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Amaresh Chakrabarti · Manish Arora  
Editors

# Industry 4.0 and Advanced Manufacturing

Proceedings of I-4AM 2019

 Springer

*Editors*

Amaresh Chakrabarti  
Centre for Product Design  
and Manufacturing  
Indian Institute of Science  
Bengaluru, Karnataka, India

Manish Arora  
Centre for Product Design  
and Manufacturing  
Indian Institute of Science  
Bengaluru, Karnataka, India

ISSN 2195-4356

ISSN 2195-4364 (electronic)

Lecture Notes in Mechanical Engineering

ISBN 978-981-15-5688-3

ISBN 978-981-15-5689-0 (eBook)

<https://doi.org/10.1007/978-981-15-5689-0>

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# Preface

Industry 4.0 is about using connected intelligence to usher in greater productivity, quality, flexibility, safety and resource utilisation across manufacturing enterprises, in which advanced manufacturing such as robotics or additive manufacturing plays a critical role.

The collection of papers in this book volume constitutes the Proceedings of the First International Conference on *Industry 4.0 and Advanced Manufacturing* (I-4AM 19) held at the National Science Seminar Complex, Indian Institute of Science, Bangalore, India, during 28–29 June 2019. I-4AM 19 is the first in a series of biennial conferences held in India to bring together all stakeholders in manufacturing and Industry 4.0, in particular those in academia and industry in both India and abroad, for them to deliberate on the nature, needs, challenges, opportunities, problems and solutions in this transformational area of endeavour.

I-4AM 19 was hosted in Bangalore, the “silicon plateau” of the world, with the second fastest growing community of start-ups, many of which are exploring emerging technologies such as IOT, IIOT, digital twins, sensor networks, I4.0 and so on to design new products, systems and services. The theme for I-4AM 19 was aligned with this ambiance. A specific focus of this conference is to provide a platform for exploring avenues for creating a vision of, and enablers for sustainable, affordable and human-centric Industry 4.0 and to showcase cutting-edge practice, research and educational innovation in this crucial and rapidly evolving area.

Forty-four abstracts were submitted to I-4AM 19, from which 40 were accepted for submission as full papers. Thirty-nine full papers were submitted, which were reviewed by experts from the I-4AM 19 International Programme Committee comprising 34 members from over 20 institutions, industries or organisations. Finally, 28 full papers, authored by 76 researchers (76 unique authors) from 40 institutions, industries or organisations from 3 countries and from 3 continents, were selected for presentation at the conference and for publication as chapters in this book.

I-4AM 19 had 28 papers with podium presentations followed by discussion. It had six academic keynotes from prominent researchers and practitioners from around the world such as Mike Gregory from University of Cambridge, UK; Niels Lohse, from

Loughborough University, UK; Rudra Pratap from Indian Institute of Science, Bangalore, India; Suhas Joshi from Indian Institute of Technology, Bombay, India; Ramesh Babu N. from Indian Institute of Technology, Madras, India; and Suresh Palanisamy, from Swinburne University, Australia. It had five Industrial keynotes from prominent industry and organisations around India such as Debashish Bhattacharjee from Tata Steel, India; Thanga Jawahar from Tata Consultancy Services, India; Purnendu Sinha from the Tata Group, Bengaluru, India; Chandrashekar Bharathi from AceMicromatic MIT, India; and Vidyabhushana Hande from Siemens Technology, India.

It had five panel discussions: “Policy Challenges and Opportunities in Industry 4.0 and Advanced Manufacturing”; “Challenges and Opportunities for Industry in Industry 4.0 and Advanced Manufacturing”; “Challenges and Opportunities in Precision Manufacturing for the Strategic Sector”; “Challenges and Opportunities for Training and Research in Advanced Manufacturing and Industry 4.0”; and “Challenges and Opportunities for Start-ups in Advanced Manufacturing and Industry 4.0”. Over 40 thought leaders from industry, academia and policy sectors participated in the panel discussions. Ten start-ups were invited to join I-4AM 19 free of cost; were given stalls to display their products; and special sessions were organised in which they could interact with successful entrepreneurs who advised them on entrepreneurship.

Bengaluru, India

Amaresh Chakrabarti  
Manish Arora

# About This book

This book, *Industry 4.0 and Advanced Manufacturing—Proceedings of I-4AM 2019*, focuses on the following topics:

- Materials Processing and Joining;
- Controls, Autonomous Systems, and Robotics;
- Policy and Entrepreneurship;
- Supply Chains and Industry 4.0;
- Digital Manufacturing; and
- Sustainable Manufacturing.

On behalf of the Steering Committee, Advisory Committee, Organising Committee and Co-chairs, we thank all the authors, delegates, institutions and organisations that participated in the conference. We also thank the members of the International Programme Committee for their support in reviewing the papers for I-4AM 19, which is essential for maintaining the quality of the conference, and for their support in helping us put this book together.

We are thankful to the major partners: (Confederation of Indian Industry (CII), Fraunhofer and VDMA); the major sponsors (UK Science and Innovation Network and Springer); other industry partners (Ashok Leyland, Tata Consultancy Services (TCS), Yaskawa, Toyota Kirloskar and Faurecia) and partnering departments (Centre for Product design and Manufacturing, Robert Bosch Centre for Cyber Physical Systems, Department of Aerospace Engineering, Department of Electronic Systems Engineering, Department of Electrical Communications Engineering, Centre for Sustainable Technology, Department of Instrumentation and Applied Physics, Department of Civil Engineering, Department of Materials Engineering, Department of Mechanical Engineering and Department of Management Studies) for their kind endorsement of I-4AM 19. We thank the Indian Institute of Science (IISc), Bangalore, and its Centre for Product Design and Manufacturing, for their support of this event by allowing their premises to be used for the various functions in the conference. We also wish to place on record and acknowledge the enormous support provided by Mr. Venu Allam, Mr. Karthick B., Ms. Nishath Salma, Dr. Shakuntala Acharya, Mr. Ranjan B. S. C., Mr. Kiran Ghadge, Mr. Puneeth

K. S., Mr. Ishaan Kaushal, Mr. Apoorv Bhatt, Mr. Anubhab Majumdar, Mr. Paridhi S. and Mr. Dhiraj Kumar of IISc in managing the review process, in the preparation of the conference programme and booklet, and for their help in preparing this book and the conference as a whole. We also thank the large and dedicated group of student volunteers of IISc Bangalore in the organisation of the conference. Finally, we thank Springer, especially its Editor Ms. Swati Meherishi and its editorial support team, for their wonderful support.

Bengaluru, India

Amaresh Chakrabarti  
Manish Arora

# About the Conference

Industry 4.0 is about using connected intelligence to usher in greater productivity, quality, flexibility, safety and resource utilisation across manufacturing enterprises, in which advanced manufacturing such as robotics or additive manufacturing plays a critical role. This conference intended to provide a platform to bring together all stakeholders in manufacturing and Industry 4.0, in particular those in academia, industry and policy in both India and abroad, for them to deliberate on the nature, needs, challenges, opportunities, problems and solutions in this transformational area of endeavour. A specific focus of this conference has been to provide a platform for exploring avenues for creating a vision of, and enablers for sustainable, affordable and human-centric Industry 4.0 and for showcasing cutting edge practice, research and educational innovation in this crucial and rapidly evolving area.

I-4AM 19 (pronounced i-forum 2019) included keynotes, panel discussions and mentoring sessions from thought leaders in industry, academia, strategic sectors and policy bodies, as well as presentation sessions for research papers. All research papers submitted had undergone peer review process by the International Programme Committee; selected papers have been published in a proceedings book published by Springer.

I-4AM 19 was organised by the Centre for Product Design and Manufacturing, Indian Institute of Science, under its CEFC on I4.0India@IISc (Smart Factory) within the SAMARTH Udyog Bharat 4.0 programme of the Department of Heavy Industries, Government of India.

The conference contained:

- Keynote presentations from eminent experts from industry, academia, policy and strategic sectors;
- Panel discussions by thought leaders from major stakeholders in advanced manufacturing and industry 4.0;
- Presentations of peer-reviewed papers as podium presentations;
- Mentoring sessions for start-ups;
- Display of innovations from start-ups in industrial stalls.

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## About the Editors

**Amaresh Chakrabarti** is a Senior Professor and current Chairman for the Centre for Product Design & Manufacturing, Indian Institute of Science (IISc), Bangalore, India. He received his B.E. in Mechanical Engineering from IEST Shibpur India, M.E. in Mechanical Systems Design from IISc Bangalore, and Ph.D. in Engineering Design from the University of Cambridge, UK. His research interests are in synthesis, creativity, sustainability, informatics, research methodology and Industry 4.0. He has published 18 books, over 300 peer-reviewed articles, and is the series editor for Springer's book series on Design Science & Innovation. He has been granted/pending for 10 patent applications. He serves on the editorial boards of numerous prestigious journals and has been on the Advisory and Management Board of the Design Society; member of the CII National Committee on Design India; Jury for the India Design Mark; and invitee to the CII Smart Manufacturing Council India. He is an Honorary Fellow of the Institution of Engineering Designers, the peer society under the UK Royal Charter in engineering design, and TUM Ambassador Awardee from TU Munich Germany.

**Manish Arora** is Assistant Professor at the Centre for Product Design and Manufacturing, Indian Institute of Science, Bengaluru. He obtained his Ph.D. in Applied Physics from the University of Twente, The Netherlands (2006) and B.Tech. in Chemical Engineering from Indian Institute of Technology, Delhi (2002). He has 70+ patent and research publications both in national and international level to his credit. His areas of interest include biomedical devices, co-design, collaboration, open-source in design and quality manufacturing of medical devices. He is the Principal Investigator in UTSAAH Lab, which aims at developing affordable and accessible medical technology solutions for promoting universal healthcare. He teaches courses at IISc on Mechatronics and Design of Biomedical Devices and Systems.