

Module 1 (Adv. Science for Industrial Process)

Lesson1: Operation management strategy in industry 4.0 context

Industry 4.0 framework, concept, theories, tools and techniques. Discussion of their impact on modern operation management in strategic level.

Lesson 2: Smart product and co-created design concept

The smart product and co-created design concept and tools. Applying product design tools to design smart product that correspond to business strategy in modern digital environment

Lesson 3: Smart manufacturing concept

The smart manufacturing concept such as cyber-physical systems, computer integrated manufacturing and automation in order to design the high levels of adaptability production process.

Lesson 4: Smart operation concept

The enterprise-wide and cross-enterprise integration of the physical and virtual worlds. The design of smart production planning system and supply chain







A holistic view of manufacturing



B. Esmaeilian, S. Bahdad and B. Wang (2016) The evolution and future of manufacturing: A review, Journal of Manufacturing Systems, 39, p.79-100



Classification of manufacturing systems

Information Technology	Computerized Numerical Control machine (CNC), 1940s	Co M (1	mputer Aided Janufacturing CAM), 1960s	Computer Integrated Manufacturing
Production Philosophy	Lean Mfg. 1980s	Agile N 199	Иfg. 5	Leagile Mfg. 1999
Production Control Strategy	Push Systems: (e.g., Material Requirements Planning,	(e.g., J 1953	Pull Systems: ust in Time, Kanban 3, CONWIP, 1990)	Hybrid Push/Pull
Inventory Control Strategy	Make-to-Stock	Make-to-Forecast	Assemble-to-Order	Make-to-Order
Production Layout 🛛 💳	Single Statior Manufacturing C	n Cells	Group Technology, Cellular Manufacturin Systems, 1925	
Machining System	Dedicated Machining System	Flexible N Sys	Machining tem	Reconfigurable Machining System, 1990s
ASPECTS maeilian S Babdad	land B Wang (2016) T	he evolution an	d future of man	ATIME

Journal of Manufacturing Systems, 39, p.79-100

MSE





Definitions of smart manufacturing

IOT agenda: a technology-driven approach that utilizes Internet-connected machinery to monitor the production process

Wiki: a broad category of manufacturing that employs computer-integrated manufacturing, high levels of adaptability and rapid design changes, digital information technology, and more flexible technical workforce training

I-Scoop: the fully-integrated, collaborative manufacturing systems that respond in real time to meet changing demands and conditions in the smart factory, in the supply network, and in customer needs.

https://internetofthingsagenda.techtarget.com/definition/smart-manufacturing-SM https://en.wikipedia.org/wiki/Smart_manufacturing https://www.i-scoop.eu/industry-4-0/manufacturing-industry/





Production

Functional

Information

Integration

Asset

Communication

M. Resman et al. (2019) A new architecture model for smart manufacturing: A performance analysis and comparison with the RAMI 4.0 reference model, APEM Journal (14) p.153-165

Connected World

Enterprise

Work Centers

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Station

Control Device

Field Device

Product

Hierarchy levels MS The Old World: Industrie 3.0 Entreprise Work Hardware-based structure Centers Functions are bound to hardware Hierarchy-based communication Station Ο Product is isolated Control × Device • . Field Device Product \odot https://ec.europa.eu/futurium/en/system/files/ged/a2-schweichhartreference_architectural_model_industrie_4.0_rami_4.0.pdf Co-funded by the

Erasmus+ Programme of the European Union





Hierarchy levels

World

Smart

Factory

The New World: Industrie 4.0

- Flexible systems and machines ٠
- Functions are distributed • throughout the network
- Participants interact across ٠ hierarchy levels
- Communication among all participants
- Product is part of the network ٠



Smart Products

https://ec.europa.eu/futurium/en/system/files/ged/a2-schweichhart-

reference_architectural_model_industrie_4.0_rami_4.0.pdf



Life cycle and value stream



https://ec.europa.eu/futurium/en/system/files/ged/a2-schweichhartreference_architectural_model_industrie_4.0_rami_4.0.pdf

MS





Six-layer architecture



https://ec.europa.eu/futurium/en/system/files/ged/a2-schweichhartreference architectural model industrie 4.0 rami 4.0.pdf



Smart manufacturing ecosystem



MS

Y. Lu et al. (2015) Standard landscape and direction for smart manufacturing systems, IEEE International Conference on Automation Science and Engineering, Aug 24-28, 2015. Gothenburg, Sweden



Smart manufacturing architecture MS Stakeholders (including customers, product designers & production engineers) **Role-based** Portal Presentation & Visualisation **Discovery &** Product-Oriented querying Reporting & Interactive Detection **3D** Augmented **Configuration Language** Dashboards Publishing and Alerts services Reality Analytics Product Library Support of effective manufacturing decisions & planning. Data Ingestion, Correlation & Information Interpretation Root-cause identification for quality & productivity Actionable Actionable Insights events & information Product Data & Knowledge Management M. P. Papazoglou and A. Elgammal. Suppliers Heterogeneous Product specifies, Materials, Parts, Product Quality, Products (2017) The manufacturing Product Family, Assembly, Production Process Data Processes **Production Plans** from Product Taxonomies blueprint environment: Bringing Quality Assurance Enterprise & **Knowledge Templates Factory Floor** intelligence into manufacturing, Transformation **Data Sources** Marketplace & **Knowledge Processing Environment** Engine **IEEE** International conference on Repository Engineering, Technology and

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Innovation, Portugal









Concept of smart manufacturing enterprise



A. Kusiak (2018) Smart manufacturing, International Journal of Production Research, 56(1-2), p. 508-517





Smart manufacturing technology

Table 1 Smart Manufacturing technologies.

Categories	Technologies for Smart Manufacturing			
Vertical integration	Sensors, actuators and Programmable Logic Controllers (Pl Supervisory Control and Data Acquisition (SCADA) Manufacturing Execution System (MES) Enterprise Resource Planning (ERP) Machine to machine communication (M2M)	LC)		
Virtualization	Virtual commissioning Simulation of processes (e.g. digital manufacturing) Artificial Intelligence for predictive maintenance Artificial Intelligence for planning of production			
Automation	Machine-to-machine communication (M2M) Robots (e.g. Industrial Robots, Autonomous Guided Vehicles, or similar) Automatic nonconformities identification in production			
Traceability	Identification and traceability of raw materials Identification and traceability of final products	A.G. Frank et al (2019)		
Flexibility	Additive manufacturing Flexible and autonomous lines	Industry 4.0 technologies		
Energy management	Energy efficiency monitoring system Energy efficiency improving system	in manufacturing companies, Inter. J.		
	Co funded by the	Production Economics.		

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210, p. 15-26

Big data in manufacturing

MS



B. Esmaeilian, S. Bahdad and B. Wang (2016) The evolution and future of manufacturing: A review, Journal of Manufacturing Systems, 39, p.79-100





A. Kusiak (2019) Fundamentals of smart manufacturing: a multi-thread perspective, Annual Review in Controls, 47, p. 214-220 Co-funded by the

Erasmus+ Programme of the European Union







Smart industry readiness index

Smart Industry Readiness Index



https://www.tuvsud.com/en-sg/resource-centre/stories/smart-industry-readiness-index





Smart manufacturing books





