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Design Jigs and Fixture for Surface Grinding Long Part

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By

KHARMIZAN BINTI JAPAR

Faculty of Manufacturing Engineering

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ABSTRAK

Kajian ini tertumpu kepada rekabentuk untuk jigs dan perkakasan untuk mesin pencanai permukaan untuk mencanai benda kerja yang mempunyai saiz yang panjang dengan melakukan kajian terhadap perkakasan yang sedia ada dan mesin pencanai dan mengkaji spesifikasi dan kehendak untuk menghasilkan rekaan perkakasan yang baru. Tajuk kajian ini telah dicadangkan setelah mengenal pasti beberapa perkara yang berlaku semasa mencanai benda kerja yang bersaiz panjang seperti gegaran, ketidakstabilan benda kerja masalah untuk mencengkam material yang tidak boleh dicengkam oleh meja magnetic. Beberapa konsep telah dihasilkan dan beberapa lakaran telah disediakan. Lakaran telah dihasilkan dan selepas itu rekaan terbaik dipilih dan dilukis semula dalam CATIA .CATIA adalah alat bantuan komputer untuk tiga dimensi aplikasi interaktif aplikasi dalam pelbagai kegunaan PLM/CAD/CAM/CAE perisian komersial. Ciri-ciri dan kebolehan biasanya adalah untuk menghasilkan '3D Production Lifecycle Management software suite', CATIA menampung pelbagai peringkat dalam pembagunan pengeluaran (CAx). Daripada konseptual melalui rekaan (CAD) dan pengilangan (CAM), hingga analisis (CAE). Analisis menggunakan Finite element analisis ialah teknik simulasi komputers yang digunakan dalam analisis kejuruteraan. Ia menggunakan kaedah berangka yang dikenali sebagai teknik finite element. (FEM). Terdapat tiga fasa dalam computer analysis iaitu pra pemrosesan (mengenapasti posisi finite element modal dan factor persekitaran untuk di aplikasi), Penyelesaian analisa (penyelesaian terhadap model finite element) Pasca pemrosesan keputusan (menggunakan kaedah visual) akan digunakan untuk menganalisis sama ada lukisan boleh diterima atau tidak.

Kata kunci: CATIA, Analysis Finite Element, Jigs dan Perkakasan.

ABSTRACT

This research is focused on the designed of the jigs and fixture for the surface grinding for long part by doing the research on the existing fixture and the surface grinding machine and the specification and requirement to generate the new fixtures designed. This title had been suggested because of the problems that encounter during using the surface grinder which are the vibration of the long parts, the instability of the workpiece and problems to grind the non magnetic material so that this kind material can be grind using the surface grinder machine too. The some concept generations had been generated and do the sketching. The sketching been generated and after that the best designed selected and draw it in CATIA. CATIA is computer aided three dimensional interactive application is a multi-platform PLM/CAD/CAM/CAE commercial software. Features and capabilities commonly to as a 3D Production Lifecycle Management software suite, CATIA supports multiple stages of production development (CAx). The stages range from conceptualization, through design (CAD) and manufacturing (CAM), until analysis (CAE). The analysis using Finite element analysis is a computer simulation technique used in engineering analysis. It uses a numerical technique called the finite element method (FEM). Three phases in any computer-aided engineering task: pre processing (definition the finite element model and environmental factors to be applied to it), Analysis solver (solution of finite element model) and post processing of results (using visualization tools) will be used to analysis whether the drawing can be used or not.

Keywords: CATIA, Rapid prototyping, Finite Element Analysis, Jigs and Fixture.

CHAPTER 1

INTRODUCTION

1.1 Project Overview

This project specifically to find the best design of fixture that been used for grinding the surface of the long part using the machine that been use in the lab which is (PSG 60220 AHR). Generally it will cover machine that use jigs and fixture that been used widely in industry.

There are several type of surface grinding that been use in industry. It is important that surface grinding machine to archive very good flatness, parallelism and surface finish or workpieces. The re-examine the essential factors in grinding machine technology in order to improve performance and meet the demanding of this ever changing market.

Factor that included to the choosing of jigs and fixture for the machine are the precision, efficiency, rigidity, stability, stiffness, automation and more. There has ongoing attention to automation has resulted in another step forward minimal man power and unstaffed operation to meet high industry standards with accuracies reaching almost lapping quality. There are lots of different types of grinding machine which are:

- Horizontal double disk grinding machine
- Vertical double disk grinding machine
- Rotary table type surface grinding machine

1.2 Problem Statement

There are major problem while grinding the surface of the light workpiece which having lesser resting area tend to vibrate and fly off the magnetic table due to the high speed of the grinding wheel and the high feed used in grinders with reciprocating or rotary table. In this case, there also including the long parts that needs to be grinds that need a grinding fixture to hold on the table.

As a matter of fact manufacturing for global competitive clearly requires the success of current engineering which is the process that allows the design team to involved in a comprehensive plan for product design and manufacturing processes will result in power design errors.

Jigs and fixture are production work holding devices used to manufacture duplicate parts accurately. The correct alignment between the cutter or other tool, and the workpiece must be maintained. In many cases, it is difficult to design the locating, supporting and clamping for surface grinding long parts. To do this a jig and fixture is designed and built to hold, support and locate every long part to ensure that each surface grinded or machined within the specified limits.

1.3 Objectives

The objectives of this project are:

- To identify the locating, supporting and clamping methods and details to suit specific surface grinding long parts.
- To calculate and analyzed the clamp to hold the surface grinding long parts
- To design the jig and fixture for surface grinding long parts.

1.4 Scope of Project

This project shall concern with the basic rules for locating, such as positioning the locators, part tolerance, fool proofing and duplicate location.

Also the basic rules of clamping, including positioning the clamps, tool forces, clamping, including positioning the clamps, tool forces, clamping forces and type of clamps selected.

The other method is the basic construction principles, such as tool bodies, preformed material and fastening devices. Explore and analyzed an initial design of jig and fixture for surface grinding long part using CAD software.

The priority for this project is to design the surface grinding fixture for the long part that need to be grind.

1.5 Project Organization

Project organization is needed to make this project more organized so that all the details from the start and by the end of the project can be gathering.

In chapter one there will be project overview that consist the overall of the project, that is specify to the design fixture for surface grinding for longer part. The problem statement that state about the problem of the surface grinder for the longer part the problems encounter during the process and the problems with the existing jigs and fixture for surface grinder. The objectives of the project are to identify the details to suit specific surface grinding for long part, calculate and analyze the clamp, design the template jigs and fixture. Scope the project which is most probably concern about the jigs and fixture, selection of material and design the jigs and fixture using CAD software.

Chapter two will content the literature review using resource from books, journal, websites about the surface grinder, jigs and fixture, material that used in jigs and fixture, location and clamping.

Chapter three will be about the methodology that been used in this project which contain the details about the design, sketches, develop the numerical model.

Chapter four will be the result and analysis of the drawing and the related parameter that encounter. The numerical analysis, details drawing and the assembly drawing the related to the drawing that been choose.

Chapter five will be the discussion and the explanation about the design that been choose, the reason for choosing the design, the details about the design and the analysis that been done, including the numerical model and the material selection.

Chapter 6 will be summary and conclusion that will conclude and summarize overall about the project. It also contains the recommendation for the future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Surface Grinding

Surface grinding machine is used widely in industry to finish length and thickness of the workpiece within precise tolerances. The standard magnetic table furnished with surface grinding machines can be used satisfactorily for workpiece having resting surface parallel to the surface to be ground. Solid plates can be ground under magnetic clamping alone and no other fixtures are necessary. (P H Joshai, 2003)



Figure 2.1: Gate Precision Surface Grinding Machine
PSGG60220AHR

However, light workpieces having lesser resting area tend to tilt and fly off the magnetic table due to the high speed of the grinding wheel and the high feed used in grinders with reciprocating or rotating tables as lesser magnetic clamping forces is not sufficient to secure the workpiece during the grinding operation,. It is necessary to provide additional supports by nesting the workpiece. That can be done by placing solid plates around the workpiece, with more weight and resting area, the nest plates are hold firmly by the magnetic force of the table. The nest plate siege the workpiece from outside and arrest its movement in the horizontal plane, thus, preventing it from flying off or tilting due to high speed and feed inherent in the grinding operation. (P.H Joshai, 2003) Figure 2.2 shows the Gate Precision Surface Grinding Machine PSGG60220AHR is the machine that been focus in this thesis.

In mass production the capability of the machine should be utilized to the maximum possible magnetic table should be utilized to the maximum possible extent. Consequently, the maximum possible area of the magnetic table should be utilized to grind as many workpiece as possible in single batch. To achieve this, the jig and tool design office should furnish a layout of the workpieces on the magnetic table. For round spacers the workpiece are arranged in rows with common supporting nest plates should be lesser than the finish heght of the workpiece to prevent obstruction of the grinding wheel. (P.H Joshai, 2003)

For workpieces unsuitable for magnetic clamping, special fixtures must be designed. Surface grinding fixtures are generally similar to face milling fixture in design. However, generally face milling is the first operation whereas grinding is done at a much later stage when a number of the workpiece are available for location and clamping. (P.H Joshai, 2003)

Production devices general workholder with/without tool grinding/setting arrangement called jigs and fixture. (P.H Joshai, 2003)

2.2 Jigs and Fixture

Jigs and fixture also known as production devices holder are generally workholders with/without tool guiding/setting arrangement. (P.H Joshai, 2003)

Jigs are provided with tool guiding elements such as drill bushes. These direct the tools to the correct position on the workpiece. Jigs are rarely clamped on the machine table because it is necessary to move the jigs with the machine spindle. (P.H Joshai, 2003)

Fixtures hold the workpiece securely in the correct position with respect to the machine/cutter during operation. There is sometimes a provision of the fixture 'setting' the tool with respect to the workpiece/fixture, but the tool is not guided as in a jig. Fixtures are often clamped to the machine table. (P.H Joshai, 2003)

Fixture can also be defined as a special tool used for locating and firmly holding a workpiece in the proper position during a manufacturing operation. As a general rule it is provided with device for supporting and clamping the workpiece. In addition, it may also contain devices for guiding the tool prior to or during its actual operation. Thus, a jigs is a type of fixture with means for positively guiding and supporting tools for drilling, boring, and related operation. Hence, the drill jigs which are usually fitted with hardened are bushing to located, guide, and support rotating cutting tools. (Erik K. Henriksen, 1973)

The origin of jigs and fixtures can be tracked back to the Swiss watch and clock industry from which, after providing their usefulness, they spread throughout the entire metalworking industry. Contrary to widespread belief, the recent introduction of the n/c machine tools has not eliminated the need for fixtures; to obtain the full benefit from these machines they should be equipped with fixtures that are simpler in their build-up

and at the same time, more sophisticated in their clamping devices. (Erik K. Henriksen, 1973)

The main purpose of jigs and fixture is to locate the work quickly and accurately, support it properly and hold it securely, thereby ensuring that all parts produced in the same fixture will come out alike within specified limits. In this way accuracy and interchangeability of the parts are provided. It also reduces working time in the various phases of the operation, in the setup and clamping of the work, in the adjustment of the cutting tool to the required dimensions and during the cutting operation itself by allowing heavier feeds due to more efficient work support. (Erik K. Henriksen, 1973)

It serves to simplify otherwise complicated operation make it possible to use plain of simplified and therefore less expensive, machinery instead of the standard machines. In other words they turn plain and sample machine tools into high production equipment and convert standard machines into the equivalent of specialized equipment. (Erik K. Henriksen, 1973)

By maintaining or even improving the interchangeability of the parts, a jigs or fixtures contribute to a considerable reduction in the cost of assembly, maintenance and the subsequent supply of spare parts. Jigs and fixtures represent embodies of the principle of the transformation of skill. The skills of the experienced craftsmen, designers and engineers are permanently built into the fixture and are thereby made continuously available to the unskilled operator. One important goal is to design a fixture in such a way as to make it foolproof, and thereby contribute to added safety for the operation as well as the work. (Erik K. Henriksen, 1973)

Fixtures are often designed to incorporate other function as well as basically just holding things. Typically a fixture will also guide or even hold another tool used to perform an operation on a part. Some fixtures must design to be attached to still larger machines to accomplish their function. When working on large projects such as

automobiles, ships, boats, aircraft, the fixture may have to attach to the part to the fixture. (Paul D. Campbell, 1994)

There are three elements of jigs and fixtures:

1. Locating element: locating element is position the workpiece accurately with respect to the tool guiding or setting elements in the fixture.
2. Clamping element: these hold the workpiece securely in the located position during operation.
3. Tool guiding and setting elements: these aids guiding or setting of the tool in correct position with respect to the workpiece. Milling fixture are use setting pieces for correct positioning of milling cutter with respect to the workpiece.

There are many advantages of jigs and fixture that can be seen in productivity, where jigs and fixtures eliminate individual marking, positioning and frequent checking. This reduces operation time and increases productivity. (P.H Joshai, 2003)

In interchangeability term, jigs and fixtures facilitate uniform quality in manufacture. There is no need for selective assembly and similar components are interchangeable. (P.H Joshai, 2003)

For skill reduction, jigs and fixture simplify locating and clamping of the workpieces. Tool guiding elements ensure correct positioning of the tools with respect to the workpieces. There is no need for skillful setting of the workpieces of tools. Any average person can be trained to use jigs and fixtures the replacement of a skilled

workman with unskilled labor can affect substantial saving labor cost. (P.H Joshai, 2003)

Cost can be reduce by higher production and reducing in scrap, easy assembly and savings in labor costs result in substantial reduction in the cost of workpieces produced with jigs and fixtures. (P.H Joshai, 2003)

2.2.1 Application and classification of jigs and fixture

The obvious place for jigs and fixture is in mass production, where large quantity output offers ample opportunity for recovery of the necessary investment. However, the advantages in the use of jigs and fixture are so great and varied that these devices have also naturally found their way into the production of parts in limited quantities as well as into manufacturing processes outside of the metalworking industry. The many problems of geometry and dimensions encountered within the aircraft and missile industry have great accelerated the expanded use of jigs and fixtures. (Erik K Henriksen, 1973)

Within the machine shop, jigs and fixture are used for the following operation: boring, broaching, drilling, grinding, honing, lapping, milling, planning, profiling, facing, tapping and turning. A systematic master classification of machining fixture according to the characteristics of operation shows in Figure 4. (Erik K Henriksen, 1973)

2.3 Material Used in Jigs and Fixture

Jigs and fixture 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 phosper bronze to reduce wear of the mating parts or nylon or fibre to prevent damage to the workpiece.

High speed steel (HSS) is one of the materials that can be used to produce jigs and fixtures. High speed steel contains 18% (or 22%) tungsten for toughness and cutting strength, 4.3% chromium for better hardenability and wear resistance, and 1% vanadium for retention of hardness at high temperature (red hardness) and impact resistance. High speed steel can be air or oil hardened to RC 64 – 65 and is suitable for cutting tools such as drills, reamers and cutters. (P.H Joshai, 2003)

Die steel (high carbon) is also commonly used to produce jigs and fixtures with 1.5 – 2.3 % carbon, 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 extrusion. (P.H Joshai, 2003)

The other material that has always been used as a raw material to produce jigs and fixtures is carbon steel that contains 0.85 – 1.18% carbon and can be oil hardened to RC 62 – 63. These can be used for tools for cutting softer materials like woodwork, agriculture, etc and also for hand tools such as files, chisels and rotors. 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. (P.H Joshai, 2003)

Collet steels (spring steel) are also commonly used as a raw material for jigs and fixtures. These contain about 1% carbon and 0.5% manganese. Spring steels are usually tempered to RC 47 hardness. (P.H Joshai, 2003)

Oil hardening non-shrinking tool steel (OHNS) contains 0.9 – 1.1 % carbon, 0.5 – 2% tungsten and 0.45 – 1% vanadium, these 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). (P.H Joshai, 2003)

Cast hardening steels that can be carburized and case hardened to provide 0.6 – 1.5 thick, hard (RC 59 -63) exterior 17Mn1Cr95 steel with 1% manganese and 0.95% chromium is widely used. 15 Ni2Cr1Mo15 steel with addition nickel (2%) reduces thermal expansion up to 100 °C. Case hardness steel are suitable for parts which requires only local hardness on small wearing surface where costlier, difficult to machine full hardening tool steels are not warranted. (P.H Joshai, 2003)

High tensile steels can be classified into medium carbon steels with 0.45% - 0.65% carbon (En8 – 9) and alloy steel like 40 NiCr1Mo28 (En24). The tensile strength can be increase up to 125 kg /mm² (RC40) by tempering. Medium carbon steels are used widely for fasteners and structural work while alloy steels are used for high stress application like press rams. (P.H Joshai, 2003)

Mild steel is the cheapest and the most widely used material in jigs and fixtures. It contains less than 0.3% carbon. It is economical to make parts which are not subject to much wear and highly stress from mild steel. (P.H Joshai, 2003)

Cast iron is contains with 2 – 2.5% carbon. As it can withstand vibrations well, it is used widely in milling fixture. 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 as mild steel, while meehanite castings have heat resistant, wear resistant and corrosion resistant grades. (P.H Joshai, 2003)

Steel casting these combine the strength of steel and shapability of casting.

Nylon and fiber these are usually used as a soft lining for clamps to prevent denting or damage to the workpiece under high clamping force. Nylon or fiber pads are screwed or stuck to mild steel clamps. (P.H Joshai, 2003)

Phosphor bronze it is widely used for replaceable nuts in screw operated feeding and clamping system. Generally 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 phosphor bronze is also used in application calling for corrosion like boiler valves. (P.H Joshai, 2003)

2.4 Location

2.4.1 Principle

The location has to meet dimension requirement of the workpiece stated on the component drawing.

Location should be done on the most accurate surface of the workpiece. A machine surfaces is preferable to an unmachined one. When more than one machined surfaces are available, locate from the most accurate surface. (P.H Joshai, 2003)

Location should prevent linear and rotary motion of the workpiece along and around the three major axes x, y and z. the location system should prevent all these motion positively. (P.H Joshai, 2003)

Location system should facilitate easy and quick loading of the workpiece in the fixture. It should effected motion economy. Thus, parallel locators are preferable to those laced at right angles. (P.H Joshai, 2003)

Redundant locators need to be avoiding that can cause flatness error. The clamping force would distort the workpiece. This would cause errors as the distorted part would spring back to its original position when the workpiece is unclamped. Under

circumstance, the redundant location should be replaced by an adjustable support. (P.H Joshai, 2003)

The location system positively prevent wrong loading of the workpiece in a fixture by fool proofing.

2.4.2 Location Method

A workpiece can be located from:

1. Plane surface
2. Profile
3. Cylindrical

Location from plane surface

A plane surface can be located with three points on a surface. A rough unmachined surface can be located with three location pads having point contact. This can be done by providing three location pins having spherical surface at the locating points. The pins should be spaced as widely as possible for more accurate location. The height of the collar of the pins should be equal so that the located surface is parallel to the baseplate resting on the machine table. Additional adjustable supports are necessary to prevent distortion and vibrations in the workpiece during clamping and machining. The number of adjustable supports would depend upon the shape, strength and size of the workpiece. (P.H Joshai, 2003)

Care should be taken that the adjustable supports do not dislocate the workpiece from the locating (resting) pins. This can be done by limiting the force used for adjusting

the support. Surface which are reasonably plane (flat) such as hot or cold rolled plates can be located by fixed locating pads and adjustable supports. (P.H Joshai, 2003)

For locating very rough uneven surface, it is necessary to use adjustable locating pads. Casting and forging can be located by adjustable screw. During the first operation, it is often necessary to level the surface to be machined with a marking block by the locating pads. (P.H Joshai, 2003)

Sometimes it is difficult to reach a support which is in recess or is distant from the operator. Under such circumstances, it is necessary to provide an elaborate adjustable support. (P.H Joshai, 2003)

Location from profile

Simple components a sighting plate will be provided where appearance is important. That is slightly bigger than the workpiece to be positioned on the sighting plate in such a way that there are equal margin on all the sides. (P.H Joshai, 2003)

The profile of a workpiece can also be located by confining the profile with cylindrical locating pins. When there are considerable variation dimensions from batch to batch, an eccentric locator can be used. The eccentricity of the locator can be varied by rotating it to suit the workpieces in the batch. The eccentricity of the locator can be set to suit one of the workpieces from the milled batch and the eccentric locator would locate accurately all the workpieces in the batch. (P.H Joshai, 2003)

The profile of the workpiece can be located by providing a pocket or nest around the profile of the workpiece. The inside profile of the nest matches with the outside of the workpiece. The height of the nest should be lesser than the workpiece to permit grip over the workpiece for unloading. For thin sheet metal workpieces, finger slots or ejection arrangement should be provided for unloading the workpiece. Alternatively

partial nest can be used. Sheet metal blanks from the same die or cast components from the same mould are almost identical. Such workpieces with little variation can be located precisely by the close fitting nest. (P.H Joshai, 2003)

Location from cylinder

Location from a cylinder is the most common and convenient form of location. For when a cylinder is located on its axis and base, it can only rotate about its axis. The seating surface for the locator should be recessed to provide space for dirt or workpiece burr. This ensures proper seating of the workpiece on the locating face. (P.H Joshai, 2003)

Spingots used for locating bores should have ample lead for easy entry and their length should be short to prevent jamming of the workpiece. The long locator for fragile workpiece should be relieved at the center. When two location pins are used, the less important one should be made diamond shaped. The important full pin should be longer than diamond pin in order to facilitate easy loading of the workpiece. (P.H Joshai, 2003)

Rough cored holes and bosses are located by conical locators which often have integral clamping arrangement and drill bush. Fixed V blocks are used to locate approximately the outside surface of a cylinder. For presice location, an adjustable guided V block is necessary. The V blocks should be positioned such a way the variation in the workpiece would not effect the location for the operation. For drilling central holes, the center line of V should be vertical. (P.H Joshai, 2003)

2.4.3 Calculation

Jamming prevention lead:

μ = Co-efficient of friction

$l = \mu d$

$l_t = \sqrt{2d(D - d)}$

Diamond pin application:

$$d = 2 \sqrt{D^2/4 - V^2 - VW}$$

D: minimum \emptyset of workpiece hole

V: Variation

d: Diamond pin \emptyset

c: center distance

2.5 Clamping

2.5.1 Principle of Clamping

Position clamp on a strong supported part of the workpiece clear of the workpiece loading/unloading and cutting tool paths. It should be positioned to direct the clamping force on a strong supported part of the workpiece. Clamping on unsupported part bends slender workpiece will affected the accuracy of the operation. (P.H Joshai, 2003)

The clamping system should not obstruct the path of loading and unloading of the workpiece. The clamps in the path of loading should be retractable or swinging so

that the clamp can be withdrawn or swung clear of the path of loading and unloading of the workpiece. Clamp should not obstruct the path of the cutting tool. (P.H Joshai, 2003)

Clamp strength should be adequate to withstand operational forces without damaging the workpiece. The clamping system should be capable of holding the workpiece security against the force developed during operation. The clamping force should not dent or damage the workpiece with excessive pressure. For clamping weak or fragile workpiece, the clamping force should be distributed over a wider area of the workpiece. While clamping soft workpieces, clamps should be fitted with pads of softer materials, such as nylon or fibre to prevent damage and denting of the workpiece. (P.H Joshai, 2003)

Clamping time should be minimized by using hand knobs, tommy barss, knurled screws, handwheels and handles so that the clamp can be tightened or loosened manually without using spanners as a spanner further adds motions of picking, aligning and laying it down. (P.H Joshai, 2003)

2.5.2 Calculation

The force develops by screw:

$$F_s = \frac{F_h L}{R \tan (\phi + \alpha)}$$

F_s = Force Developed by screw

F_h = Pull or push applied to spanner

R = Pitch radius of screw thread

α = Helix angle of thread

ϕ = Friction angle of thread

L = Length of spanner or lever

2.6 Fixture Design

2.6.1 The Fixture Design

A fixture is a tool that is used to make or examine manufactured part for industry. Seldom will any manufactured part be made, moved, assembled or inspected without the used of fixture. (Paul D. Campbell, 1994)

Fixture might hold the raw materials going into a stamping press, load them into the press, hold them during pressing, remove them afterward, hold them during assembly to other parts and hold them during inspection. (Paul D. Campbell, 1994)

Fixture differed from other tools in that they designed to hold a specific part during specific operation. A welding fixture for a particular car hood will be different from the same type of fixture for another model of car. The fixture used for welding the car hood will be different from the one used to check the same hood assembly. Fixtures are often unique, unless duplicates are built to do the same job and increase production. (Paul D. Campbell, 1994)

2.6.2 Part Prints

In industry by way of necessity, no fixture is designed until a part has been designed first. Once a part design is completed, a print of the part is sent to the fixture designer, who in turn designs the tool around the existing part, in a sense, the fixture designer acts as the final design checker for the product designer. Occasionally, the fixture design will discover an error in a product design, which was overlooked by the design staff. (Paul D. Campbell, 1994)

The product design print is then marked up with the problems and returned to the product design department for correction. The fixture is set aside until the product correction is returned, and then work on the fixture resumes. (Paul D. Campbell, 1994)

2.6.3 Fixture drawing

The fixture designer and draws the fixture to exact scale on some type of translucent medium like vellum or Mylar. Vellum is a very smooth and thin paper, and Mylar is a plastic film with a grainy surface. The reason for these thin, translucent drawing medium is to accommodate the printing process used to reproduce the drawing. (Paul D. Campbell, 1994)

The fixture designer and draws the fixture on exact scale on some type of translucent is to be designed, obviously, if the fixture is to fit the part, the part must come first. The part is drawn on the fixture layout in red phantom lines. This helps in reading the prints even though all of the print lines are the same colour. Phantom lines are easier to distinguish from object lines. The red lines will print more faintly than the black object line by virtue of the printing process. (Paul D. Campbell, 1994)

For assembly fixtures, each part of the assembly to be placed in the fixture is drawn in a different colour. Generally the parts are drawn from large or most important to smallest or least important in the following order: red, blue, green, brown and orange. (Paul D. Campbell, 1994)

2.6.4 The frame

Fixture regardless of type will have some type of frame or base which holds all of the remaining components. The base might be something as basic as a piece of tooling plate,

with the remaining components just bolted to it. This is common part simple fixtures holding comparatively flat, single parts. (Paul D. Campbell, 1994)

More complex parts and assemblies might require a large tubular steel frame designed to hold the other components in otherwise awkward position. When designing a fixture frame, consideration must be taken to make it strong enough to remain stable. Consistency is the name of the game in fixture design. Struts ribs, and gussets are common parts of a fixture frame to reinforce it. (Paul D. Campbell, 1994)

2.6.5 Locator

As the fixture design develops, the designer starts by tracing the part on a sheet of drawing media (or importing it into a drawing file, if working at a computer), then developing the tool around it. Generally, the next step is to pick some place below the part where the bottom of the base or frame will sit, and draw in part of the frame. Now all that remains is filling up the empty space in between the part and the start of the frame. (Paul D. Campbell, 1994)

The designer will next start working backward from the part. Determine how to position the part on the drawing will be contingent on what operation is being performed. The part is placed in a position most convenient for the operator. A fixture for drilling holes will place the part flat to the world with the direction of the drill holes up to facilities a drill press. A checking fixture for a vehicle body panel might hold the part in the actual position it will be in during service. (Paul D. Campbell, 1994)

The part is drawn in position and the frame position and the frame position is started, the part will need something to sit on. These devices are call locator contact the part and hold it in the desired position. (Paul D. Campbell, 1994)

2.6.6 Clamps

Locators do not hold the workpiece all by themselves. The part will normally be held to the locator by a clamp. The clamp may have a separate pressure foot or the pressure foot may be part of the clamp which is come in different size and types. The clamp is just a mechanical means for applying force to the pressure foot to pinch the part between the foot and the locator. (Paul D. Campbell, 1994)

The pressure foot will vary even more than the type of the clamp. It might be as simple as a bolt with a rubber cap, or might be a specially made piece of metal to conform to a peculiarly shaped part. (Paul D. Campbell, 1994)

2.6.7 Bushings

The bushing is a tube of sort, some hardened steel to resist wear. The inside diameter of the bushing has a close tolerance to the tools to properly align it. The tool might be a drill bit, a tap, a check pin or a transducer probe. The bushing will be mounted to the fixture with its own specialized brackets. (Paul D. Campbell, 1994)

Tool must be guided as they perform their appointed task. Grinding the tool assures absolute accuracy and consistency of the manufactured part. The method of guiding tools into a fixture is with a bushing. (Paul D. Campbell, 1994)

2.6.8 Brackets

A simple bracket might consist of a piece of angle iron with one leg bolted to the base and the fixture component bolted to the other angle leg. Each situation is unique but as the part becomes more complex and larger the bracket may become the multiple weld elements of angle, tubes and plates assembled to span the fixture components closed to the workpiece and build back to the frame. (Paul D. Campbell, 1994)

Bracket might be required for the larger fixture which is more complex than the small and simple fixture.

2.6.9 Fastener

Fasteners hold the other entire component together. Fastener included but not limited to screws, bolts, nuts, dowels, roll pins, keys and adhesive (glue). These are the most common fasteners. If it is urge to use a less common fastener, there are may be an alternative that have not considered. (Paul D Campbell, 1994)

Generally, screws are preferred to bolts and nuts. Screws tend to be stronger and more accurately made. It is are quite a general category in themselves but there are preferred types. The socket head cap screw is the workhorse of fasteners. (Paul D. Campbell, 1994)

Screws hold things together well, but lack ability to hold them in position to the degree of accuracy needed for a fixture. To compensate for this short coming, screws are usually used in conjunction with dowel. (Paul D. Campbell, 1994)