

Sustainable Manufacturing

Products, Processes, and Systems

Volume 7, Issue 1

Institute for Sustainable Manufacturing Newsletter

Fall 2020

A Message from the Director



The Institute for Sustainable Manufacturing (ISM) is completing its eighth year of successful operation. ISM activities focus on products, processes and systems. ISM faculty and researchers have been at the forefront of research and applications in sustainable manufacturing. Over the years, ISM has made excellent progress with our overall mission of conducting academic research (basic and applied), offering educational programs, being engaged in innovation and developing intellectual properties, and providing industry outreach. Our research productivity with new funding, research publications, and graduate student productivity has continued to increase. Here are some highlights of our achievements in 2020:

- The ISM faculty members have been very productive in translating their research outcomes into innovation through new patents and IPs. One US patent was issued, five patent applications were filed, six provisional patents were issued, with a few new IP disclosures – details are shown on p. 2.
- Several ISM faculty delivered invited keynote presentations and lectures, and served on national-level review panels. Their research work was also recognized with awards by professional societies – details are shown on p. 2.
- Researchers from ISM and the University of Bologna, Italy began a new research collaboration in the area of **Design Innovation for Next Generation Sustainable Products**.

Also, continued active collaboration with the Technical University of Berlin, Germany in the area of **Digitally-Integrated Sustainable Manufacturing for Value Creation**.

- ISM researchers have launched a major international collaborative research project, IMPACT. This project was approved by the CIRP (International Academy for Production Engineering) in February 2020, and involves 45 researchers from 35 major research labs, universities and industry groups from 11 countries. ISM leads this effort – details are shown on p. 3.
- ISM Faculty continued to offer courses for the Online Master's Degree Program in Manufacturing Systems Engineering, with more online courses added to the list. Since this program became fully online in 2016 our enrollment has increased significantly.
- ISM faculty, in collaboration with other faculty in the College of Engineering and the Gatton College of Business and Economics have developed a new Online Masters Program in Supply Chain Engineering (SCE). This program has been approved by UK in 2020. Prof. Fazleena Badurdeen leads this initiative and serves as the director of this program.
- ISM faculty continued their industry interactions with major companies such as GE Aviation, Toyota and Lexmark International.

I. S. Jawahir, Director, ISM

Brazing of Aluminum Alloys in Space



Since 2017, Prof. Dusan P. Sekulic has been leading an estimated \$1 million international research project funded by NASA and the Roscosmos State Corporation for Space Activities in Russia. The project, "Brazing Aluminum Alloys in Space," studies fundamental scientific phenomena describing how molten metal can enable assembly, manufacturing and/or repairs to the International Space Station (ISS) and other spacecrafts. Brazing is planned under 0-g at the ISS as well as at 1-g (terrestrial conditions under controlled atmosphere and vacuum).

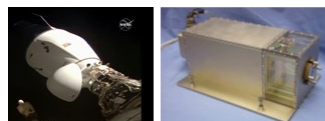
Featured research activities:

- On December 6, 2020, samples were successfully launched to the ISS by SpaceX CRS-21, and conduction of flight 0-g tests are planned to begin in May 2021.

- Terrestrial 1-g benchmark tests will be starting in March 2021, with the help of NASA contractor Techshot, Inc.
- Preliminary in-situ, real-time ground tests of Al-Si molten alloy capillary flow over aluminum alloys have been conducted in the ISM Brazing Lab at UK. Phase Field and Surface Evolver modeling of triple line movements and microstructures under both 1-g and 0-g have been conducted by partners from Washington State University, USA and Udmurt State University, Russia.



International Space Station (ISS)



Docking with ISS SUBSA furnace

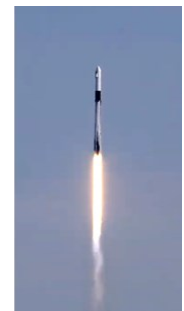


Photo credit: NASA



WASHINGTON STATE
UNIVERSITY



New US Patents, Patent Applications and IP Disclosures

Patent Issued:

Zhang, Y.M., Zhang, W.J. "Measurement of Three-Dimensional Welding Torch Orientation for Manual Arc Welding Process." U.S. Patent No. 10,773,330.

Patents Pending:

Jawahir, I.S., Bradley, R. "Innovative Manufacturing Methods for Next Generation Products, Processes and Systems." U.S. Patent Application No. 16/998,366.

Schoop, J. "High Speed Multi-Axis Machine Tool." U.S. Patent Application No. 16/798,007.

Schoop, J. "Device for Characterization Of Material Properties Under Realistic Process Conditions." U.S. Patent Application No. 16/856,533.

Werner, J., Chandra, A., Honaker, R. "Continuous Solvent Extraction Process for Generation of High-Grade Rare-Earth Oxides from Leachates Generated from Coal Sources." U.S. Patent Application No. 16/534,738.

Honaker, R., **Werner, J.**, Zhang, W. "Apparatus and Method for Power Generation and Valuable Element Recovery from Combustion By-products." U.S. Patent Application No. 16/773,081.

Provisional Patents:

Werner, J. "Ammoniacal Extraction of Copper, Gold and Other Elements of Value." U.S. Provisional Patent Application No. 62/972,379.

Werner, J. "Principles of Operation and Control of Regenerated Oxidizer in Countercurrent Leaching Configurations." U.S. Provisional Patent Application No. 62/971,472.

Werner, J. "Electrowinning Cells for the Segregation of the Cathodic and Anodic Compartments." U.S. Provisional Patent Application No. 62/972,405.

Schoop, J. "Methodology for Modeling Optimization and Real-Time Monitoring of Machining and Finishing Processes." U.S. Provisional Patent Application No. 62/837,357.

Schoop, J. "Implicit Cybersecurity for the Digital Thread in Manufacturing." U.S. Provisional Patent Application No. 63/047,478.

Okunev, D., Srivastava, S., **Badurdeen, F.** "A Web-Based Digital Thread-Driven Sustainable Manufacturing Via Digitally-Integrated, Multi-Lifecycle Product Development." International Application No. PCT/US2020/012315.

IP Disclosures:

Badurdeen, F., Rummler, D., **Jawahir, I.S.**, Elam, A. "An Engineered Business System for Sustainable Manufacturing Excellence." IP Disclosure No. 2542.

Schoop, J. "SME Efficient Machining Advisor App." IP Disclosure No. 2502.

Schoop, J. "Intelligent Machine Vision System for In-Process Tool Wear Monitoring." IP Disclosure No. 2555.

Keynote Presentations, Panel Participations, Appointments and Awards



Dr. I.S. Jawahir delivered a keynote presentation at the opening of the IMTS Spark Conference series on Sustainable Manufacturing on October 12, 2020. The presentation title was "Digitally Integrated Sustainable Manufacturing to Promote and Advance Circular Economy for Next Generation Manufacturing." The conference information is available [here](#).

Dr. Julius Schoop was invited to talk for DFG (German Science Foundation) SPP 2086 Technical Meeting virtually. The presentation title was: "Intelligent Surface Conditioning of TiAl Through Physics-informed Adaptive Control of Finish Machining."

Dr. Yuming Zhang was awarded the International Meritorious Award by the American Welding Society (AWS), 2020.



Dr. Peng Wang's paper "Transferable Two-stream Convolutional Neural Network for Human Action Recognition" received the Outstanding Technical Paper Award from the 2020 North American Manufacturing Research Conference (NAMRC).

Dr. I.S. Jawahir presented an invited lecture on "Advancing Circular Economy through Digitally-integrated Sustainable Manufacturing" on September 15, 2020, as a part of the Distinguished Lecture Series organized and hosted by the University of Technology – Malaysia (UTM). This presentation was made online and is available [here](#).



Dr. Fazleena Badurdeen was invited to be a panelist at the Circular Economy of Materials and Global Supply Chains, National Renewable Energy Laboratory (NREL) Joint Institute for Strategic Energy Analysis (JISEA) Annual (Virtual) Meeting, August 3-6, 2020.

Dr. Dusan P. Sekulic was appointed as a visiting Chair Professor at the Harbin Institute of Technology, The School of Materials Science and Engineering.

Dr. Peng Wang's paper "Attention Mechanism-Incorporated Deep Learning for AM Quality Prediction" won the Best Paper Award at the 53rd CIRP Conference on Manufacturing Systems, held on July 1-3, 2020.



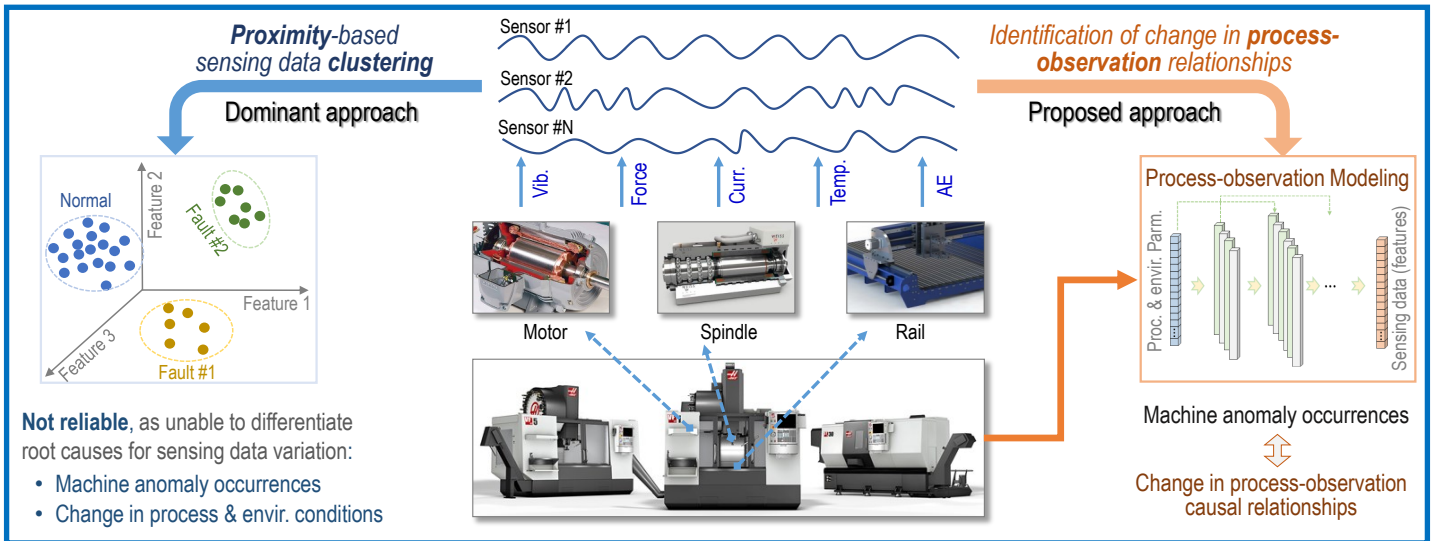
Research Spotlight: Dr. Peng Wang

Understanding Manufacturing Process Dynamics and Machine Tool Anomaly Detection Through Process Sensing and Machine Learning



Dr. Peng Wang and Dr. I. S. Jawahir received a National Science Foundation (NSF) award to design a next-generation process-sensing machine learning architecture to capture manufacturing process dynamics that reveal the underlying dependency of product quality on process settings and machine conditions. With the advancement of process sensing, the Internet of Things, data analytics, and cloud computing, more manufacturing plants favor predictive maintenance over traditional preventive maintenance. However, there are limitations in existing techniques preventing

full implementation of predictive maintenance, such as insufficient accuracy and reliability in machine tool anomaly/fault detection. To overcome these limitations, our research is developing a physically interpretable, automatic tunable, and scalable machine learning architecture that allows performing analysis of system input-output causal relationships and learning from unbalanced data and evolving machine conditions. We have also developed an effective and efficient data compression and transmission technique allowing the transmission of large amounts of industrial data from shop floors to cloud data centers for processing and analysis.



ISM Leads IMPACT Project - An International Research Collaboration

In August 2019, an ISM research group (Professors I.S. Jawahir, F. Badurdeen, J. Schoop and Peng Wang, and Dr. James Caudill) launched a new major international collaborative research project, IMPACT (Integrated Machining Performance for Assessment of Cutting Tools). In February 2020, this project was formally approved by the CIRP (International Academy for Production Engineering) with full sponsorship at the CIRP's Annual Meeting in Paris, France. This major international research collaborative project will involve about 45 researchers from renowned international research labs, including three leading cutting tool manufacturers, from 11 countries (Canada, France, Germany, Italy, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, USA). ISM leads this effort.

performance model for IMPACT. A digitally-enabled predictive capability will be developed for determining the optimal machining performance of a machining system for a given machining operation.

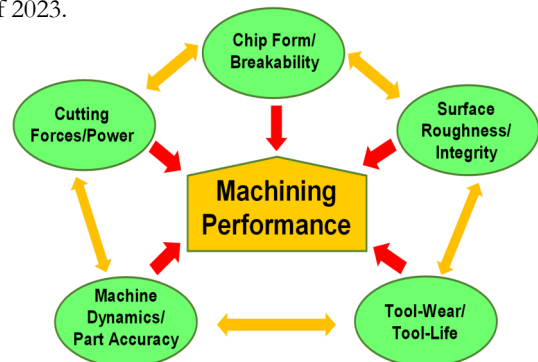
The IMPACT research group has recently identified five research focus areas: A – Evaluation of current machinability evaluation methods and practices; B – Predictive model development; C – Engineered cutting tool design; D – Smart tooling and sensor development; and E – Optimized total machining performance evaluation. Proposed collaborative research activities in all five areas are carefully placed within a three-phased project plan which is expected to reach its goals by the end of 2023.



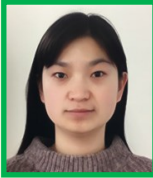
The goal of this project is to develop an integrated machinability evaluation method to characterize the overall performance of a machining system (work material, cutting tool, and machine tool). The new method includes the five major machinability parameters shown in the accompanying figure.



Advanced computational modeling and machine learning methods, in-situ material performance analysis, experimental data, and optimization techniques will be used to develop a predictive



New Postdoctoral Researchers



Yangyang Wu received her PhD in Mechanical Engineering from the University of Kentucky in 2020 and became a Postdoctoral Researcher in ISM the same year. Her advisor is Dr. Dusan P. Sekulic. She is currently working on a NASA-funded project “Brazing of Aluminum Alloys in Space,” in which brazing is planned under 0-g at the International Space Station as well as at 1-g (terrestrial condition).



James R. Caudill received his PhD in Mechanical Engineering from the University of Kentucky in 2019. He joined ISM as a Postdoctoral Researcher the same year in Dr. I.S. Jawahir’s research group. His work focuses on the generation of thermally-stable nanostructures in titanium alloys and modeling of machining and severe plastic deformation finishing processes.

International Collaborations

- Design Innovation for Next Generation Sustainable Products – Collaboration with University of Bologna (UB), Italy. **Fazleena Badurdeen** and **I.S. Jawahir** (UK); Prof. G. Campana and Dr. B. Cimatti (UB).
- Digitally-Integrated Sustainable Manufacturing for Value Creation – Collaboration with Technical University of Berlin (TUB), Berlin, Germany. **I.S. Jawahir** and **Fazleena Badurdeen** (UK); Prof. G. Seliger, Prof. F. Dietrich and Dr. P. Bilge (TUB).
- DFG Priority Program SPP 2086: Surface Conditioning in Machining Processes – International fellowship and collaboration with various leading German research institutes under the leadership of Karlsruhe Institute of Technology (KIT), Germany. **Julius Schoop** (UK), Prof. Volker Schulze (KIT).

About the Institute for Sustainable Manufacturing

Details about our new projects, lab facilities, books, recent publications, patents, and more can be found on our [website!](#)

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Journals

International Journal of Sustainable Manufacturing

www.inderscience.com/ijsm

Journal of Machining Science and Technology

www.tandfonline.com/toc/lmst20/current

ISM Faculty

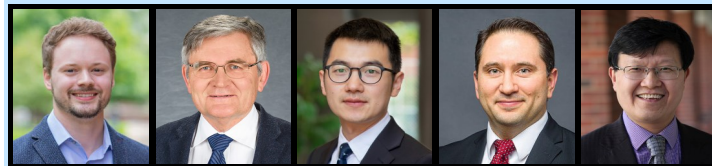


F. Badurdeen L. Holloway I.S. Jawahir W. Li K. Rouch

ISM Staff



A. Price



J. Schoop D. Sekulic P. Wang J. Werner Y. Zhang



D. Harrod

New Supply Chain Engineering Master’s Program (MS-SCE)

UK’s online MS-SCE degree will prepare you to apply scientific and mathematical principles to design, evaluate and improve transformational and logistical functions within an enterprise and among its partners across the supply chain.

Features of the MS-SCE program

- University of Kentucky’s MS-SCE and MS in Supply Chain Management programs are the only known programs in the country—and perhaps in the world—that incorporate overlapping curricula from engineering and business & economics colleges to develop future supply chain engineers and managers.
- The program is 100% online. You can pursue your degree part-time while working full-time.
- Requires five consecutive semesters to complete with two courses per semester.
- Offers fixed tuition whether you live in Kentucky or are from another state.
- No GRE score is required for admission, and No thesis is required to obtain the degree.



For additional details contact: Dr. Fazleena Badurdeen at badurdeen@uky.edu or (859) 323-3252