CHAPTER 1

DESIGN FOR MANUFACTURABILITY

DEFINITION

INTRODUCTION

COMPETITION AND VULNERABILITY
PROBLEMS WITHOUT DFM
MANUFACTURABILITY
THE EARLY EFFECTS OF DESIGN

DESIGN PHILOSOPHY

TRADITIONAL DESIGN CONSIDERATIONS
FACTORY DESIGN CONSIDERATIONS
SOCIAL DESIGN CONSIDERATIONS
MARKETING DESIGN CONSIDERATIONS
ENVIRONMENTAL DESIGN CONSIDERATIONS
DFM VERSUS DESIGN FREEDOM
UNDERSTANDING MANUFACTURING

IMPLEMENTING DFM

WHAT DFM PROGRAMS ACCOMPLISH
ORGANIZING A DFM PROGRAM
SOURCES OF DFM INFORMATION
STRUCTURING DFM INFORMATION
CHECKLISTS
DESIGN TEAMS
ENCOURAGING DFM

THE BENEFITS OF DFM

ASSEMBLY COST SAVINGS
PART FABRICATION COST SAVINGS
WORK-IN-PROCESS INVENTORY SAVINGS
MARKET FLEXIBILITY AND DELIVERY
FINISHED GOODS INVENTORY SAVINGS
MATERIALS OVERHEAD SAVINGS
MACHINERY UTILIZATION SAVINGS
FLOOR SPACE SAVINGS
QUALITY COST SAVINGS
DEVELOPMENT COST SAVINGS
PRODUCTS SOONER TO MARKET
SUPERIOR PRODUCT DESIGN
CONCLUSIONS

CONCURRENT ENGINEERING

DESIGN FOR MANUFACTURABILITY

DFM/A PRINCIPLES
DEVELOPING GUIDELINES
SUPPLIERS INVOLVEMENT
DFM/A ANALYSIS TOOLS
INTEGRATING DFM WITH CAD

DESIGN FOR QUALITY

QUALITY FUNCTION DEPLOYMENT
TAGUCHI QUALITY ENGINEERING
BENCHMARKING

DESIGN FOR THE LIFE CYCLE

DESIGN FOR TESTABILITY/INSPECTABILITY
DESIGN FOR RELIABILITY
DESIGN FOR MAINTAINABILITY AND SERVICEABILITY

DESIGN FOR COST

ENABLING TECHNOLOGY

DIGITAL PRODUCT MODELS AND DATA MANAGEMENT
DESIGN AND ANALYSIS
PROCESS DESIGN
DATA INTERCHANGE

CONCURRENT ENGINEERING AND THE ORGANIZATION

PRODUCT DEVELOPMENT TEAMS
ORGANIZATION STRUCTURE
TEAM OPERATION

IMPROVING THE DEVELOPMENT PROCESS

RESOURCE PLANNING
STREAMLINING THE DEVELOPMENT PROCESS

SUMMARY

CHAPTER 3

MANAGEMENT INVOLVEMENT IN DFM

MANAGEMENT FRAMEWORKS

ARCHITECTURE

MANUFACTURABILITY PROCESS

MANAGEMENT'S CONCERNS WITH MANUFACTURABILITY

PERFORMANCE

PROCESS INTEGRATION

MANAGEMENT INTERESTS IN THE DESIGN

CHAPTER 4

TEAM BUILDING AND TRAINING

WHERE TO BEGIN

TOOLS TO CONSIDER

START A PILOT PROJECT

TEAM SELECTION AND TRAINING

DEFINE CORPORATE OBJECTIVES

EDUCATE

IMPLEMENTATION

ASSESSMENT

INTERNALLY PUBLICIZE ACCOMPLISHMENTS

INSTITUTIONALIZE

DEVELOPING AN INTERNAL DFM MANUAL

HOW SHOULD THE DFM MANUAL BE PRESENTED?

WHAT SHOULD BE IN A DFM MANUAL

HOW TO CREATE A DFM MANUAL

HUMAN PERFORMANCE IMPROVEMENT AND TRAINING IN DFM

PLANT MODERNIZATION EFFECTS ON HUMAN PERFORMANCE

DFM AND HUMAN FACTORS ENGINEERING

HUMAN LEARNING PRINCIPLES

SYSTEMS BASED TRAINING

SUMMARY

CHAPTER 5

JUSTIFICATION OF DFM

INTRODUCTION

THE BEST TIME FOR DFM

COSTS FOR DFM USE

OTHER IMPORTANT FEATURES OF DFM

VIEWPOINTS FOR DFM

THE MACRO PERSPECTIVE

TYPES OF COST

OTHER SIGNIFICANT
COST ESTIMATING CONCEPTS

COMPUTER APPLICATIONS

OTHER SIGNIFICANT COST
ESTIMATING CONCEPTS

COST ESTIMATING

TECHNICAL ESTIMATES

HISTORICAL DATA

PREDETERMINED TIME STANDARDS

ELEMENTAL STANDARD DATA

METHODS FOR DETERMINING
RELEVANT COSTS

TRADITIONAL JUSTIFICATION

DEALING WITH INTANGIBLES

STEP 1–FIND THE FACTORS IMPORTANT
TO THE COMPANY IN MAKING A DECISION
CONCERNING PRIORITIES

STEP 2–RANK THE FACTORS
ACCORDING TO IMPORTANCE

STEP 3–SELECT A RATING SYSTEM
FOR HOW IMPROVEMENTS WILL
AFFECT EACH FACTOR

STEP 4–DEVELOP WEIGHTS FOR EACH
FACTOR THAT WILL BE USED IN
DECIDING PRIORITIES

STEP 5–DEVELOP A CONSISTENT
APPROACH TO DECIDE
PRIORITY OF IMPROVEMENTS

USING QUALITY TOOLS IN DFM

BASIC CONCEPTS

DEFINITIONS OF KEY TERMS
THE DEMING PROCESS MANAGEMENT CYCLE
A PROCESS VIEW OF DFM ACTIVITIES

QUALITY TOOLS

STRUCTURED PLANNING METHODS
QUALITY FUNCTION DEPLOYMENT
PROCESS DOCUMENTATION AND ANALYSIS
STATISTICAL METHODS
BENCHMARKING

QUALITY TOOLS IN THE DESIGN STAGE

PLAN
DO
STUDY
ACT

QUALITY TOOLS IN THE TRANSITION STAGE

PLAN
DO
STUDY
ACT

QUALITY TOOLS IN THE PRODUCTION OPERATIONS STAGE

PLAN
DO
STUDY
ACT
SUMMARY

COMPUTER-AIDED TECHNOLOGY

CHAPTER CONTENTS:

DESIGN FOR ASSEMBLY

RELATING DFA TO DFM

DFA ANALYSIS
WHY IS DFA IMPORTANT?

GETTING STARTED: DEVELOP THE TEAM

MANAGEMENT MUST BE ON YOUR SIDE
ENCOURAGE A CREATIVE CLIMATE
SELECT A MANUFACTURING SITE AND DECIDE ON THE PROCESS
THE TEAM OWNS THE PRODUCT
SELECT AND APPLY DFA TOOLS

APPLYING THE DFA PROCESS

PRODUCT GOALS
ESTABLISH DFA PRINCIPLES
APPLY MECHANICAL DFA PRINCIPLES
USE DFA METRICS

IMPROVING PRODUCT SERVICEABILITY

INCLUDE FIELD SERVICE ADVICE
DFA REDESIGN APPROACHES
THE DIFFERENCE BETWEEN DFA AND DFS
DFS CONSIDERATIONS

RECYCLABILITY

WHO IS DOING IT
CONSIDERATIONS

PRELIMINARY DESIGN ISSUES

CREATIVE THINKING IN DFM/A

WHAT IS CREATIVITY?
WHAT IS CREATIVE THINKING?
WHAT IS CREATIVE PROBLEM SOLVING?
WHY AREN'T ENGINEERS CREATIVE?

ROADBLOCKS TO CREATIVE THINKING

PERCEPTUAL ROADBLOCKS
EMOTIONAL ROADBLOCKS
CULTURAL ROADBLOCKS
HABITUAL BLOCKS

DEVELOPING CREATIVE THINKING

THE CREATIVE ENVIRONMENT
VERTICAL (CONVERGENT) THINKING
LATERAL (DIVERGENT) THINKING
LATERAL THINKING VERSUS VERTICAL THINKING
ACTIVATING LATERAL THINKING

CREATIVE PROBLEM SOLVING TECHNIQUES

INDIVIDUAL TECHNIQUES
GROUP TECHNIQUES

APPLYING CREATIVE PROBLEM SOLVING TO DFM/A

CREATIVE THINKING IN DFA
CREATIVE THINKING IN PROCESS SELECTION
CREATIVE THINKING IN MATERIAL SELECTION
CREATIVE THINKING IN MATERIAL AND PROCESS SELECTION

CONCEPTUAL DESIGN

GENERAL METHODS FOR CONCEPTUAL DESIGN
FACILITATION OF CONCEPTUAL DESIGN BY COMPUTERS

FUNCTIONAL EFFICIENCY TECHNIQUES FOR ASSURING ECONOMICAL DFM

THE CONCEPT OF FUNCTION

RELATIONSHIPS AMONG FUNCTIONS

FEATURE FUNCTIONS VERSUS SYSTEM FUNCTIONS

THE QUANTIFICATION OF FUNCTION

FUNCTIONAL DESIGN EFFICIENCY

EXAMPLE OF USING FUNCTIONAL EFFICIENCY FOR DESIGN REVIEW

A CONCEPTUAL DESIGN SYSTEM

METHODOLOGY FOR BUILDING A CONCEPTUAL DESIGN SYSTEM

SPECIFICATION OF REQUIREMENTS AND FUNCTIONS

REPRESENTATION OF SPECIFIED FUNCTIONS

DESIGN SYNTHESIS

ARCHITECTURE OF THE SYSTEM FOR CONCEPTUAL DESIGN

SUMMARY

APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN DFM

INTRODUCTION

THE NATURE OF ARTIFICIAL INTELLIGENCE (AI)

SELECTING AN APPROPRIATE APPLICATION

SUGGESTIONS FOR DFM EXPERT SYSTEM APPLICATIONS

SUGGESTIONS FOR DFM NEURAL NETWORK APPLICATIONS

GENERAL PRODUCT DESIGN

IMPACT OF DESIGN CONCEPT AND EARLY PROJECT DECISIONS

EVALUATING MANUFACTURABILITY OF CONCEPTUAL DESIGNS

PRODUCIBILITY

PRODUCIBILITY ASSESSMENT FOR DOD CONTRACTS

PA FOR DECISION MAKERS AND MANAGERS

PA TOOLS FOR ENGINEERS

GEOMETRIC TOLERANCING STRUCTURE AND LANGUAGE FOR CONCURRENT ENGINEERING (CE)

INTRODUCTION

PRODUCT DEFINITION

THE LANGUAGE OF CONCURRENT ENGINEERING—Y14.5M

CONCURRENT ENGINEERING

TOOLING AND FUNCTIONAL GAGING

SUMMARY

ENVIRONMENTALLY RESPONSIBLE PRODUCT DESIGN

INTRODUCTION

SUMMARY

HUMAN FACTORS ISSUES IN PRODUCT DESIGN

PRODUCT USABILITY

PRODUCT SAFETY AND LIABILITY

QUALITY CONTROL AND INSPECTION

PRODUCT ASSEMBLY

MAINTENANCE

IMPACT OF EQUIPMENT RELIABILITY

WORKSTATION DESIGN AND OPERATOR TRAINING

DESIGN FOR SERVICEABILITY

THE EFFECT OF DESIGN ON SERVICE

DESIGN CONSIDERATIONS FOR SERVICEABILITY

AN IDEAL TO STRIVE FOR

SUMMARY

DESIGN CRITERIA FOR PRODUCT AND PACKAGE

PRODUCT DESIGN
MATERIAL TYPE
MATERIAL SIZE
PRODUCT SHAPE
PACKAGE DESIGN
MATERIAL TYPE
MATERIAL THICKNESS
PACKAGE SHAPE
PACKAGE SEAL

SUPPLIER CERTIFICATION

INTRODUCTION
APPROACH
DESIGN OF THE CERTIFICATION PROGRAM
SUPPLIER CRITERIA
INITIAL CONTACT
PLANT VISIT
IMPLEMENTATION
AWARD
MAINTENANCE OF CERTIFICATION
SUMMARY

MACHINING

SIMPLIFYING MACHINING IN THE DESIGN STAGE

NONTRADITIONAL MACHINING

FLEXIBLE MANUFACTURING CELLS AND SYSTEMS

FORMING

METAL FORMING METHODS

FINEBLANKING

ROLL FORMING

PRECISION FORMING

DESIGN IMPLICATIONS OF THE PROCESS
UPSETTING
METAL FLOW PRINCIPLES
UPSETTING
FORWARD EXTRUSION
BACKWARD EXTRUSION
DRAWING
COINING
SHEAR FORMING
NOSING/FLARING
BENDING

METAL SPINNING

THE SPINNING PROCESS
ADVANTAGES OF METAL SPINNING
TOLERANCES
SURFACE FINISH
GEOMETRIES
MATERIALS

CONVENTIONAL PIPING DESIGN FOR BEND FABRICATION

BENDING APPROACH
DESIGN CONSIDERATIONS
MATERIAL
CLAMPING LENGTHS
PRESSURE DIE AND PUSHWAY LENGTHS
COMPOUND BENDS
OPTIMUM RADII
POST-BEND TREATMENT
EQUIPMENT SPACING
PIPE RACK SPACING
PIPE HANGER LOCATIONS
FIELD WELDS
LUBRICANTS
ANCHORS

TUBE FABRICATING AND BENDING

BEND CONFIGURATION (ENVELOPE)
ENDFORMING
ATTACHMENTS (WELDMENTS)
OTHER CONSIDERATIONS

CAD APPLICATIONS IN SHEET METAL CUTTING, PUNCHING AND BENDING

CAD MODELING OF SHEET METAL PARTS

COST ESTIMATING

NC SHEET METAL SOFTWARE

FORGINGS

WHY SELECT FORGINGS?

TYPES OF FORGINGS

IMPRESSION DIE FORGINGS

OPEN-DIE FORGINGS

SEAMLESS ROLLED RINGS

SPECIAL PROCESSES FOR NEAR NET SHAPE FORGING

COLD FORGING PROCESSES— DESIGN CONSIDERATIONS

SUMMARY

CASTING

CONCEPTUAL FRAMEWORK

ALLOY CHARACTERISTICS AND DESIGN

DEVELOPING A MODEL

SOLIDIFICATION SHRINKAGE

JUNCTION DESIGNS

SOFT VERSUS HIGHLY CONFIGURED SHAPES

SLAG AND DROSS

INFINITELY VARIABLE SHAPES

SIMPLIFYING TOOLING

DESIGN AND SECONDARY OPERATIONS

CASTING DRAWINGS, DIMENSIONS AND TOLERANCES

FINISHING AND COATING

DESIGN GUIDELINES FOR PAINTED PARTS

PAINTING TECHNOLOGY
DESIGN SPECIFICS

POWDER COATING

PART GEOMETRY
COATING CHARACTERISTICS
FIXTURING REQUIREMENTS
SUBSTRATES
FILM CHARACTERISTICS
PERFORMANCE

ELECTROCHEMICAL METALLIZING

BATH ELECTROPLATING
THERMAL SPRAY METALLIZING
WELDING
ELECTROCHEMICAL METALLIZING
SUMMARY

THERMAL SPRAY COATING

MATERIALS COMMONLY COATED
FINISHING AND SEALING
SHAPE CAPABILITIES
ADVANTAGES OF THERMAL SPRAY COATINGS
APPLICATIONS
DESIGNING PARTS FOR THERMAL SPRAY COATINGS

HEAT TREATING

PART DESIGN FOR INDUCTION HEAT TREAT
MEASUREMENT TECHNIQUES
STATISTICAL PROCESS CONTROL
PART MATERIAL

FASTENING AND JOINING

FASTENERS

ADHESIVE ASSEMBLY

WELDED ASSEMBLIES

MATERIALS

PLASTIC PRODUCTS

FAILURE ANALYSIS—
WHY PRODUCTS FAIL
SUPPLIER CHECKLIST
PROTOTYPING
CLASSIFICATION OF PLASTICS
MATERIAL SELECTION
PRODUCT DESIGN CONSIDERATIONS
TYPICAL DESIGN
CONCERNS AND LIMITATIONS
SHRINKAGE
SECONDARY OPERATIONS
SURFACE PREPARATION
DECORATIVE PROCESSES
SUMMARY

COMPOSITES

LIQUID COMPOSITES MOLDING
FIBER COMPOSITES
SHEET MOLDING COMPOUNDS
MOLDED COMPOSITE GEARS

CERAMICS

ENGINEERED CERAMICS

POWDER METALLURGY

POWDER FORGING
METAL INJECTION MOLDING
ADVANTAGES AND LIMITATIONS OF PM
COMPARING PM WITH OTHER PROCESSES
PM MATERIALS
PM DESIGN
TOOLING CONSIDERATIONS
SHAPES

DESIGN FOR ELECTRONIC ASSEMBLY

INTRODUCTION

OVERVIEW

THE MERGER OF TECHNOLOGY AND BUSINESS

LOOKING BEYOND TRADITIONAL SOURCES FOR NEW PRODUCTIVITY

SALES AND EMPLOYMENT TRENDS

BUSINESS DRIVERS

THE TECHNOLOGY DRIVERS

PRINTED WIRE ASSEMBLY (PWA)

DEVELOPMENT

LEVELS OF TECHNOLOGY

GLOBAL USE OF PACKAGE TYPES

CHOICES

BALANCING TECHNOLOGY

A GUIDE TO FINDING THE BALANCE

DESIGNING IN THE QUALITY

INDUSTRY PREFERRED COMPONENTS

STANDARDIZATION

COST-EFFICIENT PRINTED WIRE BOARDS

DESIGN FEATURES FOR PREFERRED PRINTED WIRE ASSEMBLY PROCESSES

OTHER ABILITIES TO CONSIDER

THE NEED TO DESIGN FOR MANUFACTURABILITY

SUCCESSFUL DESIGN

BEFORE DFM—VALUE ENGINEERING

PRINTED WIRING ASSEMBLY TECHNOLOGIES

THROUGH-HOLE TECHNOLOGY

SURFACE MOUNT TECHNOLOGY

THE RULES OF DFM

USE STANDARD PARTS

DESIGN FOR EASE OF ORIENTATION

DETERMINE PROCESS CAPABILITIES

ELIMINATE MULTIPLE SOLDER AND CLEANING STEPS

ELIMINATE ADJUSTMENTS

MINIMIZE THE NUMBER OF DIFFERENT PARTS

PUBLISH UP-TO-DATE DFM DESIGN GUIDELINES

DESIGN FOR VARIABILITY

IDENTIFY DEFECT RATES BY CAUSE

IMPLEMENTING DFM

PEOPLE PARTICIPATION

PREDICTIVE TOOLS

MANAGEMENT COMMITMENT

AUTOMATING THE DFM PROCESS

PROCESS EXAMPLE

SUITABLE PARTS AND MATERIALS

DESIGN FOR TESTABILITY

HOW (AND WHY) CIRCUITS ARE TESTED

KEY TESTABILITY TECHNIQUES

TESTABILITY DEFINITIONS

REQUIREMENTS FOR DESIGNERS

RELIABILITY CALCULATIONS

GOALS FOR TESTABILITY

JUSTIFYING TESTABILITY

TESTABILITY SUCCESS

AWARENESS

TESTABILITY BENEFITS

TESTABILITY TRENDS FOR THE FUTURE

IMPLEMENTING A STANDARD TEST STRATEGY FOR ELECTRONIC PRINTED CIRCUIT BOARDS

STANDARD TEST ARCHITECTURE

BI-DIRECT CELL MODES OF OPERATION
TEST ACCESS PORT
TAP INSTRUCTIONS
DESIGN PROCESS
ATPG AND PARTIAL SCAN
TESTABILITY RULES AND GUIDELINES
ECONOMICS OF TEST GENERATION
TEST MIGRATION

DESIGN FOR RELIABILITY

GUIDELINES FOR DFR
PROBABILISTIC DESIGN APPROACH
METHODS AND TOOLS FOR DFR
MAINTAINING RELIABILITY
DURING PRODUCTION
SUMMARY