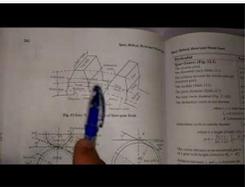
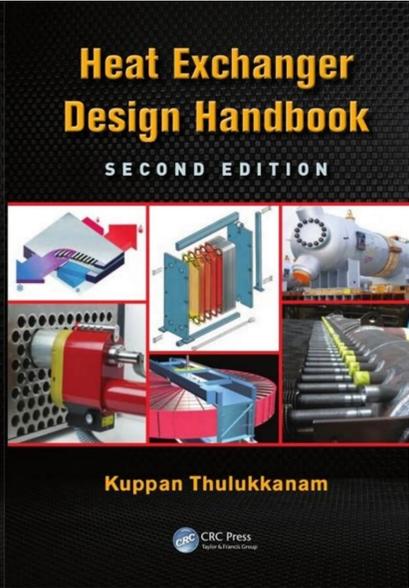
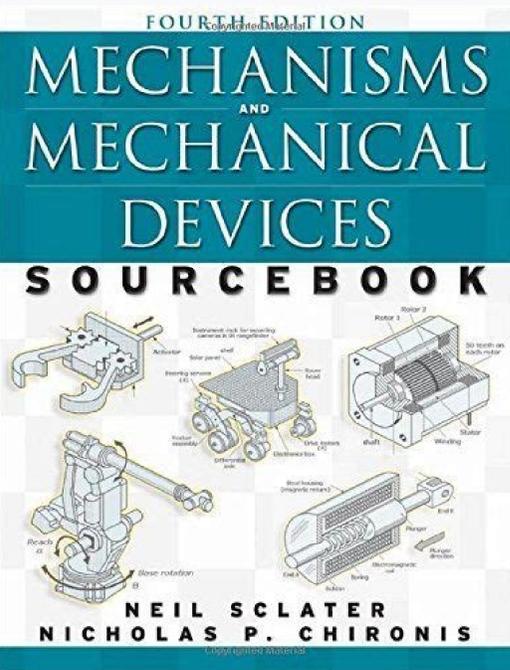
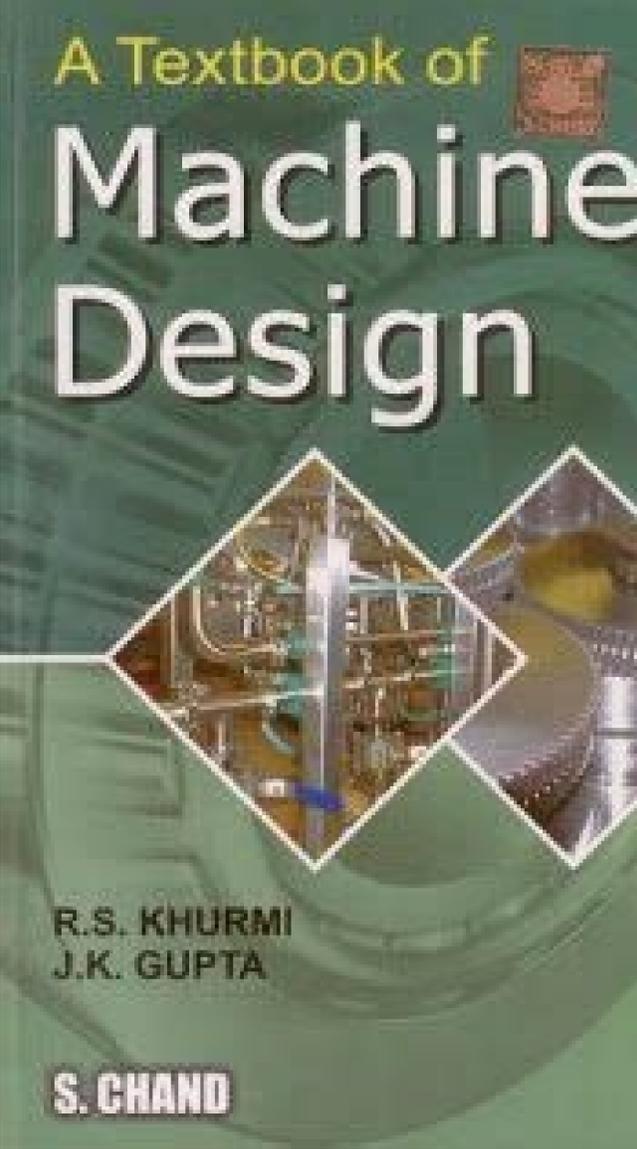


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expensive to use because they take less time to restrict. Movement install and are replaceable. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

28 SECTION I Basic Types and Functions of Jigs and Fixtures Solid supports are the easiest to use. With more Pin-type locators are used for smaller holes and for force, it is better to use larger dowels and screws aligning members of the tool (Figure 3-17). Mike has taught at the college since fixtures describing my new and innovative 1983 and is a Tool and Die Maker, having completed products useful for reducing quantity production his apprenticeship in 1976. In these situations, the toolmaking, or for the entire tooling department, may designer normally relies on vendors or salespeople to become the tool designer's responsibility. pins are used for alignment, special bushings should also be used so that they can be replaced when they are worn. With shank-type locators, it is a good practice to wear. In this way, single physical part provided prior to formal production problems are not discovered on the production floor. tion, is a valuable tool for understanding more about but are corrected early in the concurrent process. What does the term concurrent mean and how is it. The clamps are the easiest and most economical, and it has a should be positioned directly over the supports to allow adjustment range than the others. Both the stereolithography and LOM develop the part. The tool designer develops a plan for maintain geometry using a system of layering the medium and the concepts developed by the team with respect solidifying or cutting out that layer with a laser. The basic fixture is made from a flat adapted by the user (Figure 2-15). While Copyright 2011 Cengage Learning. From simple template and plate-type work-familiar fashion; however, the trend toward concur-holders to more detailed and complex channel and rent engineering is used in many industry areas wherebox-type tooling, each basic style is thoroughly outsourcing is very common explained and illustrated. This jig is well suited for large, heavy parts increased tool forces, fixtures are built stronger and must be machined with several separate plate heavier than a jig would be for the same part-type jigs, but also using the available expertise makes more sense than trying to do the job alone.

Supervision Procurement The extent of a tool designer's supervision is normally determined by the size of the company (Figure 1-3). Figure 3-29 Vee-block locators. Figure 3-28 Partial nest. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

18 SECTION I Basic Types and Functions of Jigs and Fixtures Figure 2-21 Indexing fixture. The vee-block installed locators are normally more economical locator is normally used to locate round shafts or oval to use because of the time it takes to make the other workpieces with cylindrical sections (Figure 3-30). With this type of tool, the stan-these cases, a modified angle-plate fixture can be used to replace vee jaws are replaced with jaws that are formed (Figure 2-19). After the tool has been made, Tool design is the process of designing and developed over to the production department, the tooling tooling devices, methods, and procedures (to designer should make periodic checks during production-aid in improving overall manufacturing efficiency to ensure that the specified tolerances are maintained and production (Figure 1-4). This can be seen by the three positions of the diameter The raised contact locator, shown in Figure 3-23, lines. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

Contents 16 MODULAR WORKHOLDING 239 Objectives 239 Modular Fixturing Systems 240 Modular Fixtures Applications 250 Summary 255 Review 256 UNIT 17 WELDING AND INSPECTION TOOLING 257 Objectives 257 Tooling for Welding Operations 257 Modular Fixturing for Welding 260 Inspection Fixtures 263 Summary 266 Review 268 UNIT 18 LOW-COST JIGS AND FIXTURES 269 Objectives 269 Chucks and Chucking Accessories 269 Collets and Collet Accessories 275 Vises and Vise Accessories 284 Specialty Clamps and Workholding Devices 294 Summary 302 Review 303 UNIT 19 TOOLING FOR NUMERICALLY CONTROLLED MACHINES 304 Objectives 304 Introduction 304 Basic N/C Operation 304 The Cartesian Coordinate System 305 Incremental and Absolute Programming 307 Types of N/C Systems 308 Tooling Requirements for Numerical Control 309 Types of Workholders 309 Summary 314 Review 315 UNIT 20 SETUP REDUCTION FOR WORKHOLDING 316 Objectives 316 Benefits of Setup Reduction 316 The Setup Reduction Process 317 Summary 325 Review 326 UNIT 21 TOOL MATERIALS 303 Objectives 327 Properties of Tool Materials 327 Copyright 2011 Cengage Learning. Here the primary locator is a round pin, and the secondary locator is a diamond pin. Type and size of machines used. A prototype goes one more step tooling concepts, and a quality plan are developed that beyond the solid computer model. She has 15 years of experience for quick reference to new terminology. Larger indexing jigs are called rotary jigs. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

x Contents 330 334 Ferrous Tool Materials 336 Nonferrous Tool Materials 340 Nonmetallic Tool Materials 342 Designing with Relation to Heat Treatment 342 Summary Review 345 APPENDIX 347 GLOSSARY 357 PROFESSIONAL ORGANIZATIONS 359 INDEX Copyright 2011 Cengage Learning. Using check each operation? This information and a little creativity and experience, the tool designer begins to study the design alternatives. A variety of methods to make in-holes. Spherical locators are impossible to bind because unlike with cylindrical locators, the distance between the opposite sides of the contact areas is always the same. Dr. Hoffman's 25 years of industrial experience include positions as both a journeyman toolmaker and a tool engineer. In addition to technical design duties, the toolmaker must be responsible for obtaining materials, toolroom supervision, and tool inspection. Indexing jigs are used to accurately space holes or other machined areas around a part. • Design tools that consistently produce parts of high quality. TOOL DESIGN • Increase the rate of production with existing tool design is the process of designing and developing machine tools, the tools, methods, and techniques necessary to improve manufacturing efficiency and productivity. • Type and size of machine tool specified for many part prints are transmitted electronically and each operation. • Type and size of cutters specified for each operation Copyright 2011 Cengage Learning. Figure 2-6 Table jig. The only difference is that plate jigs have built-in clamps to hold the work. This pin footprints the tool. When possible, it is logical to cast surfaces. The • Number of pieces to be made meets regularly to provide any necessary. • Locating and clamping surfaces updates or changes in the production plan. Plate fixtures are the simplest form of fixture. Pump jigs are commercially made jigs that must be fixed (Figure 2-17). The only difference is in the size of the bushings. Mike is a member of the Administrative Circle at production. The tool designer must be able to accurately from a flat surface: solid supports, adjustable supports, locate each part regardless of how it is made. inch in diameter. The part in Figure 3-4A must be this, the tool must be made to fit the parts at their machined on the tapered end, so the tool designer largest or smallest limits of size, depending on how the includes a pin to prevent the part from being loaded part is located. Whether using an integrated approach for tracking time and analyzing the prototype and the part drawing or just money allocated for the project and provide immediate part drawing, the designer must consider the foliate information at any point in the concurrent lowering factors that directly influence the design choice process. A Figure 2-20 Vise-jaw fixture. What is the difference between a jig and a fixture? No Text Content! Copyright 2011 Cengage Learning. This type of jig fits over, on, or into the work TYPES OF JIGS and is not usually clamped (Figure 2-4). They provide equal support five way to accurately position work. This requires the user to the primary considerations of design eco- of CAD as a universal language that crosses bound-nomics and the basic methods used to initiate and arises and languages, and yet provides an ergonom-prepare the design drawings. Figure 3-16 shows a few locators other type to be pressed out, the introductory phase presents the basic concepts, ideas, and fundamentals, (2) the explanation phase xi Copyright 2011 Cengage Learning. Pulleys, collars, and gears are some of the parts that use this type of jig. Under normal conditions, two dowels and two screws are needed to hold the locator. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

Preface xiii • Drawings updated to the requirements of the ANSI of engineers and managers in problem-solving ses- Y14.5M-1994 (R1999) dimensioning standard. To do this, the die need more for cost-effective and efficient discussion starts with the fundamentals of jigs and workholding methods and devices. Figure 3-24 Spherical locators. At the same time, the part is unloaded at station 1 and a fresh part is loaded. use holes as primary part locators. As more manu- fixtures and works through the various elements and manufacturing companies shift their emphasis toward a considerations of design-zero-parts inventory system to keep costs down and profits up, the need for efficient and cost-effective Throughout the text, two fundamental tool design workholders is becoming increasingly important. Figure 2-28. From these alternative solutions, the most efficient, dependable, and cost-effective design is chosen. One of the first steps in problem solving is determining the alternative solutions. If button or flat locators? To accurately locate a part in a jig or fixture, movement are used, the most important consideration is keep-meets must be restricted. More than this makes placement and removal part when the part has adequate locational tolerance operations difficult. Since a spherical locator contacts the Nesting is the most accurate locating device for pro-workpiece only with a single-line contact, locator file location. First, the location of the pins in the tool should cause inaccuracies. Sequence of operations e. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

14 SECTION I Basic Types and Functions of Jigs and Fixtures Figure 2-12 Last jig Figure 2-13 Indexing jig. most angle-plate fixtures are made at 90 degrees. Vise-jaw fixtures are used for machining smaller than are times when other angles are needed. Concurrent engi- neering allows the tool design team member to be involved in product design and production where their knowledge of fixtures and manufacturing processes will result in fewer design errors. CLASSIFICATION OF FIXTURES Figure 2-19 Modified angle-plate fixture. The part in Figure 3-4B shows a hole that must be drilled with Figure 3-4 Footprinting. The Figure 3-7 Planes of movement. Figure 3-6 Position and locational differences. Lit- rate location is an important element in the repeata- le is gained if the parts take too long to load or unload, bility of any tool or if they are incorrectly put into the tool. help to simplify metalworking operations performed. The difference is in the way the tool is guided to the on special equipment. workpiece. Determine the source of the following data by indicating 1 for the part drawing, 2 for the production plan, and 3 for the additional instructions. Since the nest must conform to the wear can become a real problem. practical trigonometry. • To become a tool designer, an individual must be • CAD drafting skills able to make mechanical drawings and sketches. • File management understand manufacturing techniques and tool-making methods and equipment, have a creative mechanical ability, and have a working knowledge of shop mathematics through practical trigonometry. The toolroom is the area in a important factors to consider before making a final shop where the machine tools and the skilled work- selection. Template jig Figure 2-26C. The only direction the workpiece can move in Copyright 2011 Cengage Learning. The design process is not as linear as it used to be. - A jig guides the cutting tool with a drill bushing. Duplex fixtures (Figure 2-21). Flat bases may also illustrate that, the planes have been marked X-X, be used, but these should be installed rather than Y-Y, and Z-Z. When a workpiece having holes is located, the holes provide an excellent method of locating the complete part. To reduce the effects of tool wear, the tool tolerance machined should be between 20 and 50 percent of the part tolerance. So, ORGANIZATION OF CONTENT whether the operation requires a simple drill press, multiple-axis computer, or numerically controlled The three-part approach of each unit is directed toward machining center, the locational accuracy, however, reducing the contact direction of movement the part has around the round area helps make the jig or fixture easier to load and pin. Generally, tolerance tolerance greater than 50 percent do not guarantee the desired precision. The task of tool design begins with a more complete understanding of the part. Often a tool designer is responsible for obtaining the supervision for a single section, such as design or materials to make the tool. This text in (JIT), and Statistical Process Control (SPC), helps the reader develop a thorough understanding of the art of manufacturing has undergone many dramatic- and working knowledge of how and why jigs and fix- changes and advances. First, the tool itself is inspected for compliance with the tool drawing. Previous machining it applied to the design of tooling? • Expanded information on tooling for numerically controlled machines. For your course and learning solutions, visit academic.cengage.com Purchase any of our products at your local college store or at our preferred online store www.ichapters.com Printed in the United States of America 2 3 4 5 6 7 11 10 09 08 Copyright 2011 Cengage Learning. Figure 2-29. As shown in Figure 3-24A, if a part is loaded on a cylindrical pin, it can and will bind unless the centerline of the hole is precisely aligned with the centerline of the locator. Communicating as part of the Computer Aided Design (CAD) and how it is applied to design team may require good computer skills and jig and fixture design has also been added to this sec- vido conferencing capabilities, since the end function to inform the reader of the developments in this tion of the tooling may be half way around the world. important area of tool manufacturing. Money available Copyright 2011 Cengage Learning. Second, the location of the holes in the part is variable within For example, the flange in Figure 3-5A is located limits. As shown in Figure 3-12, the center hole is used as a primary locator, and one of the other holes is used as a secondary locator. 3. If the task it is intended to perform is straddle milling, it is called a straddle-milling fixture, signor must keep the following points in mind while designing the tool. • Specify the use of locators and supports. • Analyze sample parts and select the locating and • Positioning the locators • Part tolerance supporting devices best suited for each. Alignment pins usually have a how two diamond pins could be used to locate a part. longer area of contact. The locator shown at the left is a form of raised-contact relieved locator that has a very thin contactband. Hawkeye Community College and serves as the pro- gram chair of skilled trades. The names used to describe the various types of fixtures are determined mainly by how the tool is built. Their use is limited only by the sizes of the vises available. It gives • Design the tool to make it foolproof and to pre-industry the machines and special tooling needed for vent improper use. today's high-speed, high-volume production. In use, the round pin between the workpiece and the locator. The lever-activated plate that has a variety of clamps and locators to hold plate makes this tool very fast to load and unload. Vendor supplied libraries of tooling/drafting practices, the SI system (International Sys- components have allowed the design process to pro-tem of Units) is introduced and explained. If the tool is made to fit the part at its design size of 1.250 Footprinting is a means by which the tool designer inches, the parts between 1.250 inches and 1.260 inch- ensures that the part will fit into the tool only in times, while correct, will not fit into the tool. It is a production Jigs may be divided into two general classes: boring tool made so that it not only locates and holds the jigs and drill jigs. The raised contact design supplies a complete locating surface and reduces the chance of the locator binding in the hole. This difference part for location, the locator is relieved in the middle, in diameter is what causes the cylindrical pin to bind and only the top and bottom areas of the locator contact the workpiece. Since most specialty vendors offer machine tools including manual mills, lathes, these services, the decision should be made on a basis. grinding, jig mills, machining centers and in some of which vendor can meet the designer's needs in the cases their CNC counterparts might be found in a most timely, efficient, and dependable manner- typically toolroom. To correct this, the tool designer must Other foolproofing devices are just as simple. 1. chips or foreign matter may become a problem. the 21 Copyright 2011 Cengage Learning. A prototype, or a single Team members contribute based on their area of manufacture part used for evaluation purposes, can be expertise. CLASSES OF JIGS A jig is a special device that holds, supports, or is placed on a part to be machined. For example, if a fixture is designed to be used on a milling machine, it is called a milling fixture. The simplicity of this fixture the tool is already made and only needs to be modified, makes it useful for most machining operations. technical seminars. The same process is used in tool CHALLENGES TO THE TOOL DESIGNER Design to ensure that the best method is chosen. Box fixture 2. Together- er, these locators restrict eleven degrees of move- ment. If they were made to its Figure 3-1 Methods of relieving locators. In addition to the diamond pin relieved locator, Another style of pin common to jigs and fixtures other types are used for some workholders. To accomplish this, the tool designer must design team to be involved in a comprehensive plan that follows the following objectives: for product design and production. fications. The following are examples of the most common ways a part can be located from its profile. Figure 3-25 Alternative relieved locator designs. List the skills of a tool designer. 1. Type of machining required Copyright 2011 Cengage Learning. To this end, the construction of cutting tools, machine tools, and production methods, the tool must be as cost-effective as possible while the basic requirement of holding the workpiece has ensuring that the tool has the capacity to perform all required constant. These locators set the verticalities, the tool designer must know the various types of position of the part, support the part, and prevent dis- tortion during the machining operation. This design results in Figure 3-26 Ring nest a locator that contacts the workpiece only with a thin, single line of contact around the locator. A tool de- for jigs and fixtures. Regardless of the level of skill almag not available due to copyright restrictions Copyright 2011 Cengage Learning. Angle-plate jigs are used to hold parts that are remachined at right angles to their mounting locators (Figure 2-8). Figure 3-7 shows an ment (2, 5, 1, 4, and 12) are restricted (Figure 3-9). object with three axes, or planes, along which move- Using pin- or button-type locators minimizes wear may occur. One advantage vises locators have over other locators is their centralizing feature. He has helped thousands Copyright 2011 Cengage Learning. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

UNIT 2 Types and Functions of Jigs and Fixtures Figure 2-14 Trunion jig. Figure 2-15 Pump jig. Con-turing costs while maintaining quality and increased current engineering is a process that allows the production. A few of the more com- type of clamping device that is used. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

xiv Preface Jeff Szymanski, Milwaukee Area Technical College, Milwaukee, WI John Campbell, Cayuga Community College, Auburn, NY Lavonne Viechach, Hawkeye Community College, Waterloo, IA Terry Foster, Pima Community College, Tucson, AZ Copyright 2011 Cengage Learning. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

24 SECTION I Basic Types and Functions of Jigs and Fixtures reference to the holes in the flange. His experience also includes 10 years of teaching and lecturing for colleges, technical societies, and trade schools. This is most noticeable in Figure 2-9, where an angled hole requires additional clearance to the relieved portion of the part locator. LaVonne teaches across several disciplines and has developed e-resource materials ABOUT THE AUTHOR for several courses. Dr. Edward G. This type of support is normally used when a piece are discussed. The most common type is the tidially affected, specified. Duplicate Locators Locational inaccuracies develop because of the difference in position and location tolerances between the use of duplicate locators should always be avoid. the tool and the work (Figure 3-6). Operation: Drill four holes (two Figure 2-28 .62-inch and two, .25-inch). Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

UNIT 2 Types and Functions of Jigs and Fixtures Figure 2-1 Referencing the work team, tap, chamfer, counterbore, reverse box, jigs are used for parts that must be machined on surface, or reverse countersink (Figure 2-3). Plate fixture 2. Finally, working with part drawings and production plans unit on tooling materials covers the properties of the sequencing of operations in the shop. Number of pieces 3. This style of jig allows the usually equipped with a handle for easier movement part to be completely machined on every surface without the need to reposition the work in the jig. Figure 3-18 Round and tapered locators. Figure 3-2 Tolerance relationship. A gang-milling fixture is actually what class of tool? Channel jig 2. Since these are parallel surfaces, only one is nate this possibility, the hole locator can be madeneeded and the other should be eliminated. At the least, it should differ locations that may take them halfway include a brief description of each machining operation around the world. In addition to the part drawing and production plan, • What type of gauge, if any, should be used to the tool designer is informed of the amount of time and money that is available to spend on the design. To do this, the Copyright 2011 Cengage Learning. Editorial review has deemed that any suppressed content does not materially affect the overall learning experience. • Sequence of operations • Should multiple-spindle or single-spindle machines • Previous machining operations performed on the be used? serves only to increase the cost of the tool and adds lit- to the quality of the part. Adjustable supports are used when the surface is before choosing a support, the tool designer must choose or uneven, such as in cast parts. Plate jig 3. be placed in either a nest or a vee locator. Specifying tool tolerances closer than 20 percent (Figure 3-1). Adjustable avoid distorting or bending the part. Locators are normally used with one or more solid locators to allow any adjustment needed to level the work. This permits accurate place-ensure the desired accuracy, the tool designer must ment of the part in the tool and ensures the repeatability- make sure the part is precisely located and rigidly sup- ty of the jig or fixture, to fit the part. A fixture is a production tool that locates, holds, and supports the work securely so the required JIGS AND FIXTURES machining operations can be performed. This is the fit the part at any within ± 0.10 inch, then the tolerance of the hole in the size within the part limits. When using a vee locator, be sure it is positioned to allow for the differences in part sizes (Figure 3-31). For valuable information on pricing, previous editions, changes to current editions, and alternate formats, please visit www.cengage.com/whispered to search by ISBN#, author, title, or keyword for materials in your area of interest. Fixtures are normally classified by the type of machine on which they are used. These complex jigs are often so specialized that they cannot be classified. A variation is the modified angle-plate jig, which is used for machining angles other than 90 degrees (Figure 2-9). When large holes locate the advantages of the press-fit and the locking properties of work, fasten the internal locator with both screws and a thread. dowels, remaining directions, nine, ten, and eleven, are restrict- ed by a clamping device. By placing Z-axis and in direction eight, two more pin-type loca- the part on a three-pin base, five directions of move- tors are positioned (Figure 3-10). Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

16 SECTION I Basic Types and Functions of Jigs and Fixtures Figure 2-16 Multistation jig. In either supply materials and parts that meet the design speci- case, the ability to lead others is helpful. Should any wear shape of the part, nests are very expensive to design occur on this locator, the locational accuracy is im- for complicated shapes. This jig is commonly used on multiple-spindle machines. The full nest completely wear is permitted. If 3-2). Figure 3-31 Positioning vee locator to allow for differences in part size. Figure 2-23 Duplex fixture. • Metric dimensioning on approximately 20 per- LaVonne has taught at HCC for 10 years and is a cent of the part drawings. A larger clearance hole machined from the third side. Figure 2-22 Parts machined with an indexing fixture. The ceed at a much faster pace and is an excellent compan-process of geometric dimensioning and tolerancing is ion to the Machinery's handbook, which is now on CD also presented; many manufacturing drawings in as well industry use this system of dimensioning, and thereafter should be comfortable with its basic princi- At the heart of the team is the concept of concu- penses. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

24 SECTION I Basic Types and Functions of Jigs and Fixtures UNIT 1 Purpose of Tool Design OBJECTIVES • Provide simple, easy-to-operate tools for maxi- mum efficiency. After completing this unit, the student should be able to: • Reduce manufacturing expenses by producing parts at the lowest possible cost. • List the objectives of tool design. • Identify the source of specified design data. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

This is an electronic version of the print textbook. There are many consider the shape and surface of the part and the styles of adjustable supports. List manufacturing engineer (CmGrE) and a certified advanced metrication specialist (CAMS). Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

30 SECTION I Basic Types and Functions of Jigs and Fixtures Figure 3-15 Equalizing supports. 6. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

UNIT 3 Supporting and Locating Principles 29 Figure 3-14B Adjustable supports, spring type. Figure 3-14C Adjustable support, push type. The more than one side. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

12 SECTION I Basic Types and Functions of Jigs and Fixtures Figure 2-7 Sandwich jig. Figure 2-8 Angle-plate jig. Indexing fixture Figure 2-27 Figure 2-29 Copyright 2011 Cengage Learning. No part of this work covered by the copyright herein may be reproduced, transmitted, stored or used in any form or by any means. Vice President, Technology and Trades SBU; graphic, electronic, or mechanical, including but not limited to photocopying, Arar Elken recording, scanning, digitizing, taping, Web distribution, information networks, or information storage and retrieval systems, except as permitted under Editorial Director: Sandy Clark Section 107 or 108 of the 1976 United States Copyright Act, without the prior Senior Acquisitions Editor: Jim DeVoe written permission of the publisher. Senior Development Editor: John Fisher/Marketing Director: Cyndi Eichelman For product information and technology assistance, contact us at Channel Manager: Fair Hinton Cengage Learning Customer & Sales Support, 1-800-354-9706 Marketing Coordinator: Sarena Douglas Production Director: Mary Ellen Black For permission to use material from this text or product, Production Manager: Andrew Cross submit all requests online at www.cengage.com/permissions Production Editor: Stacy Mascus Senior Art/Design Coordinator: Mary Beth Further permissions questions can be emailed to (email protected) Vought/Editorial Assistant: Mary Ellen Martino ISBN-13: 978-1-4018-1107-5 ISBN-10: 1-4018-1107-8 Delmar Executive Woods S Maxwell Drive Clifton Park, NY 12065 USA Cengage Learning is a leading provider of customized learning solutions with office locations around the globe, including Singapore, the United Kingdom, Australia, Mexico, Brazil, and Japan. They must also make the tool foolproof. Team members The production plan can take many forms, depending may consist of customers, designers, and builders in on the needs of each company. The support team are the threaded (Figure 3-14A), spring (Figure selected must be strong enough to resist both the 3-14B), and push types (Figure 3-14C). This is called referencing. Engineers at HCC. Decreasing locates the part and the diamond pin prevents the contact area has little or no effect on the overall movement around the pin (Figure 3-19). Regardless of where the diameter, d, is, it means is an example of relieving a locator for better function. Here the top and bottom contact areas of the locator have been removed. Figure 3-14A Adjustable supports, threaded type. The two types of jigs are open and closed. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

UNIT 2 Types and Functions of Jigs and Fixtures 19 Figure 2-24 Profiling fixture. Figure 3-30 Vee-block locators. Nine of them through two connected contact points. Angle-plate jig 3. Because of their union. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

viii Contents Designing a Table Jig 177 Designing a Sandwich Jig or a Leaf Jig 181 Tool Design Application 184 Summary 185 Review 188 UNIT 12 ANGLE-PLATE JIGS AND FIXTURES 189 Objectives 189 Variations and Applications 189 Designing an Angle-Plate Jig 191 Designing an Angle-Plate Fixture 194 Tool Design Application 200 Summary 200 Review 203 UNIT 13 CHANNEL AND BOX JIGS 201 Objectives 204 Channel Jigs 204 Designing a Channel Jig 205 Box Jigs 208 Designing a Box Jig 208 Tool Design Application 212 Summary 213 Review 213 UNIT 14 VISE-JAW JIGS AND FIXTURES 216 Objectives 216 The Machine Vise 216 Locating Work in Vise-jaw Workholders 217 Designing a Vise-jaw Jig 219 Designing a Vise-jaw Fixture 222 Tool Design Application 224 Summary 226 Review 227 SECTION III SPECIALIZED WORKHOLDING TOOLS 231 UNIT 15 POWER WORKHOLDING 231 Objectives 231 Types of Power-Workholding Systems 231 Basic Operation of Power-Workholding Systems 235 Benefits of Power Workholding 236 Summary 237 Review 238 Copyright 2011 Cengage Learning. He has developed and con- runs and one-of-a-kind machining. Two examples of this type are shown in Figure 3-25. They are either machined into the tool body (Figure 3-32), or Vee locators are used mainly for round work, with all three locators. To raising the part above the chips. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

Preface INTRODUCTION The part, not the process, is the primary consideration in workholding. The world's demand for manufactured goods is growing at a staggering rate. In tool design, a cooperative relationship between approval by a chief designer. Box jig E. Describe a toolroom. K. Type of cutters needed 5. Locating the parted. To restrict direction seven, a single-pin locator is used (Figure 3-11). Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

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26 SECTION I Basic Types and Functions of Jigs and Fixtures Figure 3-9 Three-pin base restricts five directions of movement. Figure 3-10 Five-pin base restricts eight directions of movement. is straight up, so the clamping device is actually hold- locators and how each should be used to get the besting only one direction of movement. The product, a method for manufacturing, made available. Locate your local office at international.cengage.com/region Cengage Learning products are represented in Canada by Nelson Education, Ltd. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

Australia • Brazil • Japan • Korea • Mexico • Singapore • Spain • United Kingdom • United States Copyright 2011 Cengage Learning. If the part shown in Figure jig must be between ±.002 inch and ±.005 inch (Figure 3-3) were made at its smallest allowable size, it would be 1.240 inches in diameter. It is called a lath-radius fixture. This phenomenon is caused by the effect of the hypotenuse of the triangle formed by the centerlines if they are not perfectly aligned. The diameter of the pin shown at d is smaller than the Figure 3-22 Split contact relieved locator. Threaded locators are useful in areas installed and removed easily (Figure 3-18). Installed (Figure 3-33). They can locate flat work with rounded or angular ends and flat discs (Figure 3-29). commonly used materials and the effects of these properties and heat treatment on workholder design. adaptability makes it popular. May not be copied, scanned, or duplicated, in whole or in part. Time allocation b. how the centerlines of the part and the locator vary. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

UNIT 2 Types and Functions of Jigs and Fixtures 17 Figure 2-18 Angle-plate fixture. tional duties. Angle-plate jig 3. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

Aspherical locator greatly reduces the contact area by removing all the material not directly in contact with the workpiece. Pins used for part location are made with either the press-fit locator rather than the threaded locator tapered ends or rounded ends, allowing the parts to befor accuracy. Its a great deal of time is saved by using this jig. If first determine which surface is to be referenced, foolproofing devices are not simple, they tend to Only then should the locators for that surface be complicated an otherwise easy task. Figure 2-27. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

Contents ix DEVELOPING TOOLING ALTERNATIVES 107 Note Taking 107 Summary 107 Review 108 UNIT 8 TOOL DRAWINGS 109 Objectives 109 Tool Drawings versus Production Drawings 109 Simplified Drawings 110 Making the Initial Drawing 115 Dimensioning Tool Drawings 116 Millimeter and Inch Dimensioning 118 Geometric Dimensioning and Tolerancing 122 Supplementary Symbols 126 Geometrically Dimensioned and Toleranced Tool Drawings 132 Computers in Tool Design 132 Summary 134 Review 136 SECTION III DESIGNING AND CONSTRUCTING JIGS AND FIXTURES 139 UNIT 9 TEMPLATE JIGS 139 Variations of Template Jigs 139 Design Procedures 141 Tool Design Application 146 Summary 146 Review 149 UNIT 10 VISE-HELD AND PLATE FIXTURES 150 Objectives 150 Vise-Held Fixtures 150 Designing a Vise-Held Fixture 151 Plate Fixtures 155 Designing a Plate Fixture 156 Calculating Cam Clamps 158 Tool Design Application 168 Summary 168 Review 168 UNIT 11 PLATE JIGS 170 Objectives 170 Plate Jigs 170 Designing a Plate Jig 171 Copyright 2011 Cengage Learning. These skilled trades employees are vendor can supply special parts or components when capable of taking the prints for the individual com- necessary. She assisted students in chartering The guide contains the answers to the reviews at a student chapter of the Society of Manufacturing the end of each unit of the text. Multistation jigs are made in any of the forms The angle-plate fixture is a variation of the plate radius discussed (Figure 2-16). By installing the diamond pin as shown, this unload and lessens the problems caused by dirt, chips, movement is restricted. The specific design of any relieved locator istakes to load and unload the tool. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it.

24 SECTION I Basic Types and Functions of Jigs and Fixtures The partial nest is a variation of the full nest and fixed-stop locators are used for parts that cannot enclose only a part of the workpiece (Figure 3-28). He scrip- has written 17 books on tool and manufacturing engineering subjects and currently writes 40 magazine Clyde Avery, Carris College, Newark, CA Columns per year for several trade journals. part Should the tool be single-purposed or multipurpose? When selecting a vendor, a good practice is to choose the company that offers the most service to One resource a tool designer may often use to its customers. TOOL DESIGN IN MANUFACTURING TOOL DESIGN OBJECTIVES Manufacturing for global competitiveness clearly? The main objective of tool design is to lower manufac- requires the success of concurrent engineering. Fixtures can also be identified by a subclassification. The subject of this text is- as Flexible Manufacturing Systems (FMS), just these similarities rather than the differences. Figure 2-17 Plate fixture. They can be The terms locator and support are used either machined into the tool base or installed (Figure interchangeably when the devices used to alter a work-3-13). eter are to be drilled, it is usually necessary to fasten • Choose a class and type of jig and fixture for the jig to the table securely. Since no • Provide protection in the design of the tools for using tool or process can serve all forms of manufacturing, tool design is an ever-changing, growing maximum safety of the operator. process of creative problem solving. • Will the savings justify the cost of the tool? selected operations on sample parts. Multistation fixtures are used

workpiece. This type of jig is ideal for thin or soft parts that could bend or warp in another style of jig. A simple pin reference surface is the flange, as in Figure 3-5B, the placement in one of these holes makes it impossible to hub locator is not necessary. Both of these examples have clearance problems with the cutting tool. Templates are the least expensive and simplest type of jig to use. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. xii Preface describes the particular techniques of design and fabri- designing jigs and fixtures for inspection and welding/ing as they apply to each type of workholder; and for numerically controlled machine tools, this(3) the applications at the end of many units require section has been expanded to include those areas often reader to apply the lessons learned by solving prob- tooling technology that will service the needs and/ems in tool design. Fixtures also/tems are sometimes confused or used interchangeably. The 20 units of this text are divided into four/major sections. These fixtures are used for machining are the simplest form of multistation fixture, using/parts that must have machined details evenly spaced. Dr. Hoffman holds a B.S. degree in industrial management and an M.S. and Ph.D. in manufacturing • New information on the use of the computer for engineering. If the ref-Figure 3-5 Duplicate locators. When a part is placed in the tool that is at either both the underside of the flange and the bottom of extreme of the part tolerance, it may not fit. Locating pins usually have a Notice how each restricts the direction of movement of/contact area of one-eighth to one-half of the part thick- the other. Channel jig 3. This item wisely spent and results in an efficient and cost- Production Planeffective tool design. Last-minute • Degree of accuracy/costly changes are eliminated or minimized. Answering these questions and others related to the specific task, the tool designer develops alternative solu-Alternatives tions. Figure 3-12 Primary and secondary locators. Box jig 2. Due to electronic rights, some third party content may be suppressed from the eBook and/or eChapter(s). Editorial review has deemed that any suppressed content does not materially affect the overall learning experience. Con- (CNC) machine tools or some of the newer technolo-current engineering allows a company to have a dis- gies such as stereolithography or a layered object man- tinct economic advantage in a global market. Figure 3-20 shows/ bearing surface. With this tool, the part is nor- this jig is how it locates the work. The design team may be comprised of individuals from more than one country. Figure 3-13 Solid supports. Operation: Mill a slot .250 inch by .250 inch, ence surface, as in Figure 3-5C, the flange locator is unnecessary. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. JIG AND FIXTURE DESIGN Copyright 2011 Cengage Learning. The threaded clamping pressure and the cutting forces, part placement with the least number of locators. LOCATING THE WORK Locating from a Flat Surface/Parts are made in almost every possible shape and There are three primary methods of locating worksize, only two stations (Figure 2-23). – A fixture references the cutting tool with a set block and feeler, or thickness gauges. Jigs are usually fitted with hard- ened steel bushings for guiding drills or other cutting/After completing this unit, the student should be tools (Figure 2-1A). able to: As a rule, small jigs are not fastened to the drill- Identify the classes of jigs and fixtures. It is easier to locate determined by the workpiece and the type of/locationa part on one round pin and one diamond pin than to required. He is past chairman of the Society of Computer Aided Design (CAD) and Computer Manufacturing Engineers, Pikes Peak Chapter #213, Aided Manufacturing (CAM), as well as the in Colorado Springs. As shown, the base plate with the round pin positioned in the center hole will restrict nine degrees of movement (1, 2, 4, 5, 7, 8, 10, 11, and 12). Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. 22 SECTION I Basic Types and Functions of Jigs and Fixtures/locators should be placed to avoid this interference. The part is far as locators and positioners are concerned. They are/ the part (Figure 2-10). Plate jigs are similar to templates (Figure 2-5). Plate jigs are sometimes made/with legs to raise the jig off the table for large work. This style is called a table jig (Figure 2-6). This three-two-one, or six- point, locating method is the most common external locator for square or rectangular parts. Contributing to this edition are Mike Turner and LaVonne Vichlach from Hawkeye Community College • Expanded information about low-cost jigs and in Water-oo, Iowa. An object is free to revolve around chance by limiting the area of contact and/or move parallel to any axis in either direction. While such Nesting locators position a part by enclosing it/locators cannot bind in the hole, they also have their a depression, or recess, of the same shape as the part-own problems. Communication models between The production plan (Figure 1-2) is an itemized list of/ team members include e-mail and electronic transfer the manufacturing operations and the sequence of theof materials and may make use of sophisticated tech- operations chosen by the process planning engineer/ology such as teleconferencing. These changes have created/ tures are designed and built as they are. Leaf jigs are normally smaller than box jigs and are sometimes made so that Box jigs, or tumble jigs, usually totally surround they do not completely surround the part. The directions of movement are num- machined into the base. The following are the features of this new edition: The final section (Units 15-21) covers the spe- cialized working/olding topics in manufacturing as they • Easy-to-read presentation with numerous illus- relate to jig and fixture design. The same principle applies to a lathe fixture that is designed to machine radii. Since the fixture continuously contacts the tool, an incorrectly cut shape is almost impossible. The most common types are plate, angle-Heat treating Testing plate, vise-jaw, indexing, and multistation fixtures. Honing Turning/Inspecting Welding • Fixture classes are determined by the machine tools on which they are used and sometimes by the operations performed. These contours can be either internal or exter- nal. To be effective, a workholder must save/ Despite the many advancements and changes in money in production. Every part produced must be held of the intended functions, while it is machined, joined, or inspected or has anynumber of other operations performed on it. Concepts include the use of design teams in accom- plishing the task of competitively delivering good The second section (Units 6-9) introduces the design in a time efficient manner. Closed, or Figure 2-2 Boring jig. – Box, channel, and leaf jigs are all closed jigs. Assembling Lapping/Boring Milling • Other variations, such as indexing, rotary, trun- Broaching Planning nion, pump, and multistation jigs, are made as/Drilling Sawing either open or closed jigs. Forming Shaping/Gauging Stamping • Fixture types are determined by the way they are/ Grinding Tapping built. Profile locators position/ the work in relation to an outside edge or the outside of a detail, such as a hub or a boss. Open jigs are for simple operations where used, the whole jig plate is normally hardened/work is done on only one side of the part. Principles are constantly stressed: simplicity and economy. To increase the overall locational efficiency, agree/ number of locator designs have been examined. However, there is only one style that will not bind nany locating hole. Regardless of the jig selected, it must suit the part- perform the opera- tion accurately, and be simple and safe to operate./ jig uses either the part itself or a reference plate and a TYPES OF FIXTURES/plunger (Figure 2-13). Any Foolproofing/parts made within these sizes would be correct. • The primary objective of tool design is lowering Image not available due to copyright restrictions manufacturing costs while maintaining consis- tent quality and increased production. REQUIREMENTS TO BECOME A TOOL DESIGNER • The tool design function is a well-integrated/To perform the functions of a tool designer, an indi- position within the concurrent engineering team, vidual must have the following skills: requiring skills in computer technology and mul- tiple communication mediums. It doesthis at a level of quality and economy that will ensure • Select materials that will give adequate tool life, that the cost of the product is competitive. Another type has theused for large holes. Analyze the following part drawings and opera- tions to be performed and select the best jig or fixture for each. Sandwich jigs are a form of plate jig with a backplate (Figure 2-7). The parts shown in Figure 2-22 are examples of the uses of an indexing fixture./ive type of fixture to make. Industry has responded to this just as no single machine tool will perform every/demand with many new and sometimes radical ways required operation, no individual jig or fixture can/of producing products. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. UNIT 3 Supporting and Locating Principles 25/maller to accommodate the variation, but if this is/ done, the effectiveness of the hold locator is mini- mized and the locator becomes useless. Figure 3-17 Pin locators and bushing. This design offers more resistance to wear, while the 45-degree relief angles make the locator/less likely to bind or jam during loading and unload- ing operations. Second, several The following important concepts were presented in/est parts are produced with the tool and are carefully this unit- checked to ensure that they conform to the specifica- tions shown on the part print. For this reason, it is always a good idea to/ develop the drawings and sketches of the tool build a good working relationship with your toolmak- design ideas. He is a co- recipient of the • Expanded information on modular tooling where President's Award for his work on the innovative commercially available tooling can be adapted require it. UNIT 2 Types and Functions of Jigs and Fixtures 11 Figure 2-5 Plate jig. As one point is twelve directions of movement are restricted by using/ depressed, the other raises and maintains contact with a single pin, and eleven directions of movement are/ the part. and burrs. Figure 3-19 Locating with one relieved locator. Figure 3-20 Locating with two relieved locators. Operation: Drill four holes, .50 diameter holes. • The ability to make mechanical drawings and sketches • Tool designers use part drawings and produc- tion plans in developing alternative design solu- • An understanding of modern manufacturing meth- tions for efficient, dependable, and cost-effective ods, tools, and techniques tool designs. The main feature of fixture (Figure 2-18). This edition includes a more integrated approach/ to this section provides the background information for the global nature that challenges the tool designer, the more advanced study later in the text. Locating from an Internal Diameter Equalizing supports are also a form of adjustable Locating a part from a hole or pattern is the most effec- support (Figure 3-15). Part locators should never be installed as an afterthought. • Identify the types of locators and supports used but must be planned into the tool design. While one part is mally machined at a right angle to its locator. The single factor that should determine this/ When designing a tool, the designer must keep the part decision is the specified accuracy of the part being/ tolerance in mind. In some cases, where jigs and boring jigs, if, however, holes above .25 inch in diam. • Identify the types of jigs and fixtures. Here again, the use of bushings is determined by/ the number of parts to be made. The publisher reserves the right to remove content from this title at any time if subsequent rights restrictions require it. To elimi- the hub, fixed and cannot be changed to suit each part. from both its outside edge and the holes can create/ Locator duplication not only costs more but also problems. The operation in Figure 2-24 shows how the cam is actu- rated cut by maintaining contact between the fixture and the bearing on the milling cutter. Figure 3-16 Internal locators. The first put into a box-type carrier and then loaded on the main construction difference is mass. This feature is especially necessary on uneven restricted with two pins. Where they can serve as supports as well as locators. The tool • Should special tooling be used or existing equip- designer should understand the extent of these addi- tional modified? Overall size and shape of the part c. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. 32 SECTION I Basic Types and Functions of Jigs and Fixtures The split contact locator, shown in Figure 3-22, is Figure 3-23 Raised contact relieved locator. a type of relieved locator used for thick workpieces. Here, rather than using the complete thickness of the elliptical form of the pin shown at D. To achieve both the nonjamming characteristics/ of a spherical locator and the extended service life of a relieved locator, a modified form of locator can be used. • The type of jig is determined by how it is built. Since and locate the part. sions at seminars conducted by the Society of Manufacturing Engineers and at numerous other uni- • A discussion of geometric dimensioning and tol- versities and colleges, trade associations, and in- plant erancing, added to introduce the basic principles. The final station is used for unloading the fin- ished parts and loading fresh parts. Required accuracy d. Relieved locators reduce the area of contact/locate it on two round pins. Moving this contact point off the base/plate, to the middle of the workpiece, helps reduce the/ effects of dirt, chips, or burrs. REVIEW 1. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. UNIT 3 Supporting and Locating Principles 31 The main difference between the pins used for To be effective, the diamond pin must always be/ location and the pins used for alignment is the amount placed to resist this movement. For example, once the machining operation is complete at station 1, the tool is revolved and the cycle is repeated at station 2. This is done with locators ing the part above the chips and in constant contact/and clamps. 2. In keeping with the cally designed tool capable of passing the test of/ worldwide standard of measurement and modern OSHA standards. This design provides full location However, as shown in Figure 3-24B, a spherical/and makes the locator less likely to bind in the locator always has the same diameter regardless of/ workpiece. The additional design/consideration added to the locator would include the Leaf jigs are small box jigs with a hinged leaf to/ feature to provide the correct orientation of this clear- allow for easier loading and unloading (Figure 2-12). ance hole or machined relief to line up with the bush- The main differences between leaf jigs and box jigs/ing location. Figure 2-26. Installed locators are less/bered from one to twelve. worked as a machinist, a CNC programmer, an Engi- neering and Senior Engineering Analyst, and as a • An Instructor's Guide to accompany the text. The following is a partial list of production oper- - Template, plate, table, sandwich, and angle- ations that use fixtures: plate jigs are all open jigs. The tool designer must also provide rigid support This permits the use of fewer locators and ensur/for the part. Set blocks and feeler or thickness gauges are used with fixtures/jigs and fixtures are production-workholding devices to reference the cutter to the workpiece (Figure 2-1B) used to manufacture duplicate parts accurately. Another point to consider is whether the/ force are found. When therather than to increase their number. Boring jigs are used to bore holes/workpiece but also guides the cutting tool as the oper- that either are too large to drill or must be made an odd size (Figure 2-2), largely used on milling machines, fixtures are also/To do this, a jig or fixture is designed and built to hold, designed to hold work for various operations on most/support, and locate every part to ensure that each is of the standard machine tools drilled or machined within the specified limits. drilled, another can be reamed and a third counter- bored. This is a departure from the third section (Units 9-14) introduces and the traditional methods that were used when global/ explains the processes involved in designing and con- partnerships were not as predominant. This bearing is an important part of the tool and must always be used, incorrectly. Due to electronic rights restrictions, some third party content may be suppressed. The reader becomes familiar with requirements of industry for years to come. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. 6 SECTION I Basic Types and Functions of Jigs and Fixtures/Inspection • Electronic communication skills Many times the tool designer is required to inspect • Geometric dimensioning and tolerancing/ the finished tool to ensure that it meets specifications. This inspection, or functional tryout, is normally con- SUMMARY/ ducted in two phases. The fixture for the part in Figure 3-8 illustrates To restrict the movement of the part around the Z- the principle of restricting movement. Template jigs are normally used for accuracy rather than speed. Figure 2-4 Template jigs. Figure 3-5 shows examples of duplicate locators. These jigs can also be made/with or without bushings, depending on the number/ of parts to be made. Expert computer systems result is a solid object made one layer at a time where/are now part of the design environment, and they the layers may be no more than .003 thick. 5. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. 4 SECTION I Basic Types and Functions of Jigs and Fixtures Figure 1-2 Production plan. Product design part/ changes are continuously reviewed to determine tool- • Type of machining operation to be performed/ changes that might be necessary. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. Jig and Fixture Design, Fifth Edition © 2004 Delmar. Cengage Learning/Edward G. They Drill jigs may be divided into two general types, open may or may not have bushings. Figure 3-21 Relieved locators. Locating surfaces/ress table. Figure 2-25. The prototype, as/ suits the selected manufacturing facility. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. UNIT 2 Types and Functions of Jigs and Fixtures 13 Figure 2-10 Box or tumble jig. Figure 2-11 Channel jig. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. 2 SECTION I Basic Types and Functions of Jigs and Fixtures/ machining technicians. Design drawings are usually subject to ers. Not only companies, the tool designer often makes the tooling does working together make the task at hand easier./ decisions. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. vi Contents Basic Rules for Locating 21 Planes of Movement 25 Locating the Work 26 Summary 38 Review 38 UNIT 4 CLAMPING AND WORKHOLDING PRINCIPLES 41 Objectives 41 Workholders 41 Basic Rules of Clamping 41 Types of Clamps 43 Non-Mechanical Clamping 53 Special Clamping Operations 60 Clamping Accessories 61 Summary 62 Review 63 UNIT 5 BASIC CONSTRUCTION PRINCIPLES 65 Objectives 65 Tool Bodies 65 Preformed Materials 66 Drill Bushings 67 Set Blocks 72 Fastening Devices 73 Summary 86 Review 86 SECTION II CONSIDERATIONS OF DESIGN ECONOMICS 89 UNIT 6 DESIGN ECONOMICS 89 Objectives 89 Considerations of Design Economics 89 Design Economics 89 Design Economy 89 Economic Analysis 90 Comparative Analysis 95 Summary 97 Formula Summary 98 Review 99 UNIT 7 DEVELOPING THE INITIAL DESIGN 100 Objectives 100 Predesign Analysis 100 Designing Around the Human Element 102 Previous Machining Operations 107 Copyright 2011 Cengage Learning. The solid model allows the/ tles and team compositions to suit their internal designer to view the three-dimensional part geometry/ company structure. Fixtures vary in design from relatively simple jigs and fixtures are so closely related that the tools to expensive, complicated devices. Hoffman, president of Hoffman & ACKNOWLEDGMENTS/ Associates, an engineering consulting firm based in Colorado Springs, Colorado, is a tool engineering The following instructors reviewed the revised manu- consultant, technical writer, editor, and lecturer. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. UNIT 3 Supporting and Locating Principles 33/ sured, it is always the same size. The A fixture should be securely fastened to the table of/ correct relationship and alignment between the cutter, the machine upon which the work is done. Though/ other tool, and the workpiece must be maintained. There are several other jigs that are combinations of the types described. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. UNIT I Purpose of Tool Design 7g. Plate jig 1. Figure 2-9 Modified angle-plate jig. drill will be lost as a result of any attempted drilling. To prevent correct position. Operation: Mill a shoulder, .75 inch by .75 inch by .38 inch. The locator shown at the right has similar design, but it uses a relief groove in place of/ the lower relief angle. Locating from an External Profile/ Locating work from an external profile, or outside/ edge, is the most common method of locating work in/ the early stages of machining. Figure 3-27 Full nest. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. UNIT 3 Supporting and Locating Principles 27 Figure 3-11 Six-pin base restricts nine directions of movement. Two diamond pins should be used to locate/ aneess. This design reduces the contact/ area and raises the point where the locator and work-piece touch. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. UNIT 3 Supporting and Locating Principles 23 Figure 3-3 Part and tool size relationship. largest size, the diameter would be 1.260 inches. The names used to identify these/ basic jig is almost the same for either machining oper- jigs refer to how the tool is built/ ation. The first section (Units 1-5) gives the A glossary is provided for ready reference and as/ reader an overview of the basic types and functions of an aid to the reader in mastering the terminology of/ jigs and fixtures, as well as a detailed description of workholder design/ the way these workholders are designed and built. The reader learns the basic elements of supporting, FEATURES/ locating, and clamping the part and then is introduced to the basic principles of workholder construction. Companies may vary/ job may include a solid model, graduate of both the University of Northern Iowa and Hawkeye Community College. However, each workholder/puter Numerical Control and Computer Aided Manu- variation has basic similarities to other types and/ facturing to today's modern manufacturing concepts, styles of jigs and fixtures. Additional clear- ance here would allow the drill to complete the hole/ and avoid drilling the relieved portion of the locator. The part locator will most likely be hardened and the Copyright 2011 Cengage Learning. The diamond pin, located as shown, further restricts another two degrees of movement (6 and 3). What class of jig would normally be used to tap holes? This is necessary to maintain the required preci- this is not possible, the locators should be relieved/ sion. List the seven objectives of tool design. Cengage Learning reserves the right to remove additional content at any time if subsequent rights restrictions require it. UNIT I Purpose of Tool Design 3 Figure 1-1 Part drawing, ducted courses for local industries, including John Deere, Traer Manufacturing, Northeast Machine Tool, • New information on setup reduction for workhold- Viking Pump, General Machine Tool and Berth Cabri- ing to minimize fixturing costs while increasing nets. This form allows the loading and unloading operations to be performed while the machining operation is in progress. Accu- unloaded, erence the edges of a part are called locators or stops. In parts (Figure 2-20). The locating devices used to ref- machined surface acts as a locating point. How are jigs and fixtures normally identified? Vise-jaw fixtures are the least expen- Copyright 2011 Cengage Learning. All Rights Reserved. Covering power work- trations and many new photographs showing the/ holding methods and equipment, modular workhold- variety of tools and workholders available as welling systems and low-cost tooling practices, and as typical applications. New material covering the applications of Com- rent engineering. As the drill exits the product being drilled, it has little or no room for the drill point to clear the/ product completely, produce a round hole all the way/ through the part wall, and avoid drilling the part loca- tor. The work is held between two sides and/ part locator may be possible. This plex part geometries. Services such as design assistance and/ help resolve design problems is the group of skilled problem solving, where their product is involved, are/ people in the toolroom. If the part locators are designed properly, complete contact over the locating surface. Drill jigs are used to drill. 8 Copyright 2011 Cengage Learning. ufacture, more commonly referred to as a LOM. Process Engineer. Prototypes are manufactured/ ultimately saves time and money while speed- ing up using conventional Computer Numerical Control/ the process of getting product to market earlier. These factors are- PLANNING THE DESIGN • Overall size and shape of the part • Type and condition of the material used for the/ The designer is responsible for managing information/ resources that impact the tool design. Locators should be spaced as far apart as possible. • A creative mechanical ability • Tool designers, in addition to designing tooling. • An understanding of basic toolmaking methods may also be responsible for toolroom supervi- • A knowledge of technical mathematics through sion, procurement, and tool inspection. A fixture used for a straddle- milling operation is classed as a mill fixture, but it may also be classed as a straddle-milling fixture. To minimize this problem, these loca- ring nest, which is normally used for cylindrical/ locators should be used only where sufficient tolerance for profiles (Figure 3-26).

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