Dusan N Sormaz, Ind Eng Manage 2014, 3:5
http://dx.doi.org/10.4172/2169-0316.S1.002

OMICS Group Conferences
Accelerating Scientific Discovery

International Summit on
Industrial Engineering
December 08-10, 2014 DoubleTree by Hilton Hotel San Francisco Airport, USA

Product design and planning for additive (and hybrid) manufacturing

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Manufacturing in most of the industries has shifted focus in recent decades from mass production, through just-in-time manufacturing, cellular manufacturing into rapid response manufacturing with the goal of shortening product delivery cycles. Recent developments in developing 3D printing and other additive manufacturing technologies have opened the path to both rapid response and high customization. In addition, information technologies enabled another shift: Shortening not only product delivery but product development cycle. Those technologies together enable the significant reductions of all components of the order lead time: Product design, process design, and product manufacturing and delivery time. In addition 3D printing provides for rapid delivery of customized one-of-a-kind products at reasonable cost, and also can be combined with traditional manufacturing for some products. However, such ability has a precondition: Product development and manufacturing planning have to be supported up-front to enable rapid customization. Both design and manufacturing have to be supported by knowledge, information, and data models using modern technologies. This presentation addresses a model for product design and planning for additive manufacturing. The model is based on authors research on IMPlanner in traditional manufacturing which is further extended here to include additive and hybrid manufacturing (hybrid manufacturing is one that utilizes benefits of both, additive and subtractive processes). The model includes the following components: Additive manufacturing ontology, design for additive manufacturing, additive manufacturing planning rules. Additive manufacturing ontology represents the knowledge capture model. It is built as an extension of generic product design and manufacturing ontology which establishes relationships between concepts (objects) in design (part, features, tolerances, etc), manufacturing (processes, capabilities, compatibilities, process parameters, etc) and resources (machine, tool, fixture, etc). Extensions relevant for additive/hybrid manufacturing are illustrated on several examples. Additive manufacturing brings forward completely new set of product design guidelines, which is called DfAM (Design for Additive Manufacturing). Most product design is performed using traditional Design for Manufacturing (DfM) and Design for Assembly (DfA) methodologies. AM provides opportunities to design new shape forms, which could be better suited for both design and manufacturing (for example gradient material strength or gradient density, conductivity etc.). We approach DfAM from two directions: a) design data needs to be functionally interpreted to store the designer's intent and imagination. It is crucial to understand and capture both domain-independent and domain-specific AM knowledge, to include part and product design, geometry, function, etc.; b) Design (CAD) model needs to be extended for AM, For example, contemporary CAD models are not capable to represent gradient strength of a design, nor any other property that 3D printing enables. Additive manufacturing planning procedures and rules are different from traditional. While versatility of possible shapes extends notion of manufacturing features into new direction, the whole planning process is different. It is illustrated on several examples, related to part orientation, process capabilities, and parameters. The presentation concludes with an integrative model for AM design and planning and directions for further research.

Biography

Dusan N Sormaz is an Associate Professor of Industrial and Systems Engineering at Ohio University, Athens, USA. His principal research interests are in process planning, Computer Integrated Manufacturing (CIM), simulation and lean manufacturing, and application of knowledge based systems in manufacturing. He developed the prototype of intelligent process planning system 3IPP. He has worked in a technology transfer project with Adizes Southeast Europe in Novi Sad. He also worked on FIPER project funded by NIST (ATP) in developing cost modeling tool. He has developed the distributed process plan modeling system IMPlanner and applied its algorithms in projects for Delphi automotive. Recently, he has worked on developing cost models for jet engines and turbines, and on development of corrosion modeling software. He has published his research (over 80 refereed papers) in refereed journals, the two book chapters and at international conferences. He serves as a Reviewer for several international journals (IJPR, CAD, and others), and he co-edited proceedings of Group Technology/Cellular Manufacturing World Symposium 2003. He received his PhD degree in industrial and systems engineering and MSc in computer science from University of Southern California, Los Angeles, CA, and MSc in industrial engineering and BS in mechanical engineering from University of Novi Sad, Yugoslavia. He is Member of IIE, Senior Member of SME, and Member of IEEE.

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