Introduction to Design for Manufacturing & Assembly

Overview

Course Length: 8 hours *(can be taken via flexible schedule in-center or remotely)*

Description: This course will introduce you to three areas of Design for Manufacturing and Assembly principles. Topics covered will include Introduction to Design for Manufacturing, Design for Additive Manufacturing and Design for Machining.

Course Objectives/Topics

Introduction to Design for Manufacturing
Lower product life cycle costs by mastering design for manufacturing. You'll recognize product design issues and how to avoid potential pitfalls common throughout the design and manufacturing processes. Understand all aspects of the design process that impact downstream operations, including assembly, packaging, and shipping. You'll be aware of what goes into design for manufacturing and how to increase design process efficiency in various aspects of your business.

Design for Additive Manufacturing
Discover how to take 3D printing **beyond** prototypes and leverage the technology for high volume manufacturing. Understand today's major printing modalities and design considerations to make the most of your printed parts.

Design for Machining
Master the concepts required to properly design parts for both manual and CNC machining. Learn about various subtractive processes and machines such as the mill and lathe, along with how tolerances, surface finishes, and holes work together to create a machinable design.

Please see page 2 for detailed topic list

Prerequisites

A working understanding of technical drawings (perspectives, sections, details, etc.).

Audience

This program is designed for anyone who designs, drafts, engineers, purchases, manufactures, estimates, or inspects parts and assemblies. Particular emphasis is placed on those who design and manufacture, and those responsible for quality.

Course Outlines

Introduction to Design for Manufacturing

Section 1 - Introduction to the Course

- About this Course
- Objective of the course, prerequisites and what the outcome should be Background and credibility of the author & course outline
- The Design Process
- Design for manufacturing, assembly, packaging, and shipping are interconnected
- Controlling Costs- Why to use DFMA
- When discussing why DFM is important it's necessary to think about what costs go into manufacturing

Section 2 - Design for Manufacturing of Components

- Understanding Equipment & Capabilities
- Designs should be made with available manufacturing capabilities
- Material Considerations
- DFM involes taking materials into account- type, machineability, available stock material, and manufacturing processes
- Design for ease of part Fabrication
- The shape, size and form of the part must be easy to use in manufacturing processes
- Design Parts to be Foolproof in Assembly
- Parts should be made so that assembly is foolproof and anyone can do it
- DFM for Additive Manufacturing
- Discussion on designing parts that can be manufactured using 3D printers
- DFM for Additive Manufacturing- Example
- This is a real life example with design for additive manufacturing
- Design for Manufacturing of Components Exercise
- Optimize components in this series of practice activities to go over what you've learned

Section 3 - Design For Assembly

- Minimizing Assembly Components- Why
- There are a variety of reasons why designers should reduce assembly components
- Minimizing Assembly Components- How
- There are a variety of methods to reduce components in an assembly
- Modular Designs & Ease for Assembly
- Use modular design for ease of assembly and maintenance
- Minimizing Assembly Operations
- Efficient assembly procedures and minimizing operations can add value in addition to optimizing assemblies
- Maintenance & Customer Assembly
- There are some things to consider in product maintenance and end user experience
- Design for Manufacturing Assemblies Exercise
- Optimize an assembly with series of practice activities using what you've just learned in this section

Section 4 - Tolerancing

- Tolerancing for MFG Equipment
- DFM also involves taking the manufacturing equipment tolerances into account in designs
- Feature Tolerances
- There are some basic concepts for tolerancing for part features that should be understood
- Assembly Tolerances
- Designers should take part tolerances into account in assemblies
- Tolerance Analysis
- This example will touch on all the concepts discussed in this section
- Tolerancing Exercise
- This exercise with have you calculate the tolerance for a part and annotate a drawing

Section 5 - Design for Packaging & Design for Shipping

- Packaging Considerations
- Packaging is important for end users of your product
- Shipping Considerations
- Even logistics is something that should considered when design for manufacturing

Section 6 - Case Study

- Component Design
- Create components by taking DFM into account, including tolerancing
- Assembly Design
- Use components from the previous video to look at assembly design
- Optimizing the Assembly
- This video will be optimizing the design, taking DFMA principles into account

Design for Additive Manufacturing

Section 1 - Introduction

- About this Course
- Additive Manufacturing is one of the biggest game changers and drivers of innovation in the engineering and manufacturing spaces today

Section 2 - Overview of Additive Technologies

- What is Additive Manufacturing?
- Additive manufacturing could be defined as any process where material is added together to form a finished product
- Technology Overview: FDM Printing
- Some of the most common printers that people are familiar with today are Fused Deposition Modeling, or FDM printers
- Technology Overview: Vat Photopolymerization (SLA & DLP)
- Vat Photopolymerization uses a vat of resin and lasers to fuse the material with UV light
- Technology Overview: Material Jetting
- Material Jetting uses small printheads that dispense droplets of resin material and a UV light source to solidify the material
- Technology Overview: Binder Jetting
- Binder jetting uses a chemical process between a powdered material and a binding agent
- Technology Overview: Sheet Lamination
- Sheet lamination is a process where thin layers of material are cut into a desired shape and then bonded together
- Technology Overview: Direct Energy Deposition
- Direct Energy Deposition feeds powder or metal wire onto a surface with an electron beam or high powered laser projector
- Technology Overview: Powder Bed Fusion (SLS & MJF)
- Powder Bed Fusion includes both SLS and MJF printing proceses

Section 3 - Introduction to DfAM

- What is DfAM?
- If you know you will be using an additive manufacturing process, there are some rules to consider
- DfAM Rules: Supports
- 3D printing is truly an amazing manufacturing process, however, it cannot defy gravity
- DfAM Rules: Topology
- Topology is an important factor to consider when designing for additive manufacturing
- DfAM Rules: Finishing
- The vast majority 3D printing process materials can be easily sanded or post-processed with most conventional coatings or paint

Section 4 - DfAM with HP Multi Jet Fusion

- Deeper overview of HP MJF technology
- Understanding of the technology and its process will provide a good foundation for your design considerations
- Understanding the hardware
- Take a look at the MJF hardware so you have an understanding of the workflow and get some insights into the process
- Precision, Strength, and Aesthetics
- There are tradeoffs to consider based on how features are oriented in your designs
- MJF Rules: Angles
- The angle at which a part is printed affects the finish quality and the refinement of small features
- MJF Rules: Cavities/Holes
- Parts that have infill in the print file, or have a hollow section designed in the part, will have loose powder trapped in the part when it's printed that you may want removed
- MJF Rules: Printing Thick Parts
- When printing thicker parts it can be advantageous to use an infill or lattice structure
- MJF Rules: Thin-Walled Bodies
- Thin-walls in 3D printed parts have some particular design considerations based on how the part is printed
- MJF Rules: Packing Density, Draft and Nest-ability
- 3D printed parts can be stacked in the 3D build unit when they are printed. Making the parts "nest-able" also allows more parts to be printed together since they can fit inside one another
- Think Outside the Box
- 3D printing parts allows for greater flexibility with the part design and simplifies the manufacturing process. In addition, there is room to get creative with the design and incorporate functional features in the print
- Summary
- If you know you will be using 3D printing to manufacture your parts, you should think about it during the design phase

Design for Machining

Section 1 - Introduction

- About this Course
- Machining is defined as the process of using cutting tools to remove material from a workpiece until it is converted into a desired shape

Section 2 - Basics of DFM

- Advantages/Limitations of Designing for Machining
- In conventional machining there are three major machining processes: turning, drilling, and milling
- Overview of Subtractive Processes
- Component manufacturing consists of 3 basic machining processes: subtractive, additive, and forming
- Other Subtractive Methods
- Other subtractive processes involve the creation of micro chips and do not use a sharp cutting tool to form a chip by shear deformation, as in traditional machining
- Shape Design Guidelines
- The type and shape of stock material being used depends on 3 main factors: the final shape of your manufactured product, it's end use, and the type of fabrication machinery available to you
- Tolerance/Finish Considerations
- The tolerances and surface finishes achievable by tooling must be reflected in a design when they are specified on an engineering drawing
- Material Considerations
- There are several classes of materials, and how they are used affect their cost and machinability
- Preferred Sizes and Standard Tooling
- When designing parts for machining, the cost can be kept to a minimum by designing to the standard sizes that standard cutting tools and materials are made to
- Raw Material Design Considerations
- When designing parts for machining, the standard sizes of raw material which are available, as well as the parts function, should be taken into account

Section 3 - Tolerances, Fits, and Surface Finish

- Introduction to Manufacturing Tolerances
- Generally speaking the tighter the tolerance, the more costly the feature will be, because tighter tolerances require better and often more expensive tools, machines, and skilled personnel
- Basics of GD&T
- The purpose of geometric dimensioning and tolerancing is to clearly convey a product's functional design intent on an engineering drawing
- Introduction to Manufacturing Finishes
- To minimize cost the designer should keep in mind the manufacturing process to be used and the required surface finish
- Calculation of ISO Fits and Tolerances
- In order to achieve finer finishes, components are processed with secondary operations such as honing and polishing. However, just what is required for certain applications, and what will the cost be to achieve these finishes?
- Fabrication, Machining, and Assembly
- The major reason tolerance and finish are so important is so parts can be assembled together correctly
- Effects of Tolerances and Surface Finishes
- Tolerance and surface finish play a major role in the function and cost of a part. Specifying tolerances that are too tight, and finishes that are too fine can add unnecessary cost and manufacturing time to a part

Section 4 - Manual Machining

- Turned Parts for Manual Machining
- Manual machining is still widely used for many lower volume production parts. As long as the part is kept simple, it can be cost effective to machine on non-CNC equipment
- Milled Part Considerations
- When designing parts for manual milling, much like designing parts for manual turning, the goal is to keep the part shape simple
- Design for Standard Machine Accessories
- Accessories for manual machines can be set up and used with ease and allow for the design and creation of more complex parts

Section 5 - CNC Machining

- Chamfers and Fillets, Cost Considerations
- Chamfers and fillets make our solid models look good, they are a quick and easy feature to add to a part in our CAD software. But at what cost?
- Design for Turning
- Turning is the term used for machining cylindrical, round stock on a lathe, removing material from its outside with a single-point tool as the stock rotates at high speed
- Design for Milling
- A milling machine can perform several operations: Facing, pocket milling, profile milling, contour milling, drilling, boring, and tapping
- Design for 2D Cutting
- 2D cutting refers to the cutting of many kinds of flat stock with purpose-built CNC machines

Section 6 - Fixturing and Jigs

- Effective Fixture Design & Inspection Requirements
- A good check fixture is cost-effective and permits the easy, repeatable and reproducible verification of products over time
- Jigs
- Jigs are used to position a part for machining in a way that is repeatable and very accurate

Section 7 - Hole Making

- What Factors Affect How a Hole is Produced
- Hole making is one of the most often used manufacturing processes. Many parts depend on holes for functional use, and assembly fasteners often pass through holes to hold parts together
- Tooling for Hole Making
- Drilling is not the only method used for hole making, and it’s very important to know the difference between the different types of tools and hole making methods used in machining
- Drilling Machines
- Holes can be produced on many different machines. Some machines are multi-functioned, while others are specifically for drilling holes
- Milling and Turning
- There are many options for making holes, depending on the process, diametric and locational accuracy may or may not be suitable
- Specialized Tooling and Machines
- When making or machining holes, there are certain hole-making situations that require specialized tooling or machinery