
**NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA**

# GEOMETRICAL LIBRARY OF MODULAR JIGS AND FIXTURES PACKAGE FOR SOLIDWORKS

Thesis submitted in accordance with the requirements of the National Technical University College of Malaysia for the Degree of Bachelor of Engineering (Honours) Manufacturing (Process)

By

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# DECLARATION

I hereby, declare this thesis entitled "Geometrical Library Of Modular Jigs And Fixtures Package For Solidworks" is the result of my own research except as cited in the reference.

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# ABSTRACT

Nowadays we have many modern technologies that are very useful which we can take the benefit out of it. For example in factory there are many kind of jigs and fixtures to choose from to suit with parts to be machined. In the old days we need to find the suitable jigs or fixtures by trial-an-error taking one by one and test it manually and if it is unsuitable we need to keep on looking until we get one. The advantages of new technology are greatly untapped if we just do it manually. By using SolidWorks this problem can be solved. Jigs and fixtures created in SolidWorks can save a lot of time for tool guiding and setting arrangement. In this project, the jigs and fixtures are developed as a computerized modules system that compatible for SolidWorks. For making the machining process more easily, SolidWorks software are used in preparing the components and a library of jigs and fixtures is created for milling machine, machining centre and drilling machine. This Geometrical Library Jigs and Fixture are useful for designer or machinist since their job will be easier and time saving for setup or searching for suitable jigs or fixture.

# DEDICATION

Firstly, syukur Alhamdulillah and all praises for ALLAH S.W.T, which lead me to complete this study and peace, are upon our Prophet Muhammad S.A. W.

I would like to express my appreciation and sincere gratitude to my supervisor, Mr. Abdul Rahim Bin Samsudin for his irreplaceable unfailing patience, guidance and encouragement throughout the whole course of this work. Without his valuable advice and understanding, this thesis could not been successfully completed. Special appreciation is also addressed to lecturers of Fakulti Kejuruteraan Pembuatan who have always given me guidance and support through out the completion of this thesis.

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# CHAPTER 1
# INTRODUCTION

This project is intended to create a geometrical library for Jigs and Fixtures to facilitate and develop a computerized modular system that compatible for SolidWorks. This software is choose because it can work faster through unrivaled performance and ease to use, including familiar Windows functions like drag-and-drop, point-and-click, and cut-and-paste. With SolidWorks 2005 software, design data is 100% editable, and relationships between parts, assemblies, and drawings always stay up-to-date. This software can also show the fully assemble of the Jigs and fixtures with the animation

## 1.1 Objectives

The objectives of this project are:-

- To create a geometrical library for jigs and fixtures.
- To develop a computerized modular system that compatible for SolidWorks.
- To make proper arrange able Jigs and Fixture for the company to save time in setup.

## 1.2 Scope of Works

The scopes of this project are:-

- Create a geometrical library for modular jigs and fixtures to be used at milling machine, machining centre and drilling machine using SolidWorks.
- Use SolidWorks software in preparing the components.

## 1.3 Problem Statement

SolidWorks is one of the high-end drawing software. It will be a great help to designer if the software has provided an extensive library of common parts or items such as Jigs and Fixtures. This project is intended to create a geometrical library of jigs and fixtures to facilitate the users especially designers who are involve in designing workpiece that need to do machining process. It also help machinist to setup workpiece easier by selecting proper Jigs and Fixtures available in software library to clamp the workpiece and do machining process.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Introduction

Modular fixtures have been used in the manufacturing industry for decades; they were originally developed for job or small-batch production to reduce the fixturing cost and production for which the dedicated fixture was not economically feasible. A modular fixture is assembled following the combination principle by selecting the exiting standard elements, which greatly expands the fixturing functions from using general-purpose fixture components. The flexibility is derived from the large number of fixture configurations from difference combinations of the fixture elements which may be bolted to a base plate (Thompson and Gandhi, 1986).

Modular fixture components can be disassembled after a batch of parts are produced, and then reused for new parts. The use of modular fixtures decreases the tooling cost and storage floor and shortens the lead time. Usually, the design and assembly of modular fixtures cannot be separated in a manual mode. The design of a modular fixture is in the assemblyman's mind instead of the blueprint and is modified whenever it needs. It is obvious that the designer must understand the requirements of the parts and learn about the information related to the operation. It is very often that a real part is provided to assist the fixture design and make the assembly easy.

## 2.2 Research In Geomatrical Library Of Modular Fixtures System

In this thesis several research papers published in journals with related topics are referred and discussed.

a) Fixturing faceted parts with seven modular struts : isatp, vol. 00, no., p. 0133, .)(R. Wagner, Yen Zhuang, K. Goldberg. Univ. of Southern California, Los Angeles, CA, USA (1995)"Building on results in modular fixturing of 2D parts, this paper describes a new approach to fixturing 3D parts for assembly or inspection using a particularly simple set of modular elements. The approach uses seven modular struts mounted on a regular lattice of sockets embedded in a rectangular frame. Each strut extends normal to a contact surface on the part so that only compressive forces are required to hold the part in form closure: no bending moments are exerted on the struts and the fixture does not rely on contact friction. An algorithm is given for synthesizing such fixtures. Given as input a polygonal part and desired 3D pose, the algorithm enumerates all fixtures that will hold the part in form closure and rank them based on a quality metric. They also describe a fast test for form closure in 3D.

b) (K. Penev, A.A.G. Requicha (1995)"Fixture foolproofing for polygonal parts," :isatp, vol. 00, no. ,p. 0127, .)A modular fixture is an arrangement of fixturing elements (fixels) that locate and immobilize a workpart. A complete algorithm for designing fixtures for polygonal parts in 2-D was proposed by Brost and Goldberg (1994). The algorithm finds all fixtures consisting of three fixed-size locators and one clamp on a regular grid of holes. However, often it is possible to load the workpart into the fixture in an incorrect pose. An incorrect loading may have disastrous consequences when the part program is executed. Therefore, fixtures that permit only one pose for the loaded workpiece are very desirable. We call them foolproof fixtures. In this paper we present an algorithm that accepts a fixture design, produced by the Brost-Goldberg algorithm, and augments it by inserting in certain grid holes fool proofing pins that make the incorrect loading impossible. The algorithm is complete in the sense that it either (i) produces a solution; (ii) terminates without a solution because none exists; or (iii) detects and flags those non generic situations it cannot handle. (These occur rarely.) The produced set of fool proofing pins may not be minimal. However, it is not much worse than the minimal one. Experimental results and complexity analysis are provided.

c) A "Incorporating Geometric Tolerance Information in Solid Models to build Automated Inspection System" : IEE, Part D,01)(Sourabh Tamba(2004).A major shortcoming of the current solid modeling schemes is their inability to store tolerance information. Lack of tolerance information makes it almost impossible to integrate computer-aided inspection with other modules of computer integrated manufacturing systems. If geometric tolerance information can be incorporated in CAD data structures, it will play a key role in the overall integration that the modern manufacturing industry is starving for. The current work is an attempt to make further inroads in this relatively new arena.

## 2.3 Development Of Modular Fixtures

Based on fixture component standardization, modular fixtures are designed is a series of prefabricated standard components and units with relatively tight geometric tolerances that can be assembled rapidly into a variety of design configurations to hold parts with different geometry and fixturing requirements. After certain manufacturing operations, the modular fixtures can be disassembled and reused for other jobs (Zhu and Zhang, 1990).

## 2.4 Production Devices

Production devices are generally work holders with/without tool guiding/setting arrangement. These are called jigs and fixtures.

### 2.4.1 Fixtures

Fixtures are to hold the work piece securely in the correct position with respect to the machine/cutter during operation. There is sometimes a provision in the fixtures for setting the tool with respect to the work piece/fixture, but the tool is not guided as in a jig. Fixtures are often clamped to the machine table. Its use for clamping workpiece with irregular shape.

#### 2.4.1.1 Types Of Modular Fixture System

Generally there are two types of modular Fixture system. They are:-

a) T-Slot-Based *(refer Appendix D )*
b) Dowel-Pin-Based *(refer Appendix D )*

### 2.4.2 Jigs

Jigs are provided with tool guiding elements such as drill bushes. Its direct the tool to the correct position on the work piece. Jig is rarely clamped on the machine table because it is necessary to move the jig on the table to be aligned with various bushes with the machine spindle.

## 2.5 Elements Of Jigs And Fixtures

Generally all the jigs and fixtures consist of:

a) Locating Elements, To position the work piece accurately with respect to the tool guiding or setting elements in the fixture.

b) Clamping Elements, To hold the work piece securely in the located position during operation.

c) Tool Guiding and Setting Elements. As aids guiding or setting of the tools in correct position with respect to the work piece. Drill bushings guide the drills accurately to the work piece. Milling fixtures use setting pieces for correct positioning of milling cutters with respect to the work piece.

## 2.6 Advantages Of Jigs And Fixtures

a) Productivity, Jigs and fixtures eliminate individual marking, positioning and frequent checking. Thus reduces operation time and increases productivity.

b) Interchangeability, Jigs and fixtures facilitate uniform quality in manufacture. There is no need for selective assembly. Any parts of the machine fit properly in assembly, and all similar components are interchangeable.

c) Skill Reduction, Jigs and fixtures simplify locating and clamping of the work pieces. Tool guiding elements ensure correct positioning of the tools with respect to the work pieces. These are no need for skilful setting of the work pieces of tool. Any average person can be trained to use jigs and fixtures the replacement of a skilled workman with unskilled labor can effect substantial saving in labor cost.

d) Cost Reduction, Higher production, reduction in scrap, easy assembly and savings in labor costs result in substantial reduction in the cost of work pieces produced with jigs and fixtures.

## 2.7 Materials Used In Jigs And Fixtures

Jigs and fixtures are made from a variety of materials some of which can be hardened to resist wear. It is sometimes necessary to use nonferrous metals like prosper bronze to reduce wear of the mating parts, or nylons or fibre to prevent damage to the work piece. Given below are the materials often used in jigs, fixtures, press tools, collects, etc.

a) High Speed Steels (Hss) These metals contain 18% (or 22%) tungsten for toughness and cutting strength, 4.3% chromium for better harden ability and wear resistance and 1% vanadium for retention of hardness at high temperature (red hardness) and impact resistance. HSS can be air or oil hardened to RC 64-65 and are suitable for cutting tools such as drills, reamers and cutters.

b) Die Steels, These metals are also called high carbon (1.5-2.3%) high chromium (12%) (HCHC) cold working steels and are used for cutting press tools and thread forming rolls. Hot die steels with lesser carbon (0.35%) and chromium (5%) but alloyed with molybdenum (1%) and vanadium (0.3-1%) for retention of hardness at high temperature are used for high temperature work like forging, casting and extraction.

c) Carbon Steels, These metals contain 0.85-1.18% carbon and can be oil hardened to RC62-63. They can be used for cutting softer materials like woodwork, agriculture, etc. and also for hand tool such as files, chisels and razors. The parts of jigs and fixtures like bushings and locators, which are subjected to heavy wear can also be made from carbon steels and hardened.

d) Collet Steels (Spring Steels), These metals contain about 1% carbon and 0.5% Manganese. Spring steels are usually tempered to RC 47 hardness.

e) Oil Hardening Non-Shrinking Tool Steels (OHNS), These metals contain 0.9-1.1% carbon, 0.5-2% tungsten and 0.45-1% carbon, they are used for fine parts such as taps, hand reamers, milling cutters, engraving tools and intricate press tools which cannot be ground after hardening (RC 62)

f) Case Hardening Steels, These metals can be carburized and case hardened to provide 0.6-1.5 thick, hard (RC 59-63) exterior. 17 Mn1Cr95 steel with 1% manganese and 0.95% chromium is widely used. 15 Ni2Cr1Mo15 steel with additional nickel (2%) reduces thermal expansion up to 100°C. Case hardening steels are suitable for parts which require only local hardness on small wearing surfaces where costlier, difficult to machine full hardening tool steels are not warranted.

g) High Tensile Steels, These metals can be classified into medium carbon steels with 0.45%-0.65% carbon (En8-9) and alloy steel like 40 NiCr1M028 (En24). The tensile strength can be increased up to 125 $kg/mm^2$ (RC 40) by tempering. Medium carbon steels are widely for fasteners and structural work while alloy steels are used for high stress applications like press rams.

h) Mild Steel, It is the cheapest and most widely used material in jigs and fixtures. It contains less than 0.3% carbon. It is economical to make parts which are not subjected too much wear and are not highly stressed from mild steel.

i) Cast Iron, It contains 2-2.5% carbon. As it can withstand vibrations well, it is used widely in milling fixtures. Self lubricating properties make cast iron suitable for machine slides and guide-ways. The ingenious shaping of a casting and the pattern can save a lot of machining time. Although, the strength of cast iron is only half the strength of mild steel, a wide variety of grades have been developed. Nodular cast iron is as strong mild steel, while mehanite castings have heat resistant and corrosion resistant grades.

j) Steel Castings, These combine the strength of steel and shapabilty of a casting.

k) Nylon And Fibre, These are usually as soft lining for clamps to prevent denting or damage to the work piece under high clamping force. Nylon or fiber pads are screwed or stuck to mild steel clamps.

l) Phospher Bronze, It is widely used for replaceable nuts in screw making process is time consuming and costly. So, their wear is minimized by using softer, shorter phosphor bronze mating nuts. These can be replaced periodically. Phospher bronze is also used in applications calling for corrosion resistance, like boiler valves.

## 2.8 Basic Design Steps

a) Designing a method of locating in the jig or fixture which will correctly orient the surfaces on the work piece, for matching or other manufacturing operations.

b) Designing a clamping method that will hold the work piece firmly against the locators and against cutting forces.

c) If required, designing additional intermediate supports that may be needed to prevent the work piece from springing or bending when it is subjected to the clamping forces and the cutting forces.

d) Designing the jig or fixtures body to consolidate all of the components previously designed, into one unified structure.

e) In their application, the designer must consider the dimensions, material and weight of the part to be hold by the fixtures the already existing surface finish and accuracy to its surfaces.

### 2.8.1 Basic Requirements Of Fixturing Systems

Fixtures are one of the operational equipment in manufacturing which are used to ensure the product quality and operation efficiency. Fixture design is desired to be rapid or on time, effective, and economic. The discussion of basic fixture-design requirements can be found in many fixture-design books. The following four aspects are particularly important in fixture design.

a) Ensuring Positional Accuracy of Work pieces
b) Ensuring Operation Convenience and Safety.
c) Ensuring Productivity in Job, Batch and Mass Productions.
d) Ensuring Low Production Cost.

## 2.9 Locating Principle And Locating Errors

The most important task of fixture design is to locate workpieces with an acceptable accuracy. Understanding the locating principle and locating errors is very essential in fixtures design.