

Development of Customisation module
for
NC Code generation of Tube plate drilling

(Ref: Doc No: 14-622-RD-39)

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Introduction

Feed water Heaters and Condensers are being manufactured at BHEL Bhopal unit. A typical condenser plate consists of around 10,000 to 15000 holes with different hole layout patterns depending on the design requirements. Whereas a feed water heater plate consists of around 6000 holes. These holes are being drilled using CNC drilling machines. At present, the hole layout comes in an AutoCAD drawing format. From this drawing a configuration file is generated, by reading the number of holes in each row manually. The machine movement, pitch between the holes and identification of the left out holes are done manually for completing the drilling cycle in a row. From this input file, CNC part programs are generated based on the machine configuration. In general, the tube plate is consisting of two types of pitches i.e., Triangular pitch and rectangular pitch.

The pitch between two holes is around 20 to 25mm. The drawing layout is classified as left hand side (LHS) and Right Hand Side (RHS). The layout is identified with Horizontal and vertical lines with proper indication of angles (0° , 90° , 180° , 270°).

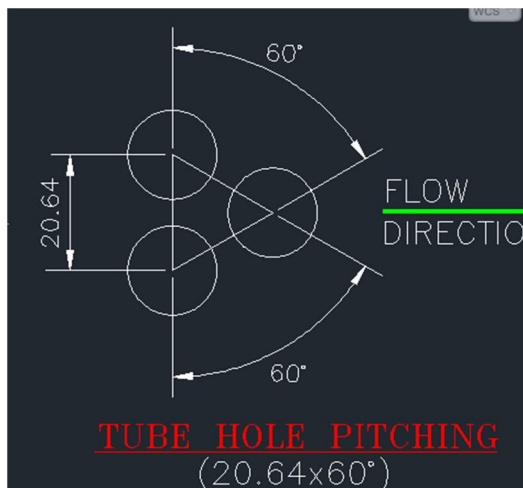


Fig1: Triangular pitch

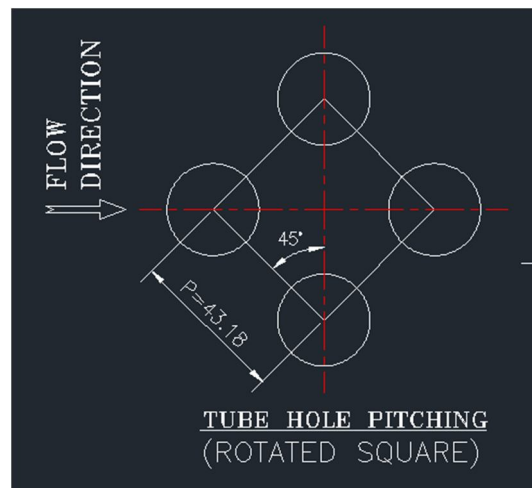


Fig2: Rectangular pitch

At present, the drilling operation is being carried out using four CNC drilling machines i.e., two single spindle CNC machines(K&W, ARBOGA), one double spindle deep hole drilling machine (LAHR) and one eight spindle multi hole drilling machine (KOLB). The two spindle drilling machine consisting of single motor for two spindles. In this machine **we cannot operate the individual spindle separately**. A constant fixed pitch plates are being used for maintaining pitch between the two spindles (Minimum Pitch between spindles: 139.60mm, Maximum pitch between spindles: 168.25mm).

The multi spindles drilling machine (8 spindles) is consisting of two motors. Each motor caters drive for four spindles. The machine is also having the capability of **operating individual spindles based on the operator's selection**.

Objectives:

- To develop a customisation module for automatic part program generation for a defined CNC machine as per the given hole layout for tube plate drilling using UG NX Platform.
- To read the drill hole centre location from the softcopy of the AutoCAD hole layout file for seamless integration.
- To develop CNC part program with a logical drilling strategy suitable for any available four CNC drilling machines presently being used in the shop floor.

Machine Configurations

1. Multi Spindle Drilling Machine (KOLB):

- No. of spindles: 8
- Controller: SIEMENS SINUMERIK 8MC
- Model: KOLB MDN 8.40
- X-axis Travel: 7000 mm
- Y-Axis Travel: 5500 mm
- Z- Axis Travel: 350 mm
- Min Pitch: 100mm (Distance between centres of two subsequent spindles)
- Max Pitch: 200mm (Distance between centres of two subsequent spindles)
- Drill bit diameter: 40mm Max
- Spindle Speed: 71 to 1400 rpm
- Spindle Feed: 10 mm to 1000mm/min
- No. of motors: 2 (4 spindles / motor)
- Motor Capacity: 50 HP/ 11.5 KW

2. K&W Single spindle drilling machine:

- Controller: SIEMENS SINUMERIK 810
- Y-Axis Travel: 700mm
- Maximum drill Diameter: 25mm

3. ARBOGA CNC 2500 Single spindle drilling machine:

- Controller: SIEMENS SINUMERIK 840D
- X- Axis Travel: 2500mm
- Y-Axis Travel: 2500mm
- Z- Axis Travel: 370 mm

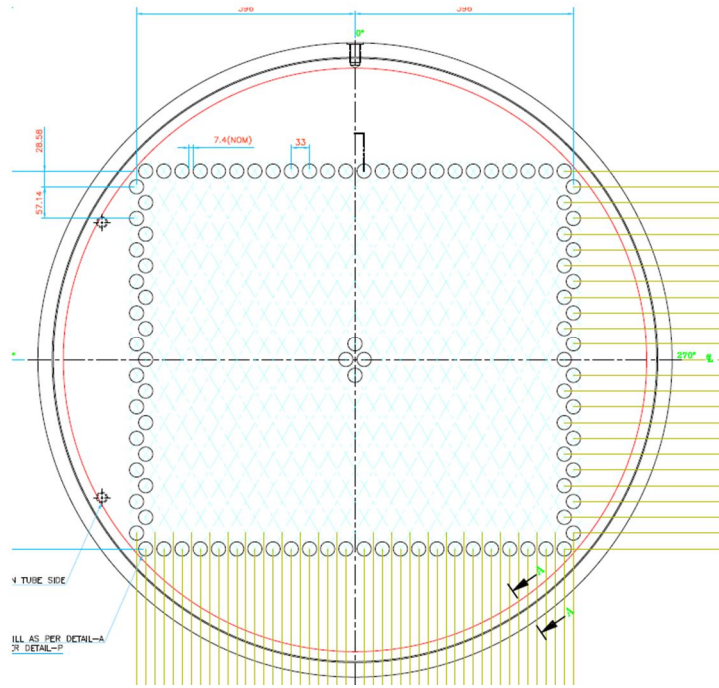


Fig 4

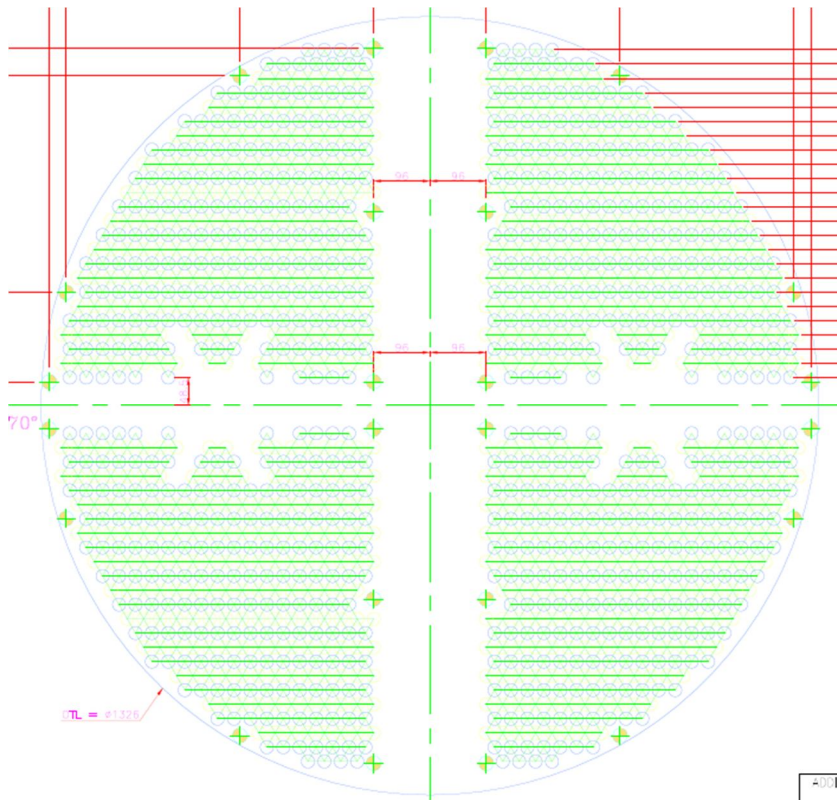


Fig 5

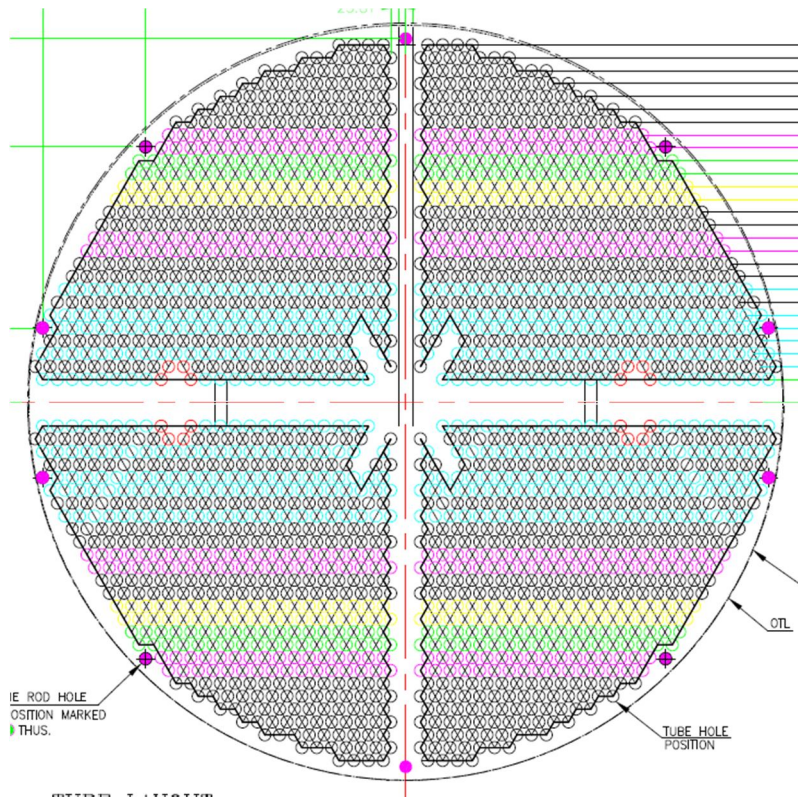


Fig 6

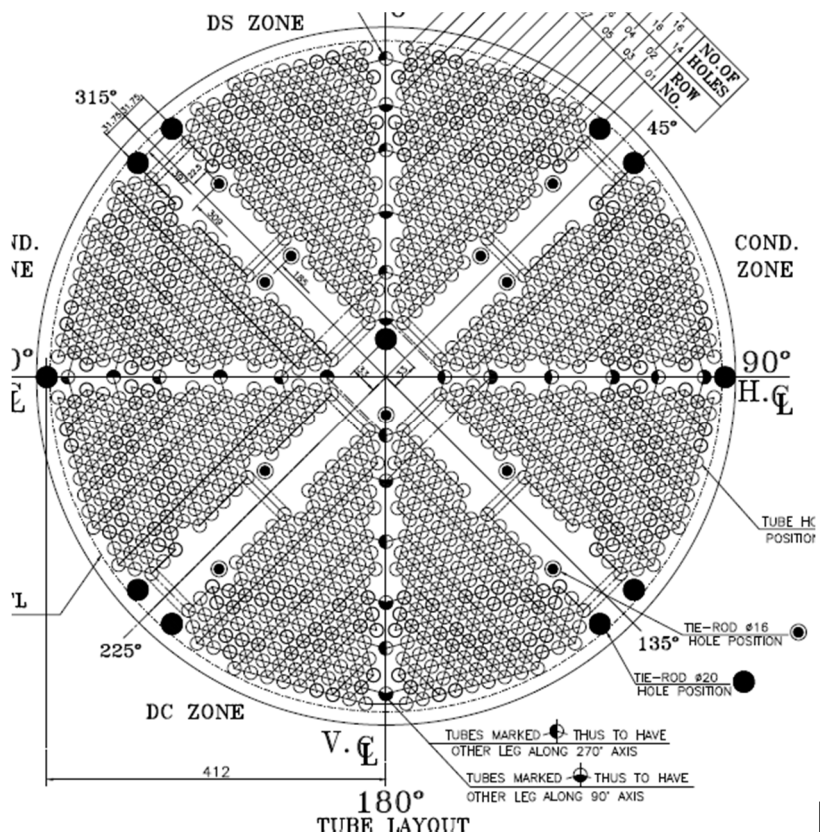
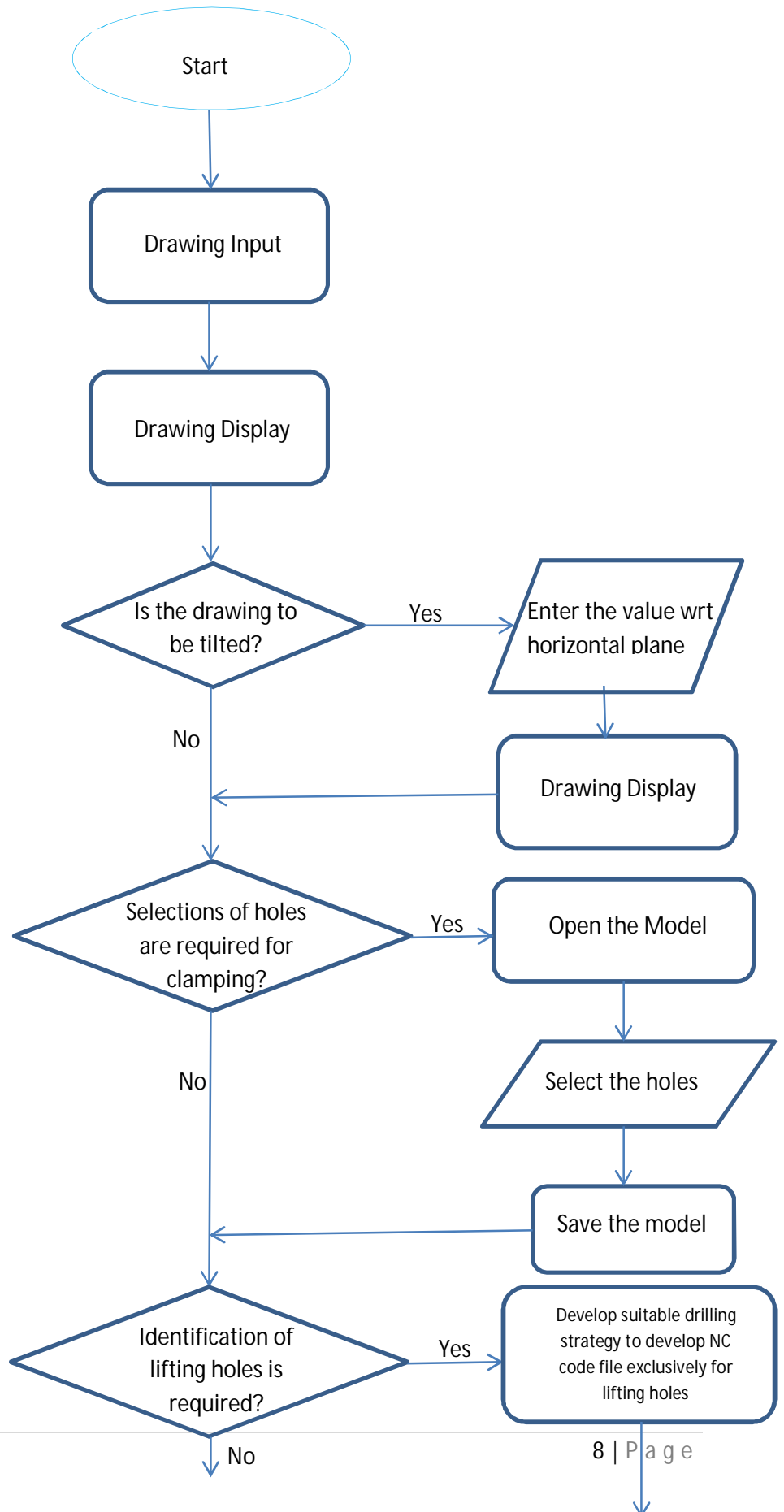
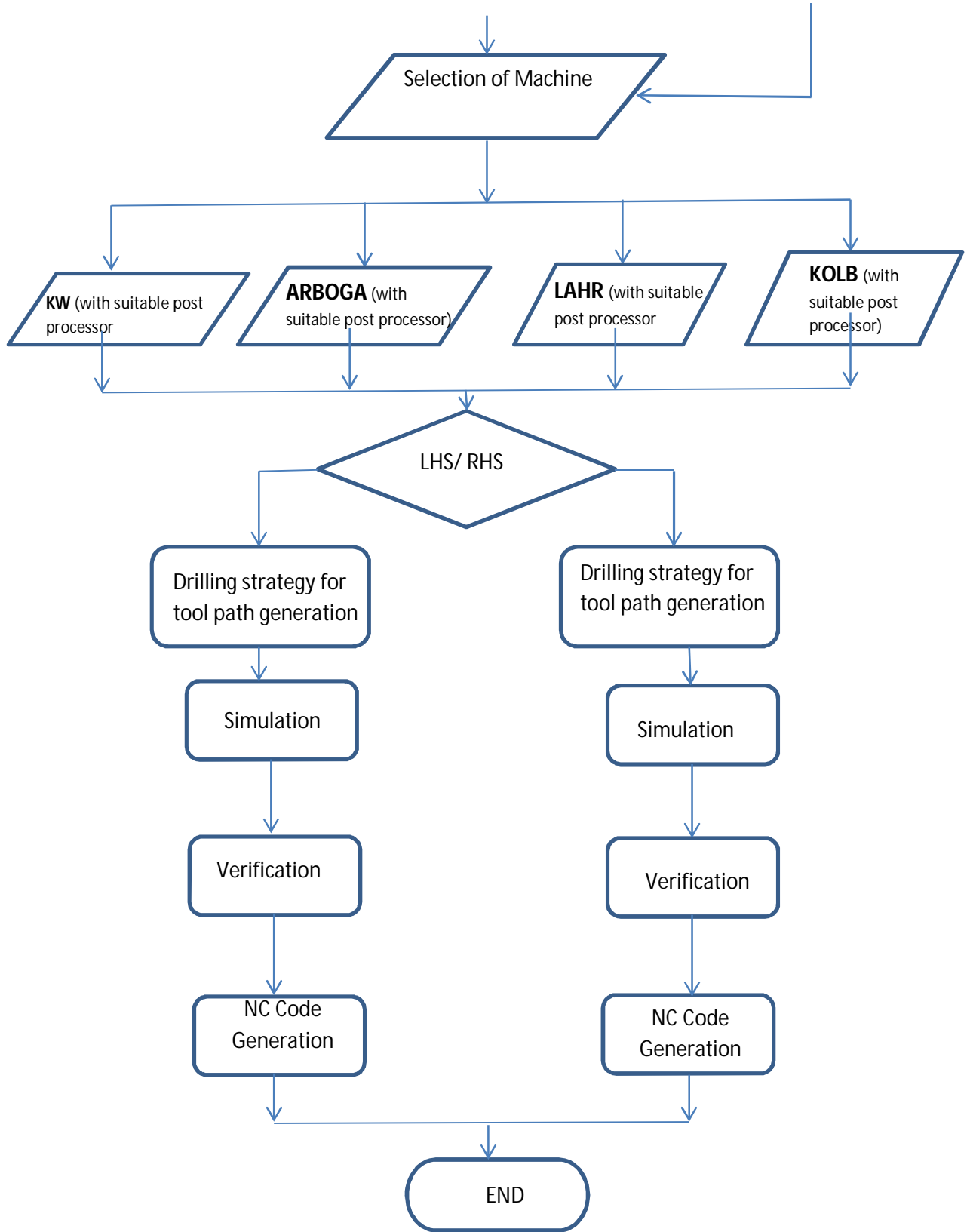


Fig 7

FLOW CHART





Scope of Work

Software to be used for development:

- NX
- NX Open
- NX Open Net Author
- NX- UI Styler
- NX-CAM

A GUI has to be developed in NX plat form for seamless integration of CAD drawing to make CNC programs for the defined CNC Machine. The flow chart given above broadly describes the scope of work to be covered under this GUI development. However, point wise description is given under for better understanding.

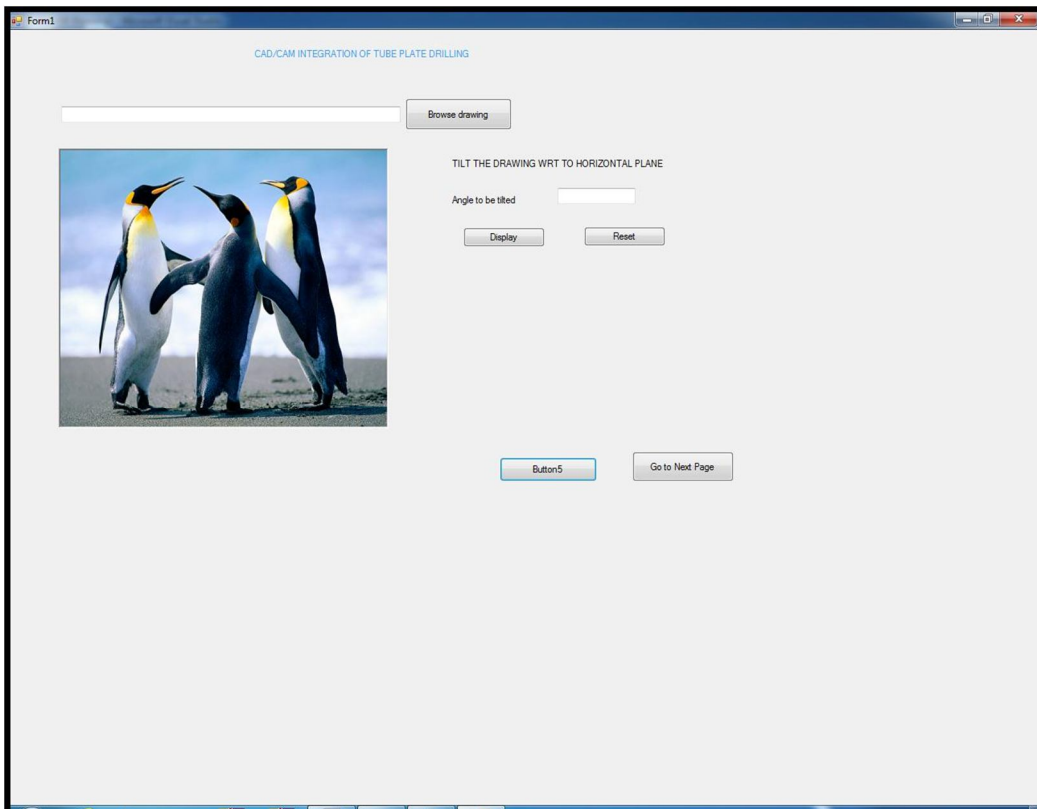
1. The layout is available in AutoCAD drawing format as 1:1 ratio.
2. AutoCAD drawing file contains the following details
 - a. Layout arrangement of the holes in the tube plate
 - b. Dimensional details of the hole arrangement
 - c. Tube specifications
 - d. Centre line references for the tube sheet/ support plate.
3. The GUI has to read the drawing file and display the image for the operator to cross check, whether the selected drawing is desired one or not.
4. The GUI should automatically derive the following tube layout details from the drawing
 - a. Drawing Scale
 - b. Origin point location
 - c. Diameter of the hole
 - d. Location of the hole
 - e. Thickness of the sheet
 - f. Material of the sheet
5. In few layouts, the hole pattern is inclined to vertical plane (refer Fig 7). In such cases, there should be an option for the operator to enter the required value of the angle, so that the hole layout shall be parallel to vertical plane.
6. For long plates, intermittent supports are required for locking. In that case certain holes in the layout are not available for drilling. The GUI has to give the option for the operator to select that zone. For this, the model has to be opened in NX and after selection of holes, the model has to be saved.
7. Some of the plates are having lifting holes, which are shown with different diameter in the hole layout. These lifting holes also to be drilled. So a separate NC code exclusively for lifting holes has to be generated.

8. The GUI has to provide selection of the CNC machine (KW, ARBOGA, LAHR, and KOLB) to the operator.
9. The GUI should have provision to select LHS alone, RHS alone or complete layout.
10. Based on the machine, the model shall be opened in the NX platform and tool path has to be generated for drilling cycles. The simulation of the generated tool path should be visualised to the operator.
11. Colour code to be implemented for the drilled hole and undrilled holes, so that the operator visualises on the screen about the machine movement and correctness of the tool path.
12. After simulation, there should be validation / checking of drilled plate (virtual) with Input model, so that the operator can check if there is any flaw in tool path generation.
13. The development of post processors for all CNC machines is under project scope only. Any information required on machine configuration files, sample programs and drilling cycles (Canned Cycles L81, 82, 83 etc.,) etc., shall be provided.
14. There should be cycle time optimisation during the tool path generation.
15. A separate drilling strategy has to be followed for individual CNC machines as mentioned below:
 - KW & ARBOGA machines are single spindle machines.
 - LAHR (Deep hole drilling machine) is a double spindle drilling machine. Single Motor drives the two spindles at a time. There is no provision to operate the spindle independently. This has to be taken care while preparing the suitable drilling strategy. For this machine, a constant pitch plate is used to maintain fixed pitch between the two spindles. Those details will be shared. The drilling always starts from bottom and go towards top. For the next line, again it has come to bottom and go up. In order to reduce, back lash in the machine, the machine should start one pitch below than the actual hole location. These details shall be explained in person, if required.
 - KOLB (Multi Spindle Drilling Machine) is a 8 spindle drilling machine. The machine is having two motors. Each motor drive four spindles. The machine is also having the facility to operate individual spindle as per operator selection. The selection logic for spindle is like this
 - Spindle 1 - 1
 - Spindle 2 - 2
 - Spindle 3 - 4
 - Spindle 4 - 10
 - Spindle 5 - 20
 - Spindle 6 - 40
 - Spindle 7 - 100
 - Spindle 8 - 200

If the operator selects all the spindles, then it goes with the command T377.
If spindle 1, 4, 7, 8 are selected – then it goes with T 311 (1+10+100+200).
For this machine, there should be a provision for the operator to select the spindles, as some of the spindles may be under break down. If the motor is failed, then the four spindles connected to that motor are not available.
These things shall be discussed across the table, if required.

16. If everything is ok, then the module should generate NC code suitable to the machine.
17. In some of the layout, different zones of layout have different pitch. In this case a separate NC code has to be generated for that individual zone only.

Dummy Screen Shots



Form2


CAD/CAM INTEGRATION OF TUBE PLATE DRILLING

Selection of Holes wrt Horizontal Plane

- LHS
- RHS

Holes to be selected for holding the plate

Display of selected zones



Form3

CAD/CAM INTEGRATION OF TUBE PLATE DRILLING

Selection of CNC Machine

- KW
- ARBOGA
- LAHR
- MSP