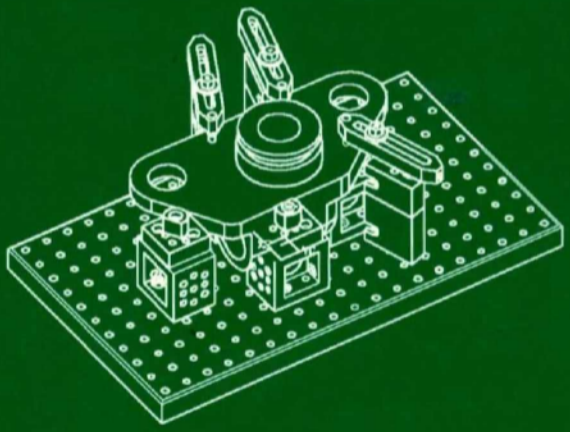
COMPUTER-AIDED FIXTURE DESIGN



YIMING (KEVIN) RONG
YAOXIANG (STEPHENS) ZHU

COMPUTER-AIDED FIXTURE DESIGN

MANUFACTURING ENGINEERING AND MATERIALS PROCESSING
A Series of Reference Books and Textbooks

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YIMING (KEVIN) RONG
Worcester Polytechnic Institute
Worcester, Massachusetts

YAOXIANG (STEPHENS) ZHU
Beijing Institute of Machinery Industry
Beijing, China

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Preface

Fixtures are important in both traditional manufacturing and modern flexible manufacturing systems (FMS), which directly affect manufacturing quality, productivity, and cost of products. The time spent on designing and fabricating fixtures significantly contributes to the production cycle in improving current products and developing new ones. Therefore, much attention has been paid to the study of fixturing in manufacturing.

In machining processes, geometric accuracy of a manufactured part depends mainly on the relative position of the workpiece to the cutting tool. Fixtures are needed to locate the workpiece relative to the machine tool in order to ensure manufacturing quality. It is clear that the primary requirements for a fixture are to locate and secure the workpiece in a given position and orientation on a worktable of the machine tool. In addition to the primary requirements in fixture design, many other demands must also be met, including ensuring productivity (e.g., easy load and unload of the workpiece, utilization of automated or semiautomated clamping devices, and easy chip disposal), special design for reducing the deformation of weak-rigidity workpieces, simple and safe operation (e.g., the use of antimistake function components for costly workpieces), and effective cost reduction (e.g., considering fixture material and fabrication processes and using standard elements with priority). Hence the fixture design is a complicated process. Application of these fundamental principles to an individual fixture design depends mainly on the designer's experience in manual fixture design.

Flexible fixturing becomes necessary in FMS and computer-integrated manufacturing systems (CIMS). In FMS or CIMS, machine tools (and other equipment) are flexible for fabrication, assembly, and treatment. They are

controlled by computers and linked by a material handling system to move parts from one workstation to another. The fixtures employed in FMS must be adaptable in order to accommodate the wide variety of parts, thus achieving true flexibility. On the other hand, CIMS includes a local integration of computer-aided design (CAD), computer-aided process planning (CAPP), computer-aided tooling (CAT), and computer-aided manufacturing (CAM). The areas of CAD, CAPP, and CAM have been studied for years and much progress has been made.

Two aspects are involved in tooling: (1) cutting tool design and selection and (2) fixture design and fabrication. The cutting tools have been highly standardized and computer selection is relatively easy. The absence of a viable flexible fixturing methodology in the marketplace is impeding the ability of FMS and CIMS to optimally minimize manufacturing costs, increase productivity, and ensure product quality.

Flexible fixturing involves employing a single device to hold parts of different shapes and sizes. Currently, the most commonly used flexible fixtures are modular fixtures. The flexibility of modular fixtures is derived from a large number of fixture configurations based on different combinations of fixture elements. There are three major difficulties in applying the modular fixtures to manufacturing systems: the complexity in design and assembly, the absence of methodologies for evaluating performances of assembled modular fixtures, and the complexity of managing and integrating fixture components and designs into an FMS or CIMS. The computer-aided fixture design (CAFD) technique has been developed toward solving these problems.

The aim of this book is to provide fundamental knowledge of CAFD techniques. The content of the book is uniquely designed for a thorough understanding of CAFD from the basic fixture-design principle, a simple application of computers to edit and modify a fixture design based on a fixture component database, a group-technology (GT)-based fixture-design retrieval system, automated generation of fixture configurations, and advanced analysis and verification of fixture designs. This book can be used as a textbook for engineering graduate students in class study or as an engineering reference book for manufacturing engineers in workshop practice.

We have worked on CAFD for many years. This book provides an overall picture and the scientific basis of CAFD, including a summary of our work as well as contributions to the field by others. Background information about fixtures and flexible fixtures in production is given in Chapter 1. Principles of fixture design and modular fixtures are introduced in Chapters 2 and 3. In Chapters 4, 5, and 6, three generations of CAFD systems are presented. Although computer-aided fixture drawing and editing systems may not be academically advanced and automated fixture design systems