

Development of Computer-Aided Design Software for Jigs and Fixtures for Drilling Flanges

Samuel Babatope Adejuyigbe, Pius Bamidele Mogaji¹ and Olatunde Abiodun Odufale¹

College of Engineering, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria
E-mail: <samueladejuyigbe@yahoo.com>

Abstract

A detailed review of relevant literature was carried out to provide basic information on the design and construction of jigs and fixtures. Also, the documentation of acquired data for the purpose of developing a suitable design process using Computer-Aided Design (CAD) was carried out. Computer software that would automatically draw the needed jigs and fixtures from the data of the flange (object) was developed. A description of the design requirements and constraints was obtained by considering the different configurations of the work piece. A geometric model of the fixture was developed and analyzed for kinematics, force and deformation compatibility. A heuristic algorithm was developed and a program was written using the default package of Java language. The program is user-friendly and was written in modules to allow for flexibility and quick responsiveness. The program was validated with real life sample data from a work piece.

Keywords: *Development, computer-aided, software, jigs and fixtures, drilling.*

Introduction

Jigs and fixtures are provided to convert standard machine tools into specialized machine tools. They are usually associated with large-scale production by semi-skilled operation, but they are also used for small-scale production when interchangeability is important, and by skilled operators or machinists when the work piece is difficult to hold without special equipment (Kempster 1978).

Jigs are machine shop devices that include means of tool guiding, they are only applicable to operations performed on a drilling machine, while fixtures are holding devices that do not include means of tool guiding, but they may include means of setting the cutter. Fixtures are used for milling, turning, grinding and similar operations.

Machine Shop

The machine tool industry is divided into several different categories such as the general machine shop, the tool room, and the production shop (Adejuyigbe and Akinlosose 1987). A general machine shop contains a number of standard machine tools that are basic to the production of a variety of metal components in operations such as turning, boring, threading, drilling, reaming, sawing, milling, filing, etc.

Jigs and Fixtures

In modern engineering, there is no application of jigs in mass production. It is like looking for needle in a haystack. During the past ten decades, many changes have been witnessed in the sphere of production engineering. Teachers have become more adventurous in their approach to the work by giving their students the opportunity of constructing such exciting engineering, casting and foundry work enamellings and etchings in metal work to an extent that would have been thought impossible to achieve years ago. It is considered now that the most important aspect

¹ Department of Mechanical Engineering, Federal University of Technology, Akure, Ondo State, Nigeria.
E-mail: <pbmogaji@futa.edu.ng; odufaleomotunde@yahoo.com>.

of education through craft is that the work should be developed along creative lines so that the students are able to solve problems of design construction by themselves.

Jigs are designed to ease certain difficulties in craft operations; they are flexible enough in use to be adapted in a variety of ways to suit the production and are not a substitute for skills. However, some experts in the field of engineering production disapprove the use of jigs with a view that the use of jigs underlines the skills of the production engineer. It is seen as a substitute for skill and means of institutionalizing laziness on the part of engineers. Such experts conclude that the uses of jigs are unprofessional. However, in spite of that sound argument, it is still interesting to learn of the decision of a vast majority of production engineers who believe that the use of jigs enhances production and does not in any way replace skills which are normally taught in schools. Jigs wide the scope of operation and reduce the difficulty of operational skill and also allow for flexibility and adaptability in various ways. The design of jigs and fixtures gives a selection of jigs found in current usage in the British industry.

Some of the designs cover non-standard and commercially available standard units with an emphasis on various clamping techniques employed. There are different types of drilling jigs and the principal ones are:

- Simple built-up jigs;
- Local jigs with angular base;
- Jigs milled from solid;
- Jigs for multi-drill;
- Turning jigs;
- Indexing jigs;
- Air-operated jigs;
- Box-type jigs;
- Latch-jigs;
- Pot-type jigs;
- Arrangements to assist in the handling of the work piece.

Jigs and Fixtures Design

The calculations and explanations on the design of the drilling jigs and fixtures were based on the six principles of jigs and fixtures design: clamping, clearance, stability, rigidity, handling and other general considerations.

The material used for all the components on the jig is mild steel (sty 80) since this is the most common available material in Nigeria.

Determination of Location

According to Aderoba (1994), the determination on location can be enumerated as follows:

- An important aspect of the design is concerned with the location of the component. The correct location influences the accuracy of the finished result, and particularly its positional relationship with other surfaces on the component.
- Unless location arrangements are reliable and consistent, the jig will not produce uniform components and all the reasons for using the jig will be nullified.
- The principles of location account for six degrees of freedom, which must be constrained against movement. The location of the job under review is done by the use of a post locator and is about 140 mm long and 44 mm wide. This is considered not to be a long locator. It is designed in such a way that it will be convenient for the user and for the purpose of assemblage. Clamping screw A is provided for this purpose of assemblage. The post locator is solid post, but there is a hole drilled at the middle of a dimension shown to allow the depth of the pre-set drill to be reached. There is another supporting screw B used to support the work during drilling.
- The tolerance provided on the two locators is 10.01 mm.
- The clearance between the job and the post locator is a push, sliding, neutral or transition, where small amounts of clearance or interference can be tolerated given the fair ease of assembly and accurate location, it can easily be pushed into position or assembled by just a hand pressure.
- The positioning of the top clamp, which is the cover with the aid of screw A, and the main frame of the jig

give a resistance to the cutting force of the drill.

- The clamp was designed in such a way that it is an integral part of the jig body. With the tolerance provided by the designs, the clamps in use are easy to assembly and natural to use and remove.

Results and Discussion

Flowchart of the Design

In developing the software for this work, the earlier works done by Adejuyigbe (1999), Case and Gao (1993), and Case *et al.* (1994) were used. The flow chart of the design shown in Fig. 1 follows from the basic principles of parameter design.

In the case of customized design, the customized design principles were followed sequentially. The input work piece parameters were simulated to obtain the customized jig design. Alternatively, a simple process leads to the design of the post locator which is the main concern of the design procedure. The design of the side plate was performed next followed by the design of both front and back plates. The design of the base metal, the work piece and the entirety of the jig design were then considered. The end results of the design were the combined components which form the detailed design.

Computer-Aided Design Software for Jigs and Fixtures for Drilling Flanges

The software begins with a welcome background screen as shown in Fig. 2. Then the inscription “Click to continue” appears and the click of a button activates the “Admin” menu which is programmed to incorporate “Log on” “Design” “Log off” and “Exit”.

A click on the “Log on” button displays a window where a password is required. The supply of the correct password activates the system. Immediately, the system activates the menu bar change to “Admin”, “Input” and “Help”.

A click on the “Design” button displays “Jig Design: Main Menu” as shown in Fig. 3.

Figure 4 shows the data parameter interface, while Fig. 5 shows the work piece design.

Fig. 6 shows the post locator design, while Fig. 7 shows the combination of work piece with post locator and base metal.

Figs. 8 and 9 show the combination of work piece, post locator, base metal with only one and both side plates, correspondingly.

Lastly, Fig. 10 shows the complete jigs and fixtures design for drilling flanges.

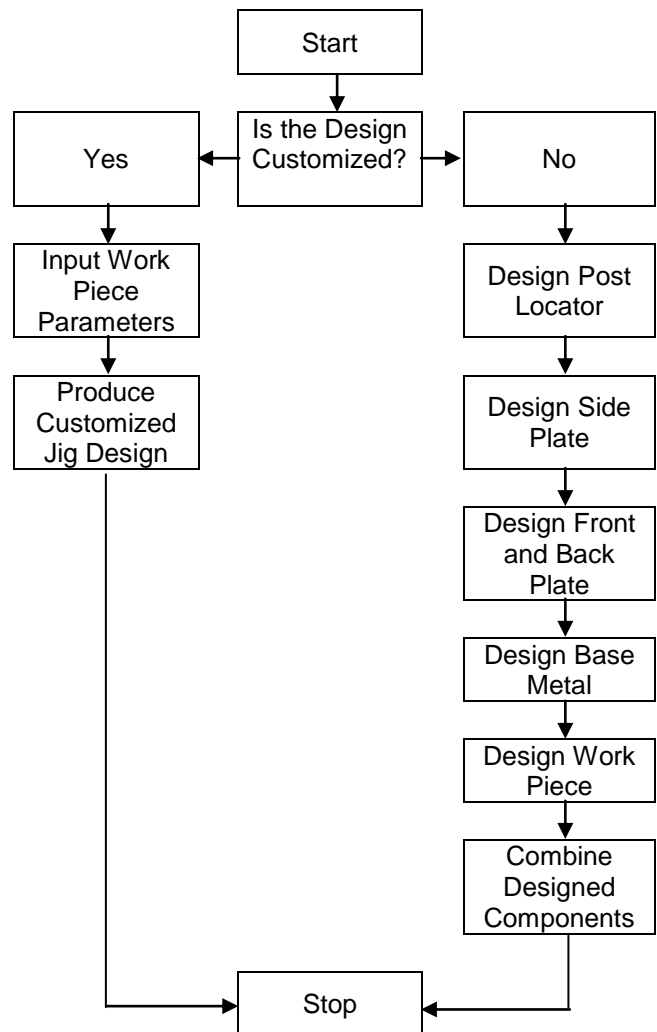


Fig. 1. Flowchart of the design.

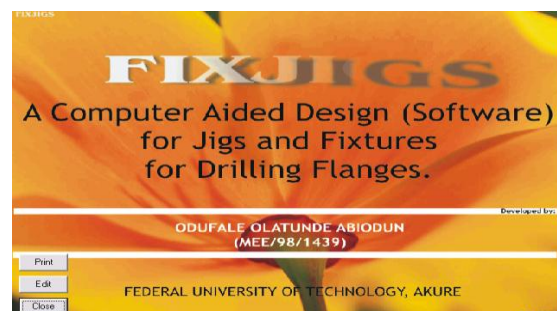


Fig. 2. Welcome screen.

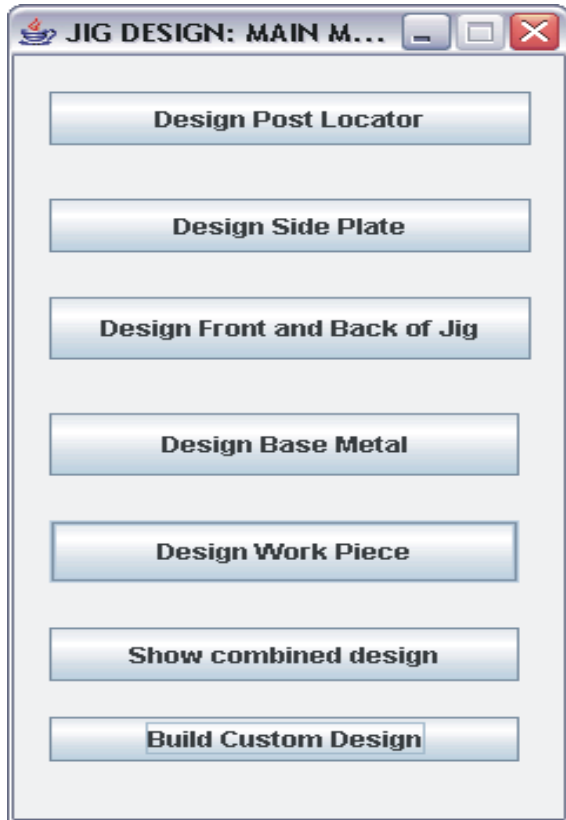


Fig. 3. Main menu of jig design.

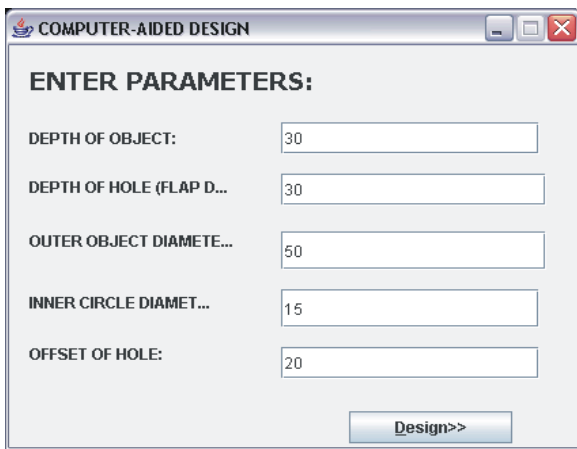


Fig. 4. Data parameter interface.

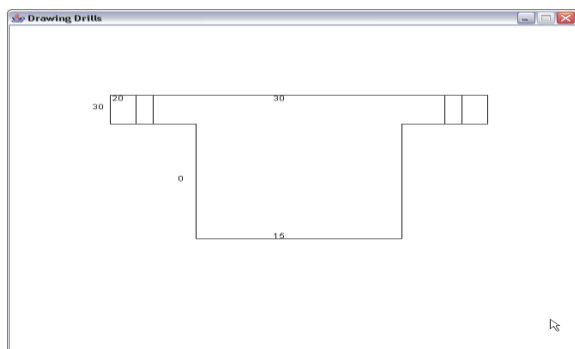


Fig. 5. Work piece design.

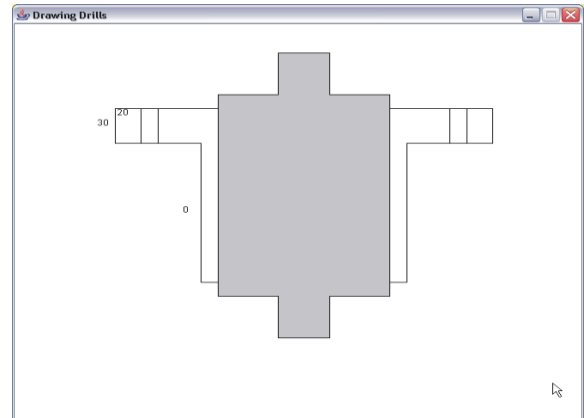


Fig. 6. Work piece with post locator.

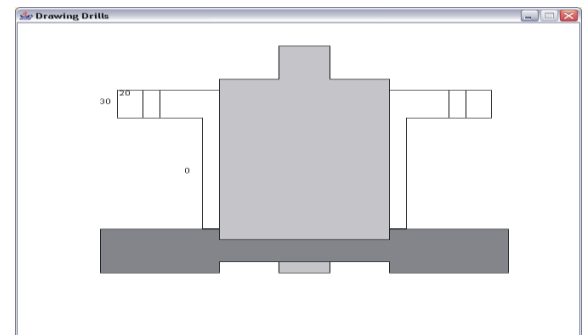


Fig. 7. Combination of work piece, post locator and base metal.

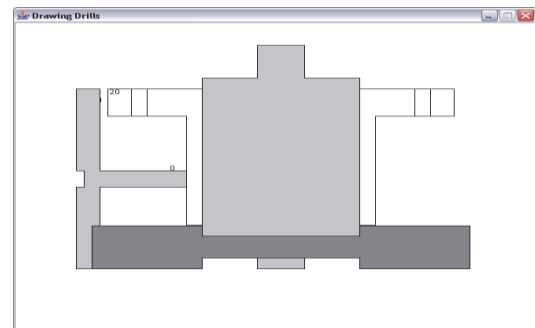


Fig. 8. Combination of work piece, post locator, base metal and side plate.

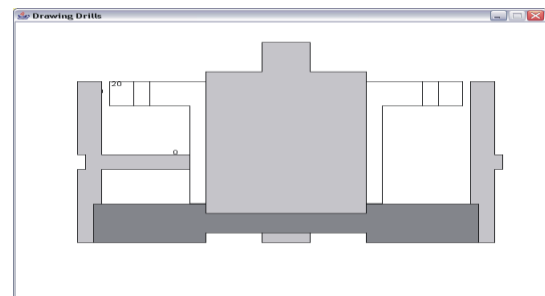


Fig. 9. Combination of work piece, post locator, base metal and both side plates.

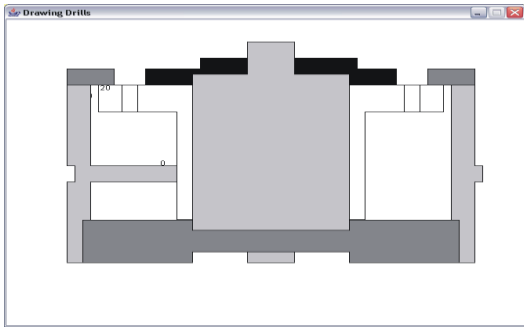


Fig. 10. Complete jigs and fixtures design for drilling flanges.

The software consecutively analyzes the parameters that are supplied and uses them to design the jigs and fixtures for drilling flanges according to the steps shown in Fig. 3.

Computer-Aided Design Dimensions

Tables 1 to 4 show the computer-aided design dimensions of the various materials used.

Table 1. Computer-aided design dimensions for post locator.

S/N	Side	Dimension (mm)
01	A	25 mm
02	B	40 mm
03	C	30 mm

Table 2. Computer-aided design dimensions for side plate.

S/N	Side	Dimension (mm)
01	A	20
02	B	50
03	C	35

Table 3. Computer-aided design dimensions for base metal.

S/N	Side	Dimension (mm)
01	A	35
02	B	30
03	C	35

Table 4. Computer-aided design dimensions for work piece.

S/N	Side	Dimension (mm)
01	A	12.0
02	B	70.0
03	C	45

Results of Long Hand Design for Jigs and Fixtures for Drilling Flanges

For comparison, the use of a long-hand design approach (manual methods) for jigs and fixtures design for drilling flanges has also been undertaken and analyzed in this work as shown in Tables 5 to 8 below.

Table 5. Manual design dimensions for post locator.

S/N	Side	Dimension (mm)
01	A	25.1
02	B	39.9
03	C	30.1

Table 6. Manual design dimensions for side plate.

S/N	Side	Dimension (mm)
01	A	20.0
02	B	50.1
03	C	35.0

Table 7. Manual design dimensions for base metal.

S/N	Side	Dimension (mm)
01	A	35.1
02	B	30.0
03	C	35.1

Table 8. Manual design dimensions for work piece.

S/N	Side	Dimension (mm)
01	A	12.0
02	B	70.0
03	C	45.0

Validation of the Computer-Aided Design after Comparison with Manually Calculated Dimensions

In validating the results, it was observed that the side dimensions obtained for the computer-aided design of jigs and fixtures for drilling flanges compared with the side dimensions obtained for the manual design are the same showing a little variance as summarized in Tables 9 to 12 below. Therefore, the computer-aided drafting that was used is good and can be used effectively in such applications.

Table 9. Comparison in dimensions for computer-aided and manual design of jigs and fixtures for drilling flanges (post locators).

S/N	Side	Computer-aided dimensions (mm)	Manual dimensions (mm)	Diff.
01	A	25.0	25.1	0.1
02	B	40.0	39.9	0.1
03	C	30.0	30.1	0.1

Table 10. Side plate dimensions comparison.

S/N	Side	Computer-aided dimensions (mm)	Manual dimensions (mm)	Diff.
01	A	20.0	20.0	0.0
02	B	50.0	50.1	0.1
03	C	35.0	35.0	0.0

Table 11. Base metal dimensions comparison.

S/N	Side	Computer-aided dimensions (mm)	Manual dimensions (mm)	Diff.
01	A	35.0	20.0	0.0
02	B	30.0	50.1	0.1
03	C	35.0	35.1	0.1

Table 12. Work piece dimensions comparison.

S/N	Side	Computer-aided dimensions (mm)	Manual dimensions (mm)	Diff.
01	A	12.0	12.0	0.0
02	B	70.0	70.0	0.0
03	C	45.0	45.0	0.0

Conclusion

With the design of the developed computer-aided design (CAD) software, the manufacture of jigs and fixtures for drilling flanges in large quantities becomes very easy. The software is very reliable, consistent and accurate compared to the hand drawing of said jigs and flanges. Also, the conventional way of producing identical results is quite time-consuming. The software gives a room for change in terms of square, rectangular, and round objects or any arbitrary shape.

This work is restricted to jigs and fixtures for drilling flanges only. In further stages of this work, the production of more intricate parts could be incorporated.

References

- Adejuyigbe, S.B.; and Akinlososo, K.R. 1987. Metal Work for Senior Secondary School. Book Three. Ilesanmi Press (Educational Publisher) Ltd., Imo, Ilesa, Oyo State, Nigeria.
- Adejuyigbe, S.B. 1999. Computer-aided design and drafting (CADD) in process modelling of sand casting. M. Eng. Thesis, Department of Mechanical/Production Engineering, Federal University of Technology, Akure, Ondo State, Nigeria.
- Aderoba, A.A. 1994. A computer program for determining animate and inanimate power requirements for mechanised agriculture. *Agricultural Engineer* 49(2): 60-3.
- Case, K.; and Gao, J.X. 1993. Feature technology: An overview. *International Journal of Computer Integrated Manufacturing* 6(1-2): 2-12.
- Case, K.; Gao, J.X.; and Gindy, N.N.Z. 1994. The implementation of a feature-based component representation for CAD/CAM integration. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture* 208(1): 71-80, February.
- Kempster, M.H.A. 1978. *An Introduction to Jig and Tool Design*. 3rd ed., Edward Arnold ELBS, London, UK.