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EDITORIAL PREFACE

This is the *Sixth* Issue of Volume *Six* for International Journal of Engineering (IJE). The Journal is published bi-monthly, with papers being peer reviewed to high international standards. The International Journal of Engineering is not limited to a specific aspect of engineering but it is devoted to the publication of high quality papers on all division of engineering in general. IJE intends to disseminate knowledge in the various disciplines of the engineering field from theoretical, practical and analytical research to physical implications and theoretical or quantitative discussion intended for academic and industrial progress. In order to position IJE as one of the good journal on engineering sciences, a group of highly valuable scholars are serving on the editorial board. The International Editorial Board ensures that significant developments in engineering from around the world are reflected in the Journal. Some important topics covers by journal are nuclear engineering, mechanical engineering, computer engineering, electrical engineering, civil & structural engineering etc.

The initial efforts helped to shape the editorial policy and to sharpen the focus of the journal. Started with Volume 6, 2012, IJE appears with more focused issues. Besides normal publications, IJE intend to organized special issues on more focused topics. Each special issue will have a designated editor (editors) – either member of the editorial board or another recognized specialist in the respective field.

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The Necessity of Nuclear Power in Iran

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Abstract

In the past two years, Iran's electricity consumption has been increased with an average of 7% over the years. So, as for the Iran's development programs, it is predicted that this trend continues to rise. On the other hand, despite the widespread development of resources, climatic conditions and restrictions in hydro-electric has caused to decrease the share of electricity generation from dams and water resources within the past 40 years more than 25% to less than 4% and the increasing of country's electricity production dependency to power plant steam and gas or compound cycle. also coal resources is limited in our country and cannot be used to electric power generation, thus production of electricity in power plants nationwide compared to global average depends on the hydrocarbon fuel.

Primary hydrocarbon energy conversion process to electricity is relatively low and negative environmental impacts, so It seems, turning to nuclear power generation, an inevitable and mentioned plans for country's future power supply, and stop this process will damage the country's economic development.

Keywords: Nuclear Power, Energy, Iran.

1. INTRODUCTION

According to important roles, wide ranges, broader applications of nuclear energy, nuclear power plant commissioning and its development in Iran, use of energy carriers, new energy (a core - the wind - the sun) usages located in the agenda of large countries, large manpower and financial investment has done on it so investment on the increasing of strategic expansion coefficient of each country leads to researches about nuclear energy. For sustainable development at the strategic necessity of nuclear and solar energy, especially new dimensions of economic, political and even security are important for countries.

Use of nuclear power from less than one Gw in 1960 to 100 Gw in 1970 and nearly reached to 300 Gw in the late 1980s. off course in the late 1980s the use of nuclear power intensity was decreased to about 366 Gw in 2005 and thus reached the highest expansion after 1980 the People's Republic of China. More than two-thirds of nuclear plants were canceled which start of their implementation was after 1970.

During the 1970s, 1980s fossil fuel prices reduction and increasing of cost to build a nuclear power plant reduce the demands of the Government for the construction of nuclear power plants. In 1973 the fuel crisis caused to increase a further demand of countries like France and Japan which do not have a lot of oil resources to nuclear power plant manufacturing so they can provide respectively 80% and 30% of their electrical energy from these sources now.

in the late Thirty years in twentieth century, fearing of nuclear disasters, serious accidents such as Chernobyl disaster in 1986, problems related to nuclear waste , diseases caused by nuclear radiation and so on, they are the reasons for its reduction of nuclear power plants development in many countries.

2. The necessity of utilizing nuclear energy

The amount of uranium in the Earth's crust is relatively high so that is equal to the metal such as tin and Ge and to almost 35 times the silver resources under the Earth's Crust. Uranium is the structural mater of many environmental bodies such as soil and rocks. The average price of uranium is currently 130 USD per kg. The supplying stability of nuclear fuel is higher than many other minerals. Proportion to other minerals with increasing cost of fuel doubled, may be ten times the current uranium resources achieved. Should be noted that the price of fuel in a nuclear power plant is relatively small compared to other existing facilities, and uranium price has a so few effect on the price of electrical energy will be produced. As an example two times consumptive fuel cost increasing of light- water nuclear power plant , causes to increase the cost of reactor to 26% , for electric power production to 7 % while the two times increasing of fuel price in a gas power plant , increases the price of electric power production up to 70%.

Light water nuclear power plants in the use of low productivity are the only potential cause fission in the isotope U-235 - (about 0.7 % of the minera uranium l). In contrast to conventional light water reactors of nuclear reactors can use uranium 238 with 99/3 % of mineral uranium. Before using of uranium 238, in a special process it use for plutonium 238 productions, then for nuclear reactors.

According to worldwide power plant consumption estimations, uranium238 can produces power plant energy 5 million years for the feature.

3. Review the use of nuclear energy for electricity production in other countries

The first reactor designed specifically for power generation, by the Soviet Union in June 1954 in "aabninsk" near Moscow, which had a higher spectacle aspect. Electricity production from nuclear reactors on an industrial scale began in England in 1956 and this trend continued until 1965. This jumping during years 1972 to 1976 with average 30power plant production per year would start very high and was remarkable. One of the reasons for this growth was the oil shocks of the early 1970s had prompted several countries to provide the energy needed, turned to nuclear energy yet waste. After the jump course of 1986 the construction of process plants has been reduced, so the annual average building started was only 4 atomic reactors.

Now, France is having a total electricity production with 75 per cent share of nuclear electricity is at the top of the world. Respectively then be Lithuania (73 percent), Belgium (57 percent), Bulgaria and Slovakia (47 percent) and Sweden (48.6 percent). America in spite of generates Nuclear power about 20 % of within the world, from late 1960 until mid-1980 does not have explosive growth. But many countries still seek to meet their energy needs through nuclear power. Obtained to predict the trend of nuclear power an ascending trend will continue until the coming decades. In this context, Asia and Eastern Europe will be the main areas in the nuclear power plant construction. In this regard, Japan with more than 25,000 megawatts of capacity to build nuclear power plants among these countries is located at the top. Then also China, South Korea, Kazakhstan, Romania, India and Russia are in place. The use of nuclear energy in Canada, Argentina, France, Germany, South Africa, Switzerland and the United States over the next two decades will almost constant trend.

4. An economic view of the nuclear power usage

Today, many countries, especially Europeans, can provide a significant share of its electricity needs through nuclear power. . So that statistics show the total power plant core installed to power the world, appertain respectively, 35% to Western Europe, 33 % to North America, 16.5 % for the Far East, 13 % to Eastern Europe, and finally only 0.74 % to Central Asia. No doubt the necessity of explaining the diversity of the countries in the field of energy, nuclear power is economic as a safe option, the economic aspects of nuclear power plant replacing, with respect to price analysis production of electric power supply system are attainable. Thus, in most countries, nuclear power plant with its economic performance in any terms will be competitive with fossil fuel power plant. However, the manufacturing cost of nuclear power plant due to increased regulations, safety, built time consuming, low fossil fuel prices cause to financial cost increasing per electricity unit in these power plants.

To provide initial capital requirements and to ensure the construction site for a multi-unit cost savings of scale associated with shared facilities and facilities required at each plant, the economic advantage from the viewpoint of nuclear power plant with fossil fuels in most countries has been maintained.

5. Environmental perspective of nuclear power usage

Over the past two decades a growing trend of increased fossil fuel consumption and the types of hazardous and toxic pollutants and emissions on the human environment, serious concern and an important human needs for present and future. Obviously, this process due to the destructive and deadly effects will not persist in the future. these risks is to increase gradually the destructive effects of greenhouse gas emissions resulting from the application of fossil energies process, it is clear that nuclear energy is mentioned as an environmental approach to deal with increasing global temperature and environment pollution. So statistics show now global nuclear power plants with the current installed capacity can prevent the spread 8% of CO_2 in space that in this way act as a hydro power plants.

If the current capacity utilization of nuclear power plants electric generation through the plants were fed with coal, the year totaled 1,800 million tons of carbon dioxide, several million tons of hazardous gases, sulfur dioxide and nitrogen, about 70 million ton of ashes, equal to 90 thousand tons of heavy metals being released into the atmosphere and environment that harms is non deniable. So if the obstacles and political issues related to the expansion of the world nuclear energy can be solved, especially in developing countries and third world, this energy in the coming decades, will play a significant role in reducing pollution and greenhouse gas emissions. While the pollution caused by fossil power plant causes accidents and many problems on the human environment, nuclear fuel does not produce a harmful toxic gases, and the problem of nuclear waste is reasonable and ignorable, because the nuclear waste low volume, nuclear science progressing, in the final burial of waste in deep underground rocks and safety, technical problems solve in large extent and so in our country technological and social problems completely will be solved.

On the other hand, it seems that the protests and opposition in the field of nuclear energy is due to accidents and explosions in some nuclear power plant for example as Chernobyl, fokoshima. According to studies, the occurrence of events that led to the death of a large number of such as air crashes, broken dams, explosion, earthquake, storm, heavenly rock falls, etc… much more than events that nuclear power is can be made. However, the benefits of power compared to a nuclear power plant fossil regardless of economic issues, in addition to being a little nuclear waste and more cleaning of power plants because have not environmental pollution and the dangerous of SO_2, NO_2, CO_2 and CO, can refer to advancement of technology, use as much of modern science, to increase efficiency and use of core technology in other areas peaceful.

6. Comparison of electricity social cost in fossil and nuclear power plants

Economic assessment and studies performed to compare the production cost of electricity in common fossil and nuclear power plants show the prices of these two energy sources in social cost terms almost close and are competitive with each other. If the fossil energy consumption price for the national plant based on the price of international order, the production price per kilowatt hour in the fossil, nuclear plant can be compared.

A new study to determine the power plants social costs have been made in five European countries Belgium, Germany, France, Holland and England, the social costs resulting from the power plant in comparison is very lower than fossil power plants. In this study, the external costs per kilowatt hour of power have been met about 39/0 cents (equal to 6/122 USD). So if we take into account the social costs of electricity production in fossil and nuclear power plant economic evaluation, certainly cost per kWh of electricity in nuclear power plants, will be reduced considerably compared to the fossil. Any way fossil , nuclear power plants each of them have advantages , disadvantages Thus any creature has temporal and spatial requirements , final selection and decision depend on technological factors, values, political, economic and environmental . Certainly the diversity in energy supply and sustainable development in the field of strategy is very important. According to studies conducted in this regard, the council determined to develop nuclear energy, nuclear power plants, with 6000 MW total capacity until 1400 AH.

7. Nuclear energy superiority over other energies

In addition to the economical, use of nuclear energy as high energy is necessary. Because fossil resources are limited and are reserved for future generations the use of crude oil in the petrochemical industry has the most value. Electricity production from nuclear power plants present no contamination seven thousand megawatts production with 190 million crude oil barrels consumption, thousands tons of carbon dioxide, 150 tons of suspended particles in the air, 130 tons of sulfur, 50 tons of nitrous oxide in the environment are kinds of pollutants, While nuclear power is no such pollution.

8. CONCLUSION

Different views about the nuclear power future, suggests according to analysis of energy demand and, supply resources in the world, technological development, facts such as the depletion of fossil resources in the coming decades, nuclear energy environmental advantages, also for citing economic function, high nuclear power plant safety coefficient, a nuclear fuel cycle is less harmful than the others and the resulting progress in fusion energy field and Inhibition of nuclear fusion energy over the next half century, Undoubtedly one of the carriers available and secure nuclear energy for electricity production in the third millennium AD, is considered.

It is, therefore imperative for Iran to fill the expected capacity short-fall through the use of nuclear power to the maximum extent consistent with its technological capability and environmental and security considerations.

9. ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial and other support of this research, provided by Islamic Azad University, Islamshahr Branch, Tehran, Iran.

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SolidWorks Secondary Development with Visual Basic 6 for an Automated Modular Fixture Assembly Approach

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Abstract

Modular fixtures (MFs) play an important role in terms of cost and production time reduction in manufacturing processes. In this paper, the authors illustrate an automated approach for MFs design and assembly. This approach is based on the secondary development of SolidWorks integrating with Visual Basic (VB) 6 programing language. SolidWorks API (Application programming interface) functions were applied in order to control SolidWorks commands and assembly operations. An ActiveX DLL project was created in VB 6 and a plug-in file in .dll format was generated. The outcomes were creating new menus in SolidWorks environment for selecting, inserting, and assembling MFs elements. The approach was applied for a side clamping procedure and for a semi-circular workpiece.

Keywords: Modular fixtures, SolidWorks API, Visual basic 6, Assembly simulation.

1. INTRODUCTION

As a result of the rapid development of the manufacturing systems, productivity has become one of the goals that need to be achieved as well as production time consuming [1]. Given this evidence, modular fixtures (MFs) have been considered as one of the important factors for achieving these goals [1]. This became from the flexibility of MFs elements that provide several workholding procedures for different workpieces [2] and this brought many benefits in flexible manufacturing systems (FMSs) that use computer numerical control (CNC) machines. The design and assembly process of MFs was the aim for many previous studies. Some of them focused on the assembly relationships of the fixture elements [3]. Others concentrated on information presentation of MFs [4]. For more improvement of MFs design, CAD technology has been utilised for automating the design and assembly for fixture elements. Information models were used as a tool for supporting fixture decision [5].

An approach for positioning the fixtures with rapid reconfiguration method was presented for an "intelligent fixture system" [6]. ICAD system and UG-2 modelling were used for developing MFs design system based on CAD software [7]. AutoCAD with 2D drawings was applied [8] while AutoCAD 3D modelling was employed for this purpose [9]. For more effective automated MFs systems, three factors should be considered by the designer, the database of the fixture elements, the proper design approach, and a powerful 3D CAD software for modelling MFs design and assembly process. The database of standard fixture elements was created in the previous work as well as introducing the appropriate methodology in order to develop a computer – assisted fixture design (CAFD) [1]. SolidWorks was used as CAD software due to its excellent 3D capabilities for performing the modelling process for MFs. Based on the previous work; the use of secondary development of SolidWorks with VB 6 for automating fixture elements design and assembly is introduced in this paper.The developed approach is shown in Figure 1. This approach includes generating ActiveX DLL project in VB 6 and integrating with SolidWorks API for creating new menus in SolidWorks environment. A 3D model of the specific workpiece was designed in SolidWorks. The database for the standard fixture elements was established in the previous work [1]. The knowledge base for the assembly relationships was created by using If-then rules. This knowledge base is based on the mating features for assembly purpose in SolidWorks.

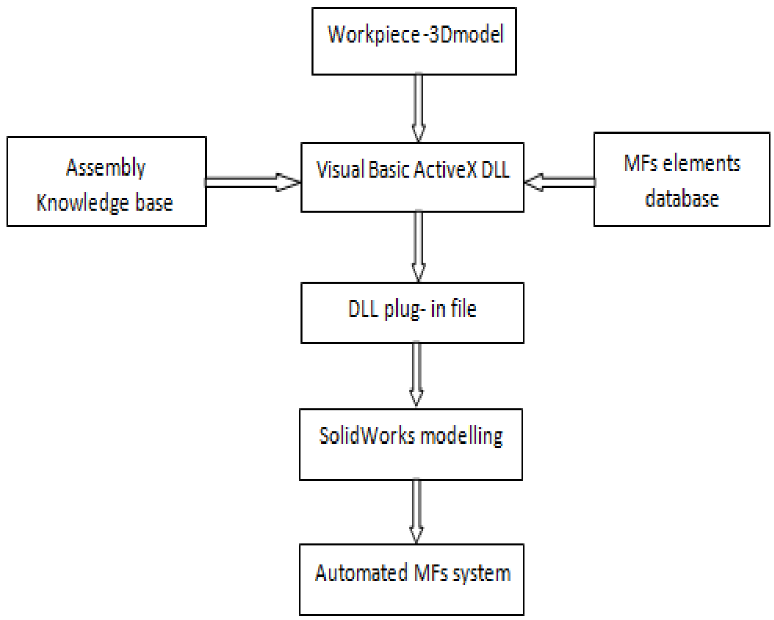

FIGURE 1: The flow chart of the developed approach.

2. WORKPIECE HOLDING PRINCIPLES

The produced workpiece should meet its specifications particularly for shape, dimensions and tolerances and to achieve this, it is important to locate and clamp the workpiece correctly on the machine [10]. Some other factors also influence the workpiece holding configuration including machining operation sequence, cost considerations, direction and strength of the cutting forces, and capabilities and orientation of the machine tools [10]. Moreover, fixture elements may be designed for a specific workpiece; and these are called dedicated fixtures. Conversely, fixtures can be selected and combined with a database of standard fixture elements; and these are called modular fixtures [10]. There is a specific function for each fixture element, and a completed fixture structure can be built from a number of elements, including the consideration of the types, classes and the functions that will lead to the appropriate machining operations.

2.1 Modular fixturing

Modular fixturing can be defined as a system for building several combinations of standard components that can serve a wide variety of workpiece. These fixture elements can be assembled and reused in order to generate different constructions of jigs and fixtures [2]. The building process of modular fixturing system depends on selecting the necessary fixture components to be assembled and this assembly process will be the base for building "more detailed systems". As a result, fixture elements can be built for any kind of workpiece by using modular fixturing systems [2]. The benefits of modular fixturing result on reducing the design and assembly time by eliminating the use of the "dedicated fixtures" and their special components [10]. Moreover, the database of the modular fixtures contains the necessary design's information with mating features for the standard elements and it is easy to be modified [10]. Modular fixturing systems were classified into three major kinds based on the construction basics: Subplate, T-slot, and dowel pin [2].

2.2 Modular fixturing building

Modular fixturing systems consist of a set of standard elements such as baseplates, locators, supporters, clamps, and all the other accessories (Figure 2). By assembling these elements together, suitable workholding systems for variety of workpiece can be achieved [2]. The assembling process starts with selecting the baseplate depending on the size of the workpiece. Then the locating elements are chosen and assembled to the baseplate. After that, the clamping elements are selected to suit the chosen workpiece. Finally, the other elements and accessories are added for completing the modular system [2]. After building the workholding modular system, the machined operations are started in order to produce the specific part or the workpiece. When the part production process is finished, the modular system is disassembled and the elements are sent to the store to be used for building other modular workholding systems [2].

Figure 3 shows an example of modular fixturing systems. The advantages of reuse the modular fixture elements lead to reducing time and costs. One hour of modular fixturing building process equals to about six hours of "conventional jig or fixture" building [2].

2.3 Visual Basic fundamentals

Visual Basic (VB) is a programming language developed by Microsoft. This language has been used widely among a high percentage of the developers as "primary development tool" compared to other programming languages [11]. VB is the advanced version of the BASIC language with "Integrated Development Environment (IDE)" which API accessing and graphical user interface [12].

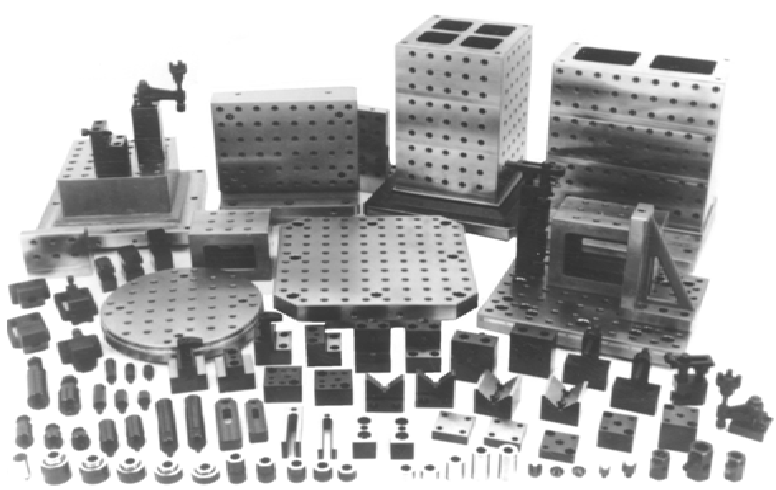

FIGURE 2: Modular fixture standard elements [2].

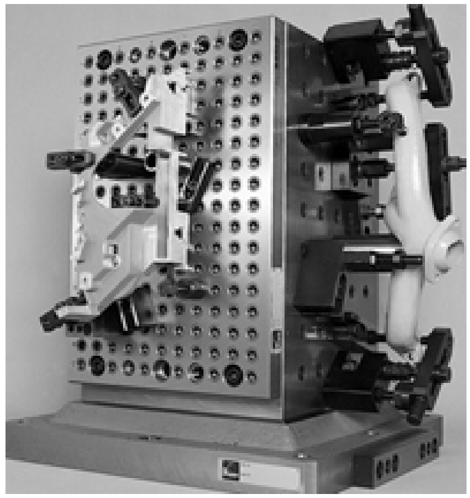

FIGURE 3: Modular workholding system [13].

Moreover, VB is considered as then engine for building the macros in all Microsoft software [11]. Therefore, VB has become an important tool for building different programs for many applications. There are different types of projects can be generated in VB. For simple programming purposes, Standard EXE is used more common by the programmers. For more advanced programming functions, ActiveX projects are used. In this research, ActiveX DLL (AvtiveX dynamic link libraries) has been created. This project allows the programmer to integrate VB with different windows applications. Also, this project controls the features and the operations of other applications by creating new menus and toolbars into the applications' environment. For database management purposes, VB is the engine of Microsoft Access for building the database and this gives the programmer the opportunity for controlling the database efficiently [11].

2.4 SolidWorks API

Application programming interface (API) is a tool to write a code in a programming language within another application. As a result, a direct integration between different applications can be developed [14]. SolidWorks is one of the applications which support API with different programming languages such as C++, Visual Basic, and Visual Studio. SolidWorks API automates the design and the assembly operations by creating codes in a specific programming language [14] and it has been applied for different design methods. API is used to develop a web service material database with SolidWorks for simplifying the selecting of the materials by the designer [15]. Bo, Qin, and Fang developed a standard parts library by using Visual Basic code with SolidWorks API functions [16]. This system is based on creating Visual Basic forms for improving the design efficiency. Peng, Jing, and Xiaoyan applied Visual Basic Net in the SolidWorks second development for simulating "3D module of architectural process" [17]. They generated add-in VB project into Solidworks for automating the assembly process. SolidWorks API was employed in designing a model of "centrifugal fan impeller" [18]. This method is based on the geometric features to create the second development with SolidWorks and VB 6. Moreover, API with the user interface implementing knowledge based design features (KBE) application can help in customising the CAD system for certain tasks [19]. Reuse software was developed by applying SolidWorks API by Tian and Liu [20]. The system was built by using VB for secondary development of the CAD system for a standard part. Zhen and Yingyi introduced an assembly method based on SolidWorks [21]. They illustrated the steps of the assembly automation procedure by using Visual C++. They also explained how the information of the parts was stored in the database. The secondary development of SolidWorks was used by Yang for developing an intelligent system for assembly based on the parametric design [22]. Delphi programming language, SolidWorks API, and Access database were the techniques for creating this system.

3. CREATING THE ASSEMBLY KNOWLEDGE BASE

Based on the assembly methodology in the previous work [11], the assembly knowledge base was developed in IF-then rule structure to meet the requirements of the side clamping layout for the selected fixture elements in this study. Examples for these rules are:

Rule 1

If the locating method is V-blocks, then define the surfaces that are used to assemble them to the baseplate.

Rule 2

If the locating surface of the V-block is defined, then identify the location of the V-block on the baseplate. This depends on the sizes of the V-block and baseplate. The location can be defined by calculating the distance of the holes on the baseplate for the correct location.

According to the findings from the above rules, the mating features for assembling the V-block and the baseplate in the SolidWorks environment were defined:

Rule 3

If the surface is defined and the location is calculated, then use coincident mate to locate the V-block to the baseplate.

Rule 4

If the surface is defined and the location is calculated, then use concentric mate to assemble the V-block with the baseplate.

4. CREATING SOLIDWORKS ADD-IN AND USER INTERFACES

In this paper, add-in code was created in order to build menus in the SolidWorks environment for automating the inserting and assembly processes. The menus were built by using VB 6 integrating with SolidWorks API (Application Programming Interface). An ActiveX DLL project was developed in VB including SolidWorks libraries as references. In this case, two libraries were referenced; these are SldWorks Type Library and SolidWorks Exposed Type library. Adding these libraries to the ActiveX DLL project allows control SolidWorks commands and functions. The developed add-in code in this study is:

```
Dim bRet As Boolean 'boolean return
Dim lRet As Long 'long return
Dim axMenuID As String
Dim lngToolbarDocTypes As Long
Set axSldWorks = ThisSW
axCookie = Cookie
bRet = axSldWorks.SetAddinCallbackInfo(App.hInstance, Me, axCookie)
axMenuID = "Modular Fixture System"
 lRet = axSldWorks.AddMenu(swDocASSEMBLY, axMenuID, 5)
axMenu1 = "Assembly@Side Clamping@" & axMenuID
 axMenu2 = "Back stop@Side Clamping@" & axMenuID
 axMenu3 = "Pivoting Clamp@Side Clamping@" & axMenuID
 axMenu4 = "Riser block@Side Clamping@" & axMenuID
 axMenu5 = "Workpiece@Side Clamping@" & axMenuID
 axMenu6 = "V-block@Side Clamping@" & axMenuID
 axMenu7 = "Baseplate@Side Clamping@" & axMenuID
 axMenu8 = "Top Clamping@" & axMenuID
```

After writing the add-in code and adding the proper VB modules and forms to the ActiveX DLL project, the .dll file is created and copied to the SolidWorks directory. Then, this .dll file is opened in the SolidWorks environment to apply the function to the developed menus.

4.1 Assembly simulation by macros

For automating the fixture elements assembly process in SolidWorks, macros were created for simulation purposes. However, these macros can be applied only for the master SolidWorks document that they have been created in. The solution for this problem was to make global macros by modifying the recorded macros. This was completed by changing VB methods and classes of the recorded macros and adding the swConst modules and swAssembly or swPart class modules. This makes the macros available for any SolidWorks documents. However, these global macros are still not in the format for the developed ActiveX DLLl project. The most important function for the add-in project is how to make the created menus calling the global macros which perform SolidWorks design and assembly. This was achieved by importing the global macros into the ActiveX DLL project as modules with .bas format and then writing a subroutine code for each macro and finally calling this subroutine by the specific menu's icon.

4.2 Implementation of the assembly simulation

The assembly simulation started by developing the macros for each fixture element and for the assembly steps. The macros for adding the fixture elements were created first. For more flexibility, a main menu called Modular Fixture System was built. Then, two sub menus were developed called Side Clamping and Top Clamping. The user can select which type of clamping system should be applied. Both sub menus is extended to other menus for the whole related fixture elements for this specific kind of fixturing (Figure 4). For the Side Clamping, the following elements were used:

- Baseplate;
- V-Block;
- Pivoting Clamp;
- Backstop;
- Riser block;
- Other accessories.

For each of these elements, a menu should be created. Then, by selecting the specific menu, a window is opened for more detail. For example, when clicking on the baseplate menu, a window of this element is opened to help the user select the proper baseplate (Figure 5). The window contains command buttons for the possible and available baseplates that could be used within the system. Each command button was highlighted by an icon of the specified baseplate and ID number was used for choosing the correct baseplate. The interface provides the flexibility for defining the location of the baseplate in X, Y, and Z directions in the SolidWorks environment. Then, the user marks the check box for the selected baseplate and then clicks on the command button.

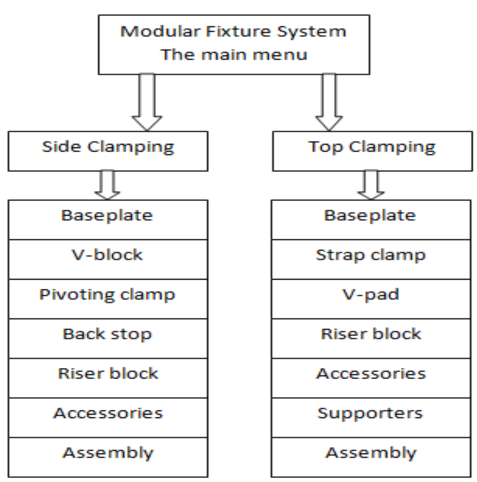

FIGURE 4: The developed main and extended menus.

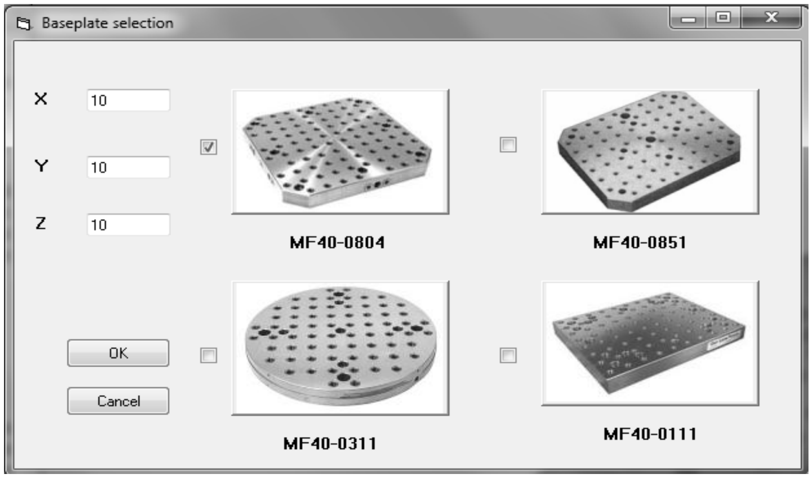

FIGURE 5: Four kinds are included in the baseplate selection interface.

In order to activate the command buttons in the baseplate selection interface, a macro was created to perform the inserting process of this element:

```
Dim swApp As Object
Dim Part As Object
Dim boolstatus As Boolean
Dim longstatus As Long, longwarnings As Long
Sub main()
Set swApp =Application.SldWorks
Set Part = swApp.ActiveDoc
boolstatus = Part.AddComponent("C:\Users\Desktop\baseplate -MF40-0804)
End Sub
```

This macro adds the baseplate MF40-0804 to the active SolidWorks application document named swApp. The macro should be now transferred to the global form by attaching swConst module and swAssembly or swPart class module. The swConst module contains the definitions for the SolidWorks API functions including the properties and methods. The swAssembly and swPart class modules define which type of SolidWorks documents that the specific macro will be applied to.

The next step is adding the macro to the ActiveX DLL project and converting it to the .bas format which makes the macro available for any SolidWorks assembly or part documents. The swConst module and swAssembly class module are also added to this project to improve availability for any assembly SolidWorks document. The previous process was followed for adding the rest of the macros for the elements to the project.

After completing selection and adding the elements to the SolidWorks environment, these elements need to be assembled. A menu called Assembly was created and added to the list of the extended menus as shown in Figure 3. By clicking this menu, an assembly interface is opened (Figure 6). This interface contains command buttons for executing the assembly simulation for the fixture elements.

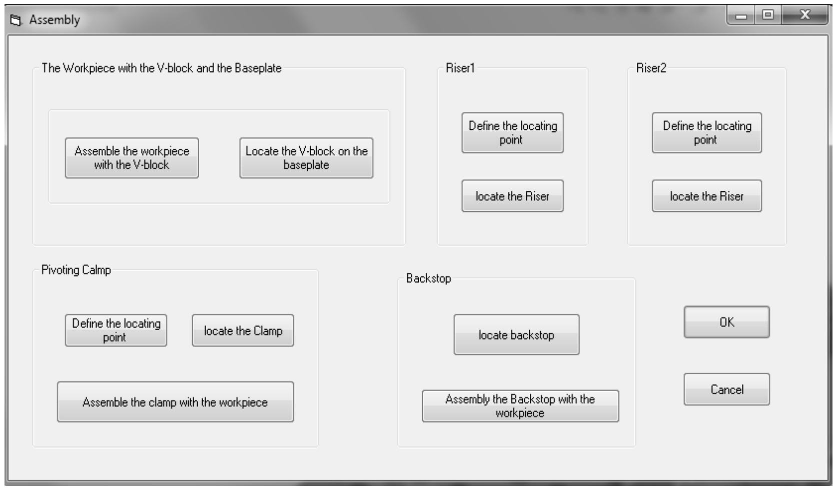

FIGURE 6: The user interface of fixture elements Assembly process.

The simulation of the assembly process begins by taking the V-block and the workpiece as an example. These two elements were added to SolidWorks and then a macro for assembling them was recorded. A tangent mate feature was used between the sime-cylindrical face of the workpiece and the two V shape faces of the V-block as shown in Figure 7. The code of assembly is:

```
Dim swApp As Object
Dim Part As Object
Dim boolstatus As Boolean
Dim longstatus As Long, longwarnings As Long
Sub main()
Set swApp = _
Application.SldWorks
Set Part = swApp.ActiveDoc
boolstatus = Part.Extension.SelectByID2("", "FACE", 0.1467759532569, 0.2282465512145,
0.2052684525268, True, 1, Nothing, 0)
boolstatus = Part.Extension.SelectByID2("", "FACE", 0.04935040746813, 0.05664959253187,
0.08677583155765, True, 1, Nothing, 0
Dim swApp As Object
Dim Part As Object
Dim boolstatus As Boolean
Dim longstatus As Long, longwarnings As Long
Sub main()
Set swApp = _
Application.SldWorks
Set Part = swApp.ActiveDoc
boolstatus = Part.Extension.SelectByID2("", "FACE", 0.1467759532569, 0.2282465512145,
0.2052684525268, True, 1, Nothing, 0)
boolstatus = Part.Extension.SelectByID2("", "FACE", 0.04935040746813, 0.05664959253187,
0.08677583155765, True, 1, Nothing, 0)
Dim myMate As Object
0.08290013687201, 0.1404353580714, True, 1, Nothing, 0)
Set myMate = Part.AddMate3(4, 1, False, 0.08962381358722, 0, 0, 0.001, 0.001, 0.5235987755983,
0.5235987755983, 0.5235987755983, False, longstatus)
Part.ClearSelection2 True
Part.EditRebuild3
boolstatus = Part.Extension.SelectByID2("", "FACE", 0.08743441472234, 0.1639087578332,
0.1920150657936, True, 1, Nothing, 0)
boolstatus = Part.Extension.SelectByID2("", "FACE", 0.146900136872,
Set myMate = Part.AddMate3(4, 1, False, 0.09399852070358, 0, 0, 0.001, 0.001, 0.5235987755983,
0.5235987755983, 0.5235987755983, False, longstatus)
Part.ClearSelection2 True
Part.EditRebuild3
End Sub
```

The same procedure was followed for transferring this code to the global form and then to the .bas form. The assembly simulation was divided into several steps in this study. For compiling the command buttons in the user interfaces, two approaches were followed. The first approach is calling the macro for each element by using the subroutine:

```
Public Sub cmdBaseplate_Click ()
Baseplate.main
End Sub
```

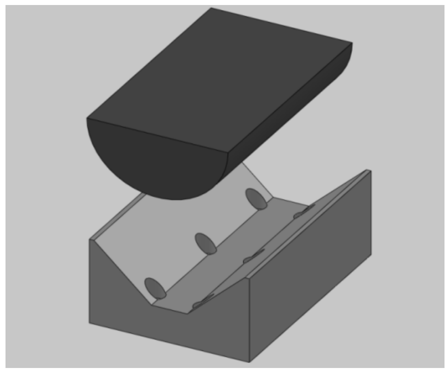

FIGURE 7: The example of the chosen V-block and the workpiece.

This subroutine calls the macro Baseplate by clicking the command button to add this element to the SolidWorks environment. The second approach is writing a code in order to compile the command button:

```
Public Sub cmdBaseplate_Click ()
Dim swApp As Object
Dim Part As Object
Dim boolstatus As Boolean
Dim longstatus As Long, longwarnings As Long
Sub main()
Set swApp = Application.SldWorks
Set Part = swApp.ActiveDoc
boolstatus=Part.AddComponent("C:\Users\Desktop\Baseplate.SLDPRT",0.1690002083701,
0.2903048910654, -0.02491659965801)
End Sub
```

Both approaches are correct and compatible. To compile these approaches, it is important to attach the macros in .bas format to the master directory of the ActiveX DLL project. The developed menus in the SolidWorks environment are shown in Figure 8.

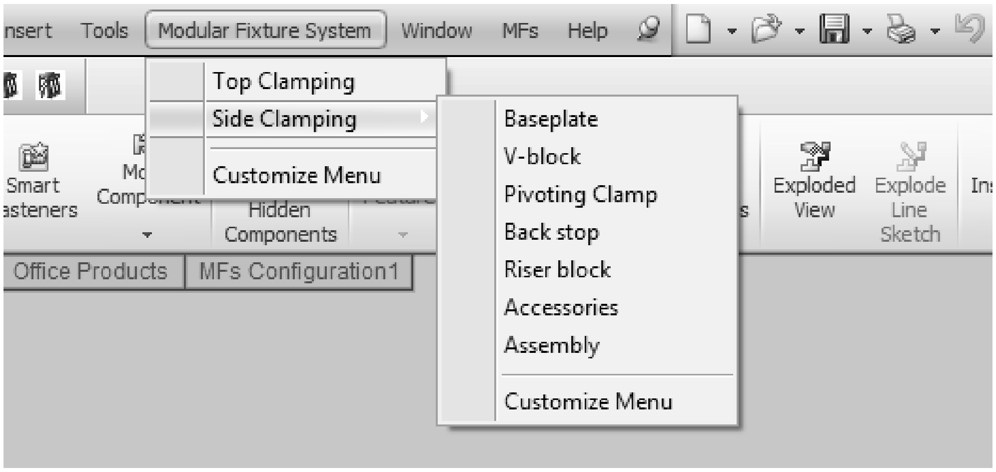

FIGURE 8: The main menu and the extended menus developed for the system.

5. RESULTS AND DISCUSSION

Simulation by macros was employed for developing the user interface for the related fixture elements. Figure 9 shows the selection of the side clamps and the back stops. The interface of V-blocks selection showed in Figure 10 while Figure 11 illustrates the riser blocks interface. Other user interfaces were developed to enhance the system's flexibility. These user interfaces were developed in a different approach because there are more details should be considered for some elements such as the necessary accessories for completing the assembly process for the fixture elements (Figure 12).

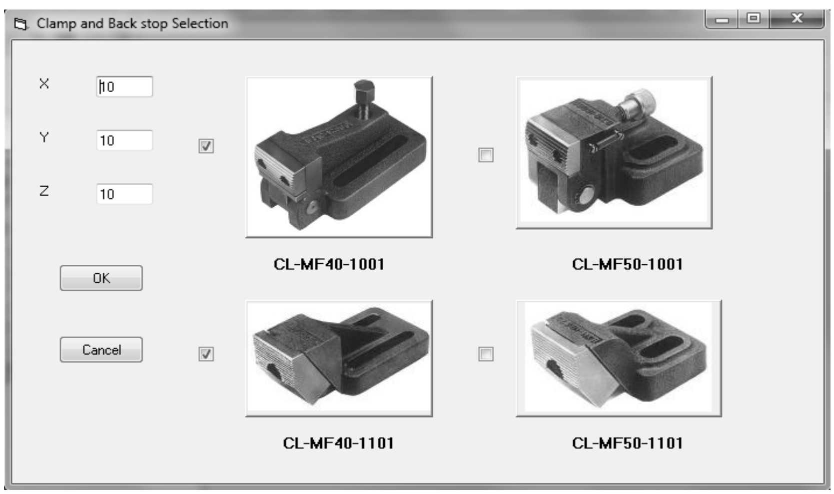

FIGURE 9: The selection window for the side clamps and the back stops.

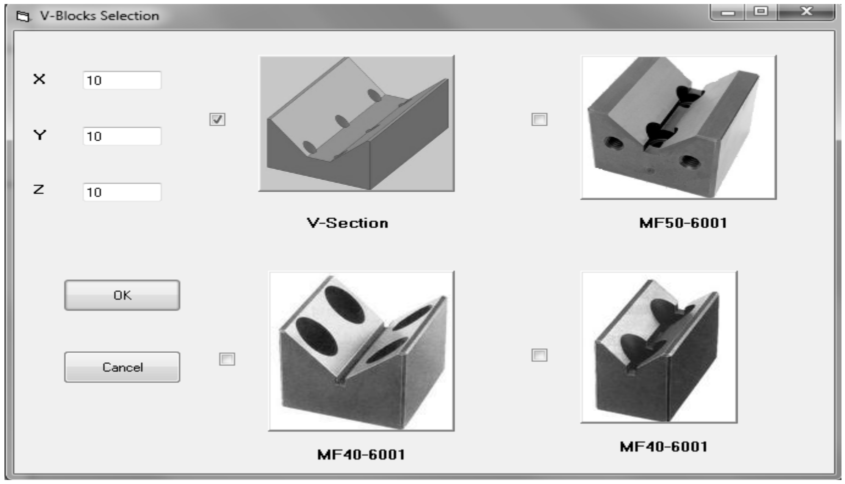

FIGURE 10: The selection window for the V-blocks in the system.

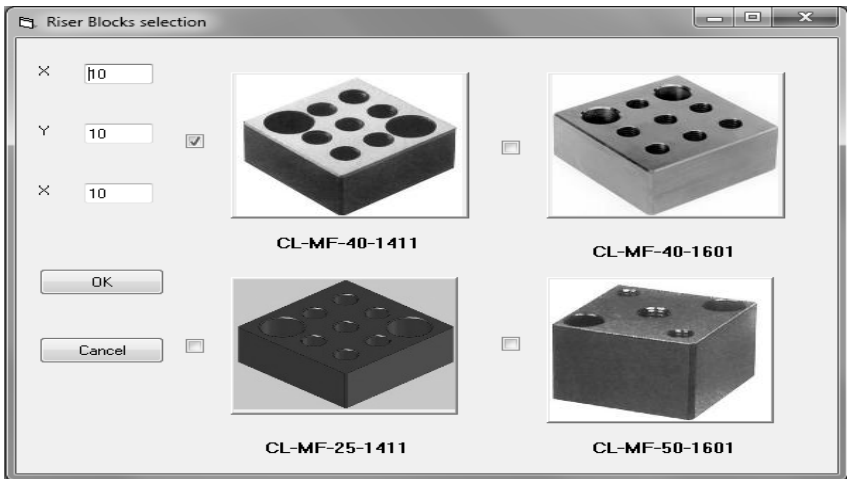

FIGURE 11: The selection window for the riser blocks in the system.

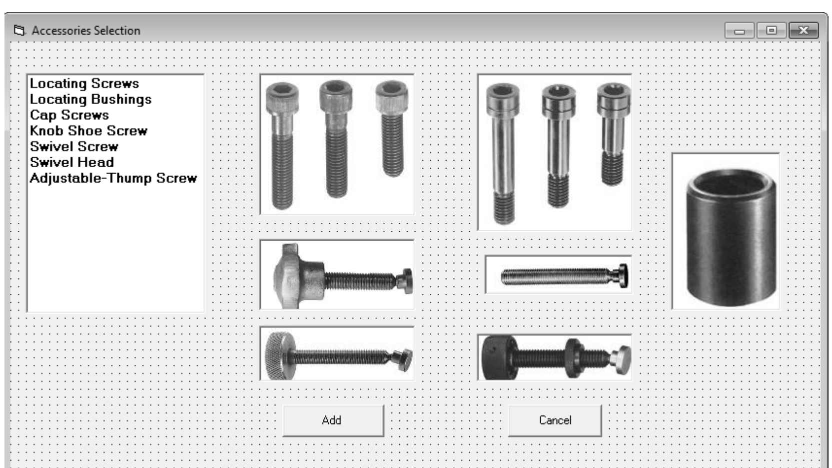

FIGURE 12: The selection window for the accessories to complete the fixturing system.

The assembly process begins after adding the components in the SolidWorks environment as shown in Figure 13. Then, macros were developed for assembling two parts appropriately as explained previously for the workpiece and the V-block. The created macros for the system were used in order to assemble:

- The workpiece with the V-block;
- The V-block with the baseplate;
- The riser block with the baseplate (two macros);
- The pivoting clamp with the riser block;
- The pivoting clamp with the workpiece;
- The back stop with the riser block;
- The backstop with the workpiece.

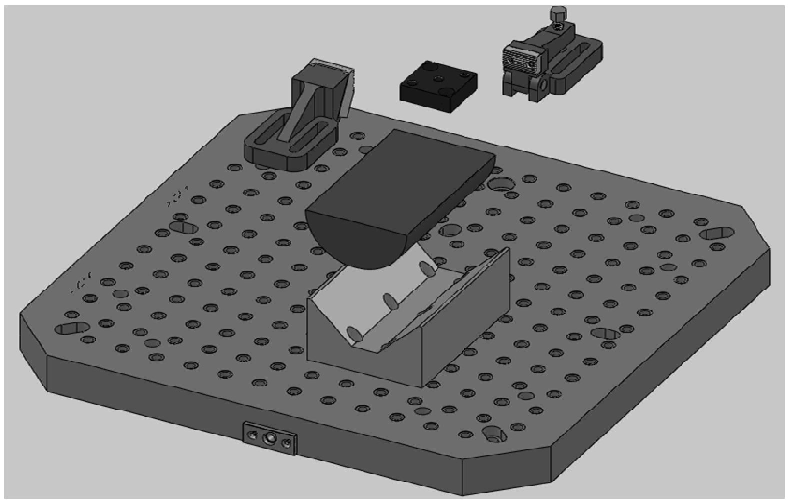

FIGURE 13: Modular fixture elements added in SolidWorks environment from the menus.

Therefore, eight steps were used for completing the assembly simulation. The process was divided into this way because errors could occur if the whole process was one step. This is related to the problems in SolidWorks when applying the functions of rotating and reviewing on the components. The positions and the directions of the elements were predefined in the VB codes.By completing the eight assembly steps, the final MFs layout is shown in Figure 14.

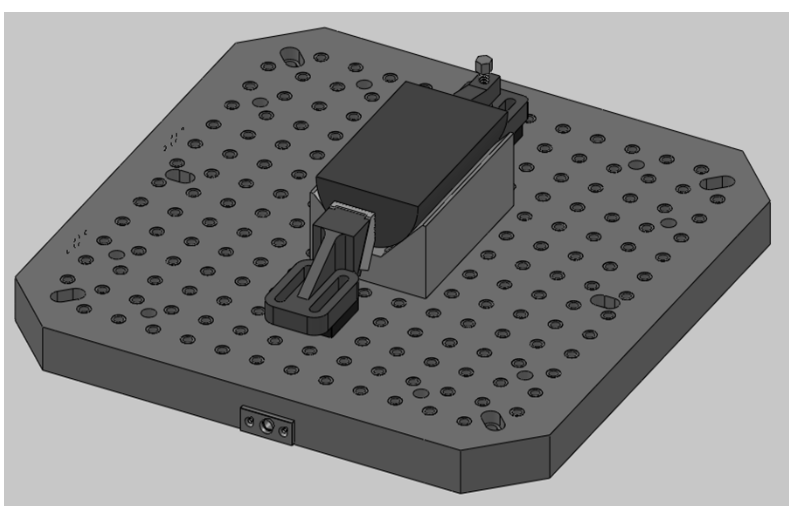

FIGURE 14: The complete layout of modular fixture elements generated after assembly.

Interference detection was running after finishing the assembly to ensure that there is no collision between the fixture components. This process was completed by SolidWorks and if interference is found, the options of mating features such as choosing the correct edges or faces should be modified to achieve the efficient assembly functions.

A layout of MFs was generated for side clamping in this paper. The layout is for a semicircular workpiece and it simulates the assembly process for the fixture elements that should be completed for this kind of workpieces for machining by CNC. This simulation provides the opportunity to overcome the errors that could happen during this process and, therefore, the appropriate MFs layout can be achieved.

Use of SolidWorks in this work provided MFs assembly with a strong support compared to previous studies. This is because the modelling environment and the 3D assembly mating features which make SolidWorks as a powerful CAD software for providing user graphic interface to assemble MFs.

As programming languages such as C++ and AutoLISP were integrated with CAD software to automate MFs assembly, VB 6 was employed in this paper due to its capabilities for building the macros in all Microsoft software and, therefore, accesses the functions of SolidWorks API for developing the graphical user interfaces and new menus. Moreover, VB 6 is considered as a flexible programming language that can be integrated with different applications. Therefore, the secondary development approach presented in this paper enhances and simplifies the automation process of MFs.

6. CONCLUSION

SolidWorks API was employed for automating the assembly process for MFs elements. The simulation of this process was completed by using macros functions in SolidWorks. For this purpose, an ActiveX DLL project was created in VB 6 and a plug-in file in .dll format was generated for developing new menus into SolidWorks environment. From these menus, user interfaces were expanded to be opened by clicking each of these menus allowing the user for selecting and inserting the right elements. The approach of applying SolidWorks API was explained in details for a semi-circular workpiece and can be applied for similar cases. The system was tested by using Interference detection tool included in SolidWorks to be sure that no collision between MFs elements. The developed approach results in saving time and cost for designing and assembling MFs elements.

The future work of this research can be directed towards extending the knowledge base for the assembly process including other fixturing methods and fixture elements to meet the requirements for building several MFs configurations. In addition, a comprehensive automated process can be achieved by extending the VB codes and macros. This leads to defining and modifying the positions and the directions of the fixture elements. Therefore, the errors can be overcome in order to make the process more efficient and in one step rather than many steps.

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