achievements and contributions to materials processing research and education. In 2015, Professor Jawahir also received a prestigious Royal Academy of Engineering (RAE) Distinguished Visiting Professorship, traveled to the United Kingdom twice in 2015, and delivered a series of seven lectures on various topics in sustainable product design and manufacturing at three major universities (University of Birmingham, University of Nottingham and Sheffield University), two research centers (MTC and AMRC) and two major manufacturing companies (Rolls-Royce and Mazak Corporation).

Title of Talk: Metrics-based Integrated Predictive Performance Models for Optimized Sustainable Product Design

Abstract: Implementing sustainable manufacturing principles and practices leads to innovation and sustainable value creation at product, process and system levels. In recent years, with the exponential growth in sustainable manufacturing research to meet the rapidly growing needs of industry and society, significant emphasis has been placed on designing innovative sustainable products and developing and implementing novel and advanced sustainable manufacturing processes to produce such sustainable products in automotive, aerospace, consumer products, biomedical and power industries. Sustainable manufacturing has been recognized as the driver for innovation in the manufacturing industrial sector. Achieving sustainable manufacturing targets inevitably requires a metrics-based analysis of sustainable manufacturing at product, process and systems levels.

This paper presents an overview of the 6R (Reduce, Reuse and Recycle, Recover, Redesign and Remanufacture) approach to promote sustainable manufacturing to enable closed-loop, multiple life-cycle material flow. The paper specifically focuses on sustainable product design for manufacture, with an in-depth analysis of product design and development processes by utilizing the novel 6R methodology. The transformation of conventional product design processes to sustainable product design/development is presented by expanding the recently-proposed metrics-based sustainable product evaluation method to include integrated predictive performance models for optimized sustainable product design. Designing sustainable products is presented as the most effective pathway towards promoting innovation and sustainable value creation.

10:00-11:30 5th Parallel Session

G01: Sustainable Design, Innovation and Services Auditorium Room

Chairs: Pinar Bilge, Jeremy Bonvoisin

- 1.7 A Manufacturing Value Modeling Methodology (MVMM): a value mapping and assessment framework for sustainable manufacturing
M. Demartini, I. Orlandi, F. Tonelli, D. Anguitta

(sdm17-019)

Sustainable manufacturing is becoming increasingly important. This requires sustainable industrial system different to today's global industry with different business models, creating different products and services requiring new strategies, frameworks, and tools. The evolution towards a 'sustainable' industrial production systems requires a holistic approach, with a fundamental reassessment of the value creation. In order to achieve this target a system design approach is required. In this paper an existing and specific Manufacturing Value Modeling Methodology (MVMM) is used as a value mapping framework to help firms in creating value propositions better suited for sustainability considering economic, environmental and social perspectives. Concerning sustainability, implementing it into the MVMM requires the setting of a catalogue that presents an overview of sustainable external and internal impact factors and a mapping between them in order to translate business goals into manufacturing strategy, and allows to improve operational performance by adopting a set of sustainable industrial practices.

- 1.8 Improving sustainability in product development projects
E. Lacasa, J.L. Santolaya, I. Millán

(sdm17-023)

Sustainable product development initiatives have been evolving for some time to support companies improve the efficiency of current production and the design of new products and services through supply chain management. The development of different methods and tools for considering environmental criteria in the same way as conventional design criteria through an Eco-design approach were carried out. Environmental assessment tools are generally based on a life cycle assessment (LCA) method, which can inform production and consumption choices because it assess the environmental performance of a product through accounting all the energy and material inputs and the associated emissions and waste outputs at each stage of its life cycle.

While using LCA to measure the environmental dimension of sustainability is widespread, similar approaches for the economic (LCC) and the social (S-LCA) dimensions of sustainability still have limited application worldwide and there is need for consistent and robust methods and indicators. This paper focuses on the production step and presents the redesign process of an airbrush in order to improve their sustainability performance. According to LCA evaluation methods, an approach based on the analysis of the flows exchanged by the industrial installation throughout the production step was developed. Different sustainability indicators were obtained. In particular, the environmental indicator of global warming, the economic indicator of value added and the social indicator of working hours were used to assess the sustainability performance. An improvement of the redesigned product indicators was achieved.

- 1.9 A Living-sphere Approach for Locally Oriented Sustainable Design
Hideki Kobayashi, Shinichi Fukushige

(sdm17-050)

Achieving a sustainable consumption and production pattern is one of the United Nation's sustainable development goals for 2030. To achieve this, it is necessary to consider the environmental burden from a product life cycle and the quality of life of the consumer. In this study, a systematic approach for connecting basic human needs and the product development process, called the living-sphere approach, is proposed. In this approach, value graphs, which visualize the value system of products, are connected to satisfiers fulfilling the basic needs set out by Max-Neef. A value graph

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links satisfiers and the traditional product development process. The significance of the proposed approach is that improving quality of daily life and traditional product development are combined in the same framework.

IS09: Sustainability of 3D Printing and Additive Manufacturing, Theatre Room **Chair: Paolo Minetola** **Co-Chair: Paolo Claudio Priarone, Michael Ryan, Diego Manfredi**

Ind03 **Metal 3D Printing: software and case history**
Paolo Betti, 3D SYSTEMS (www.3dsystems.com), Francesco Sartor, 3D University



The 3D metal printing offers significant advantages when compared with conventional production processes such as those based on CNC machines or casting. As a main result, Designers can be more focused on the product functionality that previously required long assembly operations. Now, they can create complex geometries that, otherwise, could not be produced.

Often the 3D metal printing allows the designers to delete or simplify phases of the production process, to reduce the number of components and, therefore, also to simplify the supply chain.

Some relevant point of the speech:

- Benefits that arise from the adoption of additive manufacturing technologies will be discussed.
- 3DXpert, the new and innovative 3D metal printing budgeting software will be presented.
- Materials and machinery will be presented.
- 3D Metal printed parts will be exposed.



- 13.1 Assessment of cost and energy requirements of Electron Beam Melting (EBM) and machining processes
Paolo C. Priarone, Matteo Robiglio, Giuseppe Ingarao, Luca Settineri (sdm17-008)

Additive Manufacturing is under the spotlight as potential disruptive technology, particularly for the production of complex-shaped structural metallic components. However, the actual AM process capabilities present some limitations in achieving the strict part quality requirements imposed by the aerospace and automotive sectors. Therefore, the

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integration of AM and conventional manufacturing represents an emerging scenario to be investigated. In this paper, a pure machining process and a hybrid production route (based on EBM and finish machining) are compared. The influence of material usage-related factors on costs and energy demand is discussed. The results prove that, despite precise process judgments are case-specific, the proposed methodologies are suitable to provide guidelines for identifying the optimal manufacturing route under multiple design objectives.

13.2 Engineering a more Sustainable Manufacturing Process for Metal Additive Layer Manufacturing using a Productive Process Pyramid

Paul O'Regan, Paul Prickett, Rossi Setchi, Gareth Hankins, Nick Jones (sdm17-015)

Sustainability within manufacturing is an increasingly important topic globally. One course of action being explored is to produce more parts 'right first time' so supporting an increasingly sustainable manufacturing process. This paper explores the Renishaw "productive process pyramid" and considers how it can be integrated into the ALM process. The pyramid is currently used to identify how layers of control can systematically remove variation from conventional machining processes. This application is focussed to consider how the variables that occur within the ALM manufacturing process can impact on the quality of the parts mechanically and geometrically. This approach can then inform the process foundation and process setting stages and enhance levels of in-process control.

IS06: Resource and Energy Efficiency for Sustainability Advances in Process Industries, Cinema Room

Chair: Steve Evans

Co-Chair: Maria Holgado

10.1 Virtual sector profiles for innovation sharing in process industry – Sector 01: Chemicals

H. Cervo, S. Bungener, E. Méchaussie, I. Kantor, B. Zwaenepoel, F. Maréchal, and G. Van Eetvelde

(sdm17-034)

Production data in process industry are proprietary to a company since they are key to the process design and technology expertise. However, data confidentiality restrains industry from sharing results and advancing developments in and across process sectors. Using virtual profiles that simulate the typical operating modes of a given process industry offers an elegant solution for a company to share information with the outside world. This paper proposes a generic methodology to create sector blueprints and applies it to the chemicals industry. It details the profile of a typical chemical site based on essential units and realistic data gathered from existing refineries and chemical plants.

10.2 A heuristic approach to cultivate symbiosis in industrial clusters led by process industry

A. Samie Maqbool, G. Emilio Piccolo, B. Zwaenepoel, G. Van Eetvelde

(sdm17-035)

This paper introduces a heuristic approach for industrial symbiosis (IS) facilitators to investigate and instigate better energy and resource management via synergies across process industries. The proposed method studies the industrial system at three levels; regional, cluster and company. At the company level, in-depth information is collected using a pentagonal LESTS (Legal, Economic, Spatial, Technical, Social) survey, which is formulated after weighing the regional effects on the whole system. At the cluster level, an inventory of technological and organisational opportunities is produced, offering leverage for IS activities. A gap analysis between the IS potential of the cluster and the IS appreciation on the industrial sites is visualised via LESTS pentagons. The coupled investigation at company and cluster level results in a list of realisable IS activities, which is then translated into business strategies for each participating company using a SWOT analysis.

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- 10.3 IMPROOF: Integrated model guided process optimization of steam cracking furnaces
M. R. Djokic, K. M. Van Geem, G. J. Heynderickx, S. Dekeukeleire, S. Vangaever, F. Battin-Leclerc, G.s Bellos, W. Buyschaert, B. Cuenot, T. Faravelli, M. Henneke, D. Jakobi, P. Lenain, A. Munoz, J. Olver, M. Van Goethem, P. Oud (sdm17-044)

IMPROOF will develop and demonstrate the steam cracking furnace of the 21st century by drastically improving the energy efficiency of the current state-of-the-art, in a cost effective way, while simultaneously reducing emissions of greenhouse gases and NOX per ton of ethylene produced by at least 25%. Therefore, the latest technological innovations in the field of energy efficiency and fouling minimization are implemented and combined, proving that these technologies work properly at TRL 5 and 6 levels. The first steps to reach the ultimate objective, i.e. to deploy the furnace at the demonstrator at commercial scale with the most effective technologies, will be discussed based on novel pilot scale data and modeling results.

11:30 Coffee Break, Common Area

12:00-13:00 6th Parallel Session

G01: Sustainable Design, Innovation and Services Auditorium Room

Chairs: Pinar Bilge, Jeremy Bonvoisin

- 1.10 What stops designers from designing sustainable packaging? A review of eco-design tools with regard to packaging design
Xuezi Ma, James Moultrie (sdm17-087)

Packaging has caused much waste and its sustainability has received much attention in the past decades. Designers have made efforts to mitigate environmental impacts of packaging. However, many packaging designs are still far from achieving their sustainability goals. The purpose of this study is to perform a literature review of the principal design methods and tools for sustainable packaging published over the last twenty years. The objective is to understand the main obstacles that limit their effective implementation in the packaging design process. This study develops a sustainable packaging design and development model and proposes criteria for accessing packaging tools and methods. This study has found that to achieve sustainable design, many tools have limitations in demonstrating usage and balancing trade-off situations. Most of the tools focus on defining problems rather than suggesting possible solutions.

- 1.11 Impact of a Sustainable Manufacturing-related Learning Game on Basic Knowledge and Network Thinking. A Study with High School Students
Ina Roeder, Mustafa Severengiz, Rainer Stark, Günther Seliger (sdm17-097)

Modern challenges require modern thinking, which again calls for modern teaching methods. The complex field of sustainable manufacturing cannot be taught out of school books but must be experienced. Learning games have a great potential for that. Therefore, to meet the gap in educational resources in the field of sustainable manufacturing, a learning game for high school students has been developed and its effect tested with 76 players.

- 1.12 Role of Risk Assessment in Product Design at Conceptual Design Stage: a Literature Survey
Raof Ahmad Khan, Ankush Anand, Karan Vohra, M.F Wani (sdm17-038)

Conceptual design stage in a sustainable design process is an integral part of product design. The involvement of risk during various stages of product design is also very critical for designer and thus, assessment of risk at this stage needs to be systematically carried out by the concurrent engineering design team. This research article is aimed at highlighting the role of risk assessment at conceptual design stage in product design. An effort has been made to highlight various

areas of design where the assessment of risk is significant. An example of sustainable product design where risk assessment has been performed is also illustrated here in this article.

IS09: Sustainability of 3D Printing and Additive Manufacturing, Theatre Room
Chair: Paolo Minetola
Co-Chair: Paolo Claudio Priarone, Michael Ryan, Diego Manfredi

- 13.3 Sustainable Scenarios for Engaged Manufacturing: A literature review and research directions (sdm17-062)
Michael J. Ryan, Daniel R. Eyers

Additive Manufacturing (AM) is gaining increasing interest as a sustainable manufacturing technology. One important aspect of AM is the opportunities it presents for customization by increasing involvement of customer in the design and manufacturing process. This paper presents a review of literature examining proposed future scenarios for AM implementation, with particular interest in the way customers are engaged in the process, and the effect that this might have on the future of AM supply chains. 27 distinct scenarios for future AM implementations were identified, with Engineer-to-Order and Make-to-Order proving most popular approaches, alongside a trend towards localized production. Although structured methods are available, a “genius” approach was found to have been employed in developing the majority of the scenarios evaluated.

- 13.4 Design for Additive Manufacturing using LWSM: a CAD tool for the modelling of lightweight and lattice structures (sdm17-074)
Alessandro Ceruti, Riccardo Ferrari, Alfredo Liverani

This paper presents the development of a CAD conceived to support the modelling of lightweight and lattice structures just from the initial stages of the design process. A new environment, called LWSM (acronym of LightWeight Structures Modelling), has been implemented in Python programming language in an open-source CAD software to allow the fast modelling of several sandwich structures or the filling of solid parts with cubic and tetrahedral lattice structures which can be produced by Additive Manufacturing (AM) techniques. Several tests have been carried out to validate the tool, one of which is included in the paper. The design of a bracket component inside LWSM using a traditional dense geometry and a lattice structure is described. The use of Design for Additive Manufacturing (DfAM) functions helps the user in the design of innovative structures which can produced only with AM technologies. A significant change in the shape of the part respect to traditional solutions is noticed after the use of DfAM functions by experimenters: FEM analysis confirms a strong weight reduction.

- 13.5 Tuning decision support tools for environmentally friendly manufacturing approach selection (sdm17-020)
Giuseppe Ingarao, Paolo C. Priarone, Yelin Deng, Rosa Di Lorenzo

Awareness about the environmental performance of manufacturing approaches has arisen. Comparative analyses of different manufacturing approaches as well as decision support methods should be developed in the field of metal shaping processes. The present paper aims at tuning a decision support tool for identifying when mass conserving approaches (forming based) are actually preferable over machining processes for manufacturing aluminum based components. A full LCA is developed for comparing the environmental performance of forming and machining approaches as the batch size and geometry complexity hang. The impact of the used metric on the comparative results is analyzed. Results reveal that primary energy can be used as reliable metric for identifying environmentally friendly manufacturing processes.

IS06: Resource and Energy Efficiency for Sustainability Advances in Process Industries, Cinema Room

Chair: Steve Evans

Co-Chair: Maria Holgado

- 10.4 Conceptual analysis of Eco-efficiency and Industrial Symbiosis: insights from process industry
Yan Li, Maria Holgado, Miriam Benedetti, Steve Evans (sdm17-045)

The interior relationship between Industrial Ecology, Eco-Efficiency and Industrial Symbiosis has been scarcely investigated in literature. We identify three main aspects linking the concepts, which are 'Actions', 'Stakeholders' and 'Value', and use them to drive the conceptual analysis. Considering the application and implementation, authors conduct a conceptual comparison between Eco-Efficiency and Industrial Symbiosis by using Industrial Ecology as the leading concept. A conceptual framework is developed to uncover the relationship of Industrial Ecology, Eco-Efficiency and Industrial Symbiosis, from a firm level perspective.

- 10.5 Integration of eco-efficiency and efficiency assessment methodologies: The Efficiency Framework
A. J. Baptista, E. J. Lourenço, E. J. Silva, M. A. Estrela, P. Peças (sdm17-049)

The overall aim of the Efficiency Framework is to encourage a culture of continuous improvement and sustainability within manufacturing and process industries. The framework presented supports informed decision-making processes and helps to define strategies for continuous performance improvement. The proposed innovative Efficiency Framework, materialized through the integration of concepts and results provided by eco-efficiency methodology, namely Eco-Efficiency Integrated Methodology for Production Systems (ecoPROSYS) and the lean based resource efficiency assessment method, Multi-layer Stream Mapping (MSM). Thus, the framework assesses simultaneously the environmental, economic and efficiency performance of complex production systems, which helps to identify major inefficiencies and circumstances of low eco-efficiency performance, consequently leading to the definition of improvement priorities. Ultimately, this framework aims to facilitate the overall efficiency performance assessment, by an integrated multi-dimensional analysis, presented as the Total Efficiency Index. The logic behind this index is to combine, for each unit process and for the overall production process, two fundamental efficiency aspects, namely eco-efficiency and operations efficiency.

- 10.6 Toward Industry 4.0: Efficient and Sustainable Manufacturing leveraging MAESTRI Total Efficiency Framework
E. Ferrera, R. Rossini, A. J. Baptista, S. Evans, G. Große Hovest, M. Holgado, E. Lezak, E.J. Lourenço, Z. Masluszczak, A. Schneider, E. J. Silva, O. Werner-Kytölä, M. A. Estrela (sdm17-058)

This paper presents an overview of the work under development within MAESTRI EU-funded collaborative project. The MAESTRI Total Efficiency Framework (MTEF) aims to advance the sustainability of manufacturing and process industries by providing a management system in the form of a flexible and scalable platform and methodology. The MTEF is based on four pillars: a) an effective management system targeted at process continuous improvement; b) Efficiency assessment tools to support improvements, optimisation strategies and decision support; c) Industrial Symbiosis paradigm to gain value from waste and energy exchange; d) an Internet-of-Things infrastructure to support easy integration and data exchange among shop-floor, business systems and tools.

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13:00 Lunch, Common Area

14:00-16:00 7th Parallel Session

IS05: Business model innovation for sustainable design and manufacturing,

Auditorium Room

Chairs: Peter Wells, Daniel Eyers

- 9.1 Sustainable business models of small-scale renewable energy systems: Two resource-scarce approaches for design and manufacturing
Tatu Lyytinen (sdm17-016)

We need to pay attention to both the design and manufacturing and business model approaches when analysing the sustainability of firms. Though there is increasing literature on the sustainable business model, little attention has been paid to solution design's implication for the sustainability of the business model. In this article, I compare the solution design and business model approaches of two similar small-scale bioenergy solutions (using the high-income context in a developed country and the low-income context in a developing country). The sustainability perspective is integrated into the business model framework, and the implications of technological solutions to business models are analysed. I demonstrate in this study that while a high-tech solution in the high-income context has been able to integrate technological and organisational sustainability into its business model, a low-tech solution in the low-income context has mainly focused on social sustainability, has not paid attention to ecological sustainability and is struggling with financial sustainability.

- 9.2 Co-design for resilience: solutions, services and technologies for urban spaces
Valentina Gianfrate, Jacopo Gaspari, Danila Longo (sdm17-024)

Resilience design strategies anticipate significant detrimental climate change to create optimal conditions to face the continuous and deep changes of urban environment, acting on the causes (mitigation) and on the effects (adaptation). The paper illustrates a methodology that combines technological and social aspects for the transition to resilient districts and communities with the aim to co-deliver city-based solutions and services and to drive sustainable growth in vulnerable contexts.

- 9.3 Digital Redistributed Manufacturing (RdM) Studio: A data-driven approach to business model development
C. Turner, A. Tiwari, J. L. Rivas Pizarroso, M. Moreno, D. Vladimirova, M. Zaki, M. Geißdörfer (sdm17-031)

The theme of Redistributed Manufacturing (RdM) has gained in interest over recent years. While much research has taken place into the effects of RdM on current manufacturing models very few people have proposed new business models for this concept. The RdM studio is a new approach to business model development that will allow future users to dynamically incorporate data and experiment with new redistributed manufacturing scenarios. An RdM System Dynamics (SD) model is illustrated (as a potential constituent model of the RdM studio) with a case study called ShoeLab that explores RdM scenario generation through parameter sets utilising the SD modelling method. This research provides a valuable platform on which future models and scenarios may be derived.

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- 9.4 Exploring disruptive business model innovation for the Circular Economy
Anna Aminoff, Katri Valkokari, Maria Antikainen, Outi Kettunen (sdm17-042)

Recently the concept of the Circular Economy (CE) has attracted growing interest as a novel economic model aiming to foster sustainable economic growth, boost global competitiveness, and generate new jobs. A system-wide disruptive innovation shaping new ecosystems and changing the whole process of value creation is needed to tackle the current challenges and transformation to the CE. This paper asks how disruptive business model innovations work as a change mechanism for the CE. The paper develops a conceptual framework for shaping the industrial systems towards CE ecosystems and proposes how value circles and co-creation of value with a variety of partners are crucial aspects in enabling CE. The paper highlights that the concept of value circles would be beneficial in clarifying the difference to linear value chain models and the co-existence of several overlapping value circles.

- 9.5 Business Models for Sustainability: the Case of Repurposing A Second-life for Electric Vehicle Batteries
Na Jiao, Steve Evans (sdm17-047)

The rapid development of electric vehicles (EVs) has caused a problem for the industry: what happens to the batteries at the end of their useful life in EVs? Repurposing those batteries for a less-demanding second-life application, e.g. stationary energy storage, could provide a potential solution to extract more value than just recycling or disposal. This study examines the battery second use (B2U) business models being developed by various actors that generate value through different second-use applications. Based on empirical interview data from stakeholders involved in B2U, this paper presents a typology of current B2U business models --standard, collaborative and integrative business models -- and offers implications for designing business models that incorporate sustainability at the core.

- 9.6 Circular Economy business model innovation process – case study
M. Antikainen, A. Aminoff, O. Kettunen, H. Sundqvist-Andberg, H. Paloheimo (sdm17-054)

The concept of the Circular Economy has recently caught the attention of academia as well and businesses and decision makers offering an attractive solution for an environmentally sustainable economic growth. Companies need to consider how to close material loops, reduce the resources needed and think more about how materials and products are kept in the loop as long as possible. In order to do that, companies need to find new collaboration partners and reconsider the value offered for stakeholders. To solve that, we need new or modified innovation tools and processes to guide businesses in their innovation journey resulting in novel business models in a circular economy. Thus, the aim of this study is to increase our understanding of the circular business model innovation process. Our main focus is to explore what kind of mixed methods create value in circular business model innovation and what kind of challenges there are related to each method and how is it possible to overcome those challenges. The paper highlights the importance of involving different perspectives, stakeholders and using mixed methods during the innovation process.

IS09: Sustainability of 3D Printing and Additive Manufacturing, Theatre Room

Chair: Paolo Claudio Priarone

Co-Chair: Paolo Minetola, Michael Ryan, Diego Manfredi

- 13.6 Sustainability as a value-adding concept in the early design phases? Insights from stimulated ideation sessions
Lorenzo Maccioni, Yuri Borgianni, Federico Rotini (sdm17-059)

As creativity is increasingly important in order to achieve differentiation and competitiveness in industry, designers face the challenge of conceiving and rating large numbers of new product development options. The authors' recent studies show the effectiveness of ideation procedures guided by stimuli that are submitted to designers in the form of

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abstract benefits. A rich collection of said benefits has been created to this scope; more specifically, the authors have performed a detailed clustering of the categories described in TRIZ ideality, i.e. useful functions, attenuation of undesired effects and reduction of consumed resources. Aspects related to sustainability and environmental friendliness manifestly appear in the list of stimuli and these issues are reflected in several ideas emerged in initial experiments. However, many promising product development objectives conflict with sustainability or, at least, their adherence to eco-design is arguable. The paper assesses the share of ideas that are supposed to comply with sustainability in experiments described in recent literature. Subsequently, it intends to stimulate a discussion about the introduction of measures to attract attention of designers on sustainability in the critical early product development stages also when green aspects do not represent the fundamental driver to achieve greater customer value. As well, it discusses which sustainability aspects are worth being considered adequately during the very early design phases and which ones could result as exceedingly constraining.

- 13.7 A Methodology for the Identification of Confined Spaces in Industry
Lucia Botti, Cristina Mora, Emilio Ferrari

(sdm17-078)

Work in confined space is a high-risk activity posing a serious life-threatening hazard to workers who perform it. Accidents in confined spaces frequently lead to multiple fatalities. The cause of accidents and fatalities due to confined space work is related to the lack of awareness about the presence and the risks of such hazardous workplaces. This paper introduces a methodology for the identification of confined spaces in industry. The aim is to provide a useful tool for helping researchers and practitioners to recognize of confined spaces in industry. Four different characteristics of confinement are investigated: geometric features, access, internal configuration, and atmosphere and environment. The proposed methodology includes the definition of the Confined Space Risk Index (CSRI) for the analysis of the risk related to the investigated confined space. Finally, two case studies show the application of the proposed methodology to two suspected confined spaces in industry.

- 13.8 About the use of recycled or biodegradable filaments for sustainability of 3D printing. State of the art and research opportunities
Jukka Pakkanen, Diego Manfredi, Paolo Minetola, Luca Iuliano

(sdm17-084)

Additive Manufacturing (AM) and 3D printing are drivers for material savings in manufacturing. Owing to the continuous diffusion of 3D printing driven by low-cost entry-level material extrusion printers, sustainability of a so popular AM technology is of paramount importance. Therefore, recycling 3D printed wastes and 3D parts again at the end of their life is an important issue to be addressed. Research efforts are directed towards the improvement of the biodegradability of 3D printing filaments and the replacement of oil based feedstock with bio-based compostable plastics. The aim of this work is to describe the state of the art about development and use of recycled or biodegradable filaments in 3D printing. Beyond a critical review of the literature, open issues and research opportunities are presented.

- 13.9 Additive Manufacturing as a driver for the sustainability of short-lifecycle customized products. The case study of mobile case covers
Paolo Minetola, Daniel R. Eyers

(sdm17-082)

Unlike subtractive manufacturing processes, by their own nature additive technologies offer the potential to reduce both raw material consumption and production waste. The positive impact of Additive Manufacturing on sustainability is more evident for those mass consumption products that are characterized by a short lifecycle. Nevertheless, in order to take full advantage of these technologies and let them achieve their full potential, a great change is needed in the behaviour and attitude of consumers. Compromises may be necessary to accommodate technological limitations, and customers may need to prioritize between functional and aesthetic product characteristics. The positive impact of additive manufacturing on sustainability is more evident for those mass consumption products that are characterized by a short lifecycle. The material flow and sustainability of 3D printing are described in this paper for the manufacturing of mobile case covers, and compared to those of mass production injection moulding.

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- 13.10 Sustainable Small Batch Reproduction via Additive Manufacturing and Vacuum Casting: The Case Study of a Rhinoceros Toy Figure
Milan Sljivic, Ana Pavlovic, Jovica Ilić and Mico Stanojevic (sdm17-001)

This paper aims at clarifying the relationship between two unconventional manufacturing processes, the additive manufacturing and the vacuum casting, as a sustainable way in developing prototypes and small batches, even in the presence of complex geometries. The rapid reproduction of a rhinoceros toy figure was used as case study. Starting from the 3D CAD model, acquired by reverse engineering techniques, additive manufacturing and vacuum casting processes permitted to realize its replicas. Complex functional parts in small series were manufactured with high precision, accuracy and enhanced surface finish. Furthermore, significant reductions in time and costs, both for development or production comparing to other technologies were highlighted.

16:00 Coffee Break, Common Area

IS02: The Learning Supply Chain, Cinema Room

Chair: Susan Grant

- 6.1 Barriers and enablers to supply chain knowledge sharing and learning using social media
Susan B. Grant (sdm17-036)

This research looks at the idea of interactive supplier social networks (SSN's), a novel and comparatively unexplored area in the field of supply chain management. The paper aims to understand the motivations prompting suppliers in a horizontal supply chain to share knowledge within a supplier network. A social constructionist perspective is employed to explore the factors that motivate/prevent engagement in knowledge sharing using social media tools from a customer and supplier's perspective across an insurance supply chain. The findings reveal corporate and industrial culture, work routines, technology, and a high regulatory environment can have a limiting effect on the generation of voluntary engagement in knowledge sharing between organizations and their supply chains in this sector.

- 6.2 Supply chain learning using a 3D virtual world environment
Olinkha Gustafson-Pearce, Susan Grant (sdm17-037)

This paper discusses the use of virtual world technology in relation to the unsustainability of the current levels greenhouse gas emissions, related to business travel. If it can be demonstrated that the use of virtual worlds enables users to participate in meetings and other events in a manner that benefits the individual and the organisation, without the need for the individuals to meet 'face to face', then overall, business travel can be reduced. However, creating the virtual environment that engages the user in 'meaningful' discourse, requires testing the environment against specific targets. This paper discusses that in the context of Supply Chain Management within the Insurance business, knowledge transfer is a key factor, that is currently conducted through 'standard' channels, primarily emails and the telephone. A number of team meetings are also organised, since it is felt that 'face to face' contact between members is necessary. Business travel for participants contributes to greenhouse gas emissions. Therefore, for this study, the use of 3D Virtual World (VW) tools to discover if knowledge sharing and learning within a horizontal supply chain managed by a principal insurer, was effective and reduced the need for 'face to face' meetings. A set of web based tools, applications and exercises supporting the formation of communities of inquiry and promoting knowledge

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transfer and learning, through social interaction is presented. These results are from a pilot study that was run over a four-month period across an insurance supply chain, to explore how suppliers and the principal insurer shared knowledge, using these tools. With the IoT (Internet of Things) generating multiple sources of 'streamed' data, the potential for using this type of data in a format that allows users to access data that is 'understandable' to them, is expanding. Within the insurance industry, and specifically home claims, a key priority is to have current and meaningful data on physical events and conditions available to their stakeholders and members of the supply chain. This is to enable them to make correct and timely decisions on claims, for example, weather related claims. Therefore, an environment was designed and created, which used live streaming data from the United States Geological Survey, and a variety of VW tools and techniques to illustrate this data, and to orient it to make it relevant to the home claims teams.

6.3 Manufacturing Lead Time Reduction and its effect on internal supply chain

Atanas Ivanov, Twana Jaff

(sdm17-048)

Companies seek to reduce manufacturing lead-time in order to reduce the cost of the production; short lead-times are a major source of potential competitive advantage and also can help achieve internal supply chain optimization and better sustainability. This paper proposes a study on reducing manufacturing lead time. The research methodology based on survey questionnaire and cased study in order to find potential methodologies that can reduce lead-time and its effect on internal supply chain. This research study will present a conceptual framework of the causes of excessive lead-time. The aim is to provide simple strategies for reducing manufacturing lead-time also to provide internal supply chain more efficiency.

6.4 Remanufacturing as Pathway for Achieving Circular Economy for Indonesian SMEs

Yun Arifatul Fatimah, Wahidul Biswas

(sdm17-090)

Remanufacturing could potentially offer economic and environmental benefits for Indonesian SMEs. The objective of this research is to explore as to how remanufacturing strategy could attain greater resource efficiency through resources consumption reduction and waste minimization. An assessment on resources efficiency has been performed for Indonesian remanufacturing SMEs producing auto parts. The value, contributions and limitations of remanufacturing for achieving resources efficiency were explored and some key issues including organizational, consumer behaviours and government incentives issues have been identified. Accordingly, national resources policy recommendations have been made. Future potential business value that enhances Indonesian economic, social and environmental pillars of sustainability through remanufacturing has been discussed in this paper.

6.5 Technology Foresight Scenarios For Solar Photovoltaic (PV) In India

Deepak Singh, Pranav N Desai, Asma Kouser, Latika Menon, Eugen Panaitescu

(sdm17-099)

Overview: India is a rising economic power and with a large population its energy hunger translates exponential demand trajectories. A lot has been talked and written about the potential role of abundant solar energy through Solar Photovoltaics (SPV) in quenching India's energy hunger. This research can be broadly divided into two segments. In the first segment an attempt is been made to explore (SPV technologies, actors and their policy objectives/actions) the Indian energy technology innovations system (ETIS). In the second segment an attempt is made through a primary survey to capture the space for absorption for various SPV technologies in the urban and rural areas in India. The scope of the work is for both energy security and adoption of appropriate SPV technologies to address climate change policy of India.

Methodology: Based on technology foresight analysis combining both qualitative and quantitative tools. This comprises of literature review, consumer survey, SPV technological assessment through expert interview, iterative Delphi rounds for consensus building.

Data and Analysis: Primary data was collected from the consumers through a questionnaire, apart from secondary data available from various ministries.

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Results: Futures scenario are projected in the form of a priority matrix which can be used by policy makers to enhance the space of SPV in India's ETIS in short, medium and long term futures.

16:00 Coffee Break, Common Area

16:30-17:00 Robert Howlett by KES presents the Awards Assignment: *Best presentation and Best paper assignment*
Closing and Farewell



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