DIGITAL MANUFACTURING
Digital Manufacturing allows for the…..

- Shortening of development time and cost
- Integration of knowledge coming from different manufacturing processes and departments
- Decentralized manufacturing of the increasing variety of parts and products in numerous production sites
- Focusing of manufacturing organizations on their core competences, working efficiently with other companies and suppliers, on the basis of effective IT-based cooperative engineering
BENEFITS OF DM

- Shortened product development
- Early validation of manufacturing processes
- Faster production ramp up
- Faster time to market
- Reduced manufacturing costs
- Improved product quality
- Enhanced product knowledge dissemination
- Reduction in errors
- Increase in flexibility
• VIRTUAL REALITY
• COMPUTER NETWORK
• RAPID PROTOTYPING
• MULTI MEDIA
DM is the result of merging process of the following

- Digital Technology
- Network Information Technology
- Manufacturing Technology
- Digitizing process in manufacturing process in manufacturing enterprises, manufacturing systems and production systems
CONCEPT OF DIGITAL MANUFACTURING

✓ Control Centered DM
✓ Design Centered DM
✓ Management Centered DM
✓ Manufacturing Centered DM
CONCEPT OF DIGITAL MANUFACTURING
Control Centered DM

NC
CNC
DDC (Direct Digital Control)
FMS (Flexible Manufacturing Cell)
LAN
Design Centered DM

CAD
CAPP
CAM
Management Centered DM

- Evaluate the production and management of an enterprise
- Forecasts its future and operating conditions
- Devise an investment strategy
- Arrange the assignment of production

MIS (Management Information System)

ERP (Enterprise Requirement Planning)
PDM (Products Data Management)
Manufacturing Centered DM

• Virtual reality and virtual manufacturing
• Network manufacturing and E-manufacturing
• Rapid prototyping and rapid manufacturing
DEFINITIONS OF DIGITAL MANUFACTURING

Siemens: “Digital Manufacturing is the use of an integrated, computer based system comprised of simulation, 3D visualization, analytics and collaboration tools to create product and manufacturing process definitions simultaneously”

Wikipedia: “Digital Manufacturing can be defined as an integrated approach to manufacturing that is centered around a computer system”

University of Cambridge: “The application of digital information (from multiple sources, formats, owners) for the enhancement of manufacturing processes, supply chains, products”
Important features of DM

• When it is described and expressed, its digital expression has exclusive meaning and is reusable

• When it analyzes manufacturability and evaluates the performance of a product, it has the predictability of product development and product performance

• In the network environment, the manufacturing activities have independence in distance, time and location
DIGITAL EXPRESSIONS

Establishes a digital model of products and presenting the digital definition of the entire process of the product life cycle in such a way that the computer can understand

1. GEOMETRIC MODELS (Product design & Manufacturing)
2. KNOWLEDGE MODEL
3. PHYSICAL MODEL (Product oriented performance analysis)
4. PROTOTYPE MODEL
MAUFACTURING IN NETWORK ENVIRONMENT

- Common digital manufacturing equipment used in the network
- Numerical Control (NC) and Computer Numerical Control (CNC) machine tools
- Automated welding machines
- Industrial robots
- Coordinate Measuring Machine (CMM)
THEORY SYSTEM OF DIGITAL MANUFACTURING SCIENCE

Digital manufacturing science is a science which deals the basic concepts and pivotal technologies, methods of informatics and system engineering with a target of optimal operation of the digital manufacturing system.
Basic Mathematical Theories

• Product Demand
• Product design and simulation
• Management of manufacturing process
• Operational control of production equipment
• Management of product quality
• Product sales and maintenance and other aspects
Operation reference mode of digital manufacturing system

Design, simulation and production of a product are completed in a digital environment.
Stages of Digital manufacturing system are as follows:

- Market Analysis and evaluation
- Product design and simulation
- Production and control
- Product quality management
- Marketing and sales
- Customer Services
ARCHITECTURE OF DM System includes

• Basic theories of DM science
• Key technology
• Network
• Application fields of DM
Key Technologies of DM include

• Product description technology
• Manufacturing process expression and control technology
• Manufacturing data acquisition
• Storage & processing technology
• Networks and grid technology
• Engineering database technology
• Virtual and simulation technology
• Metadata technology
Market Analysis and Evaluation system

Market Analysis Techniques

• Primary and Secondary research
• Surveys
• Focus groups
• Interviews
• Observations
• Experiments/Field trials
Production and control system

• Process control specifications
• Manufacturing Routing
• NC programs for CNC machines
• Plant Automation
• Material handling and storage facilities
• Inventory planning
• Master production schedule
• Materials requirement planning
• Production Scheduling
Digital equipment and facilities used for the optimized smooth flow of production are

i. CAM software packages to generate NC programms
ii. Computer aided process planning packages
iii. Layout optimization software
iv. Flexible automation software
v. Robots
vi. Computer controlled Automated Guided Vehicles (AGVs)
vii. Computerized automated material handling and storage facilities
viii. Inventory planning and maintenance software packages
ix. Material requirements planning (MRP) software packages
x. Sequencing and Scheduling software packages
ARCHITECTURE OF DIGITAL MANUFACTURING SYSTEM
Evolution of the Design/Build Process

- **80s**
  - 2D Technological Advance
  - Design & Validation of Manufacturing Processes

- **90s**
  - 3D Digital Mockup

- **2000**
  - Digital Manufacturing

- **2006…**
  - Integration of Product Design and Production Process Design

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“Digital Manufacturing represents an integrated suite of PLM tools that supports manufacturing process design, tool design, plant layout, and visualization through powerful virtual simulation tools that allow the manufacturing engineer to validate and optimize the manufacturing processes. “
Where Does Digital Manufacturing Fit?

Product Lifecycle: Design/Build/Automate/Maintain

Product Domain

R&D
- Materials & Product Research
- Product Design

Design Engr
- Process Planning

Mfg Engr
- Work Flow, Mfg Processes

Industrial Engr
- Controls/Tool Engr
- Design, Produce Tools, Jigs, Fixtures, & Automated Systems

Production Domain

Factory Operations/Production Systems
- Obtain, Operate, Control, & Maintain Equipment & Automated Systems to Manufacture Products

Org

Processes

Org Function (Systems)

PLM Solutions: Interoperability & Collaboration

Operations

Engineering

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What Does Digital Manufacturing Do?

♦ Manufacturing Planning
  • Define High-Level Manufacturing Processes
  • Process Planning (Assembly & Installation)
  • Define Work Instructions & Work Flow

♦ Detailed Process Design & Analysis
  • Detailed Resource Modeling & Simulation
  • Process Definition and Validation
  • 3-D Factory Layout
  • Equipment, Tool & Fixture Simulation
  • Ergonomic Simulation

♦ Validation & Virtual Commissioning
  • Control Logic Validation
  • Kinematic (Robotic) Validation
  • Quality Assurance/Process Improvement Validation
  • Sensor/Metrology Placement Validation
  • Virtual Commissioning/Validation of Automation Systems
  • Knowing that the Production System Works Prior to Launch: Priceless.
**Digital Manufacturing Redefines Concurrent Engineering**

- Product Authoring (CAD) tools are employed to define “What" is to be built.

- Manufacturing Process Design tools are used to define “How" it is to be built.

- Integration of Product & Process Design directly supports the concept of Concurrent Engineering

Digital Manufacturing facilitates the Holistic view of Product and Process Design as integral components of the overall product life cycle

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DIGITAL MANUFACTURING MODEL

Classifying by form,

• global structure model (such as the architecture of manufacturing system),
• the local structure model (such as the FMS model),
• the product structure model and
• the scheduling model of production planning

Classifying by modeling method,

☐ Mathematical analytical model (such as the state-space model),
☐ the graphic conceptual model (IDEF model) and
☐ the hybrid diagram—analysis model (such as the Petri net model)

Classifying by function,

➢ Structure description model,
➢ the system analysis model,
➢ the system design and implementation model, and
➢ the system operation and management model.
GRAI Activities

(a) Executive activities

(b) Decision-making activities

GRAI activities
CIMOSA Architecture
ORGANISATIONAL STRUCTURE MODEL

Virtual Affairs Cooperative Center (VACC)

- Task scheduling
- Risk control
- Alliance reengineering
- Member selection

Virtual Working Team (VWT)

Alternative Competence Team (ACT)

Organization structure model
OPERATION PROCESS OF A VIRTUAL MANUFACTURING ALLIANCE
FUNCTION STRUCTURE MODEL OF THE DIGITAL MANUFACTURING SCIENCE
INFORMATION MODEL OF SYSTEM MANUFACTURING RESOURCE

Information model of system manufacturing resource
R  ⇒  System manufacturing resource
RC ⇒  Common resource
RS ⇒  Special resources
RH ⇒  Human resources
ROTC ⇒  Other common system resources
RPI ⇒  Product information resources
RPMI ⇒  Information resources of the potential alliance member
RDS ⇒  Design resources (Design software, drawings, documents)
RPM  ⇒  Production manufacturing resources (Manufacturing equipment, material resources etc.)
RCI  ⇒  Customer information resources
ROT  ⇒  Other resources ROT
OPERATION AND CONTROL STRUCTURE MODEL OF DIGITAL MANUFACTURING SYSTEM
OPERATION AND CONTROL
STRUCTURE OF AGENT BASED
DIGITAL MANUFACTURING
SYSTEM