Original Research Article

COMPUTER AIDED SYSTEM FOR UNI-FUNCTIONAL JOB SHOP MACHINE SELECTION BASED ON TECHNOLOGY ADVANCEMENT.

ABSTRACT

Cost of production in manufacturing industries is very vital; it is the major determinant of profit level a company will attain. If left on controlled, it easily take away profits and the company economy will be in hazard. This production cost can be controlled during purchasing of materials to be used, equipment required for processing raw materials and required services of man power. These attributes used to be controled at the purchasing level. But when it comes to processing of material (job processing) which has alternative means of producing the required product(s) there are machines competing for the job(s) and machine that will do the job economically out of the existing alternative must be wisely selected. This study hence, developed decision rules models for selecting machine that will give optimum production cost considering alternatives available based on technology advancement of machines. The strategic decisions are: fixed cost, variable cost, and break-even point between alternatives. Computer software was developed using Microsoft Visual Basic computer language. These models and the developed software will find it's applications in Job-shop industries, institutions, mechanical and manufacturing workshops that selection of machines affects their production in developed and developing countries.

Keyword: ***Machine Selection,Uni-Functional,Optimization, Model Development.***

1. INTRODUCTION

A lathe machine is considered as cost effective equipment that can be used to perform repetitious, difficult and unsafe manufacturing tasks with high degree of accuracy. Selection of proper machine tool is one of the important issues for achieving high competitiveness in the global market. (1) The main advantage of selecting a proper machine tool lies not only in increased production and delivery, but also in improving product quality, increased product flexibility and enhanced overall productivity. (2) Improper selection of a machine tool may cause problems that affects productivity, flexibility and process capability. Evaluation and selection of a machine tool is a complex decision-making problem involving multiple conflicting criteria, such as fixed cost, variable cost and brake even point between alternatives (Martand, 2006).

Historically, Jain (2006) and AIPD (1988) gave details about lathe machine development and it's methods of operation till date. Akinnuli (2009) developed models for machinery evaluation before procurement using goal programming methods. Analysis of the benefits generated by using fuzzy numbers in aTOPSIS model developed for machine tools selection problems was carried out by Yurdalu and Lcy (2009) as well as Vijay and Shanker (2010). The Fuzzy approach was used also by Ayag and Ozdemer (2006a); Chan etal (2005);Mishra et al, (2006) and Onut et al., (2008) by using different models for decision making.

Atmani and Lashkari (1998), developed a model for machine tool selection and operational location. Angligi (2008) from University of MalaysiaPahang determinedLathe machine cutting speed for different materials. Chan and Swarnaka (2006) and Vienna (2005) went further to develop anti colony optimization models to a fuzzy goal programming for a machine tool selection and operation allocation in a Flexible Manufacturing System (FMS).

Machine tool selection and operational location in FMS was carried out by Rai et al., (2002). Yurdalul (2004) make used of analytical hierarchy process as a strategic decision-making tool to justify machine tool selection which is a great improvement on the work of Saaty (1980). Rao (2007) made use of Graph theory and Fuzzy multiple-attribute decision methods for decision making in the manufacturing environment. An intelligent approach to machine tool selection through Fuzzy analytic network process was ascribed to the effort of Ayag and Ozdemir (2006); Duran and Aguilo (2008); Sharma (2006) and Sun (2002).

These models are yet to address the issue of technological advancement that brought about improvement in speed, quality of production and accuracy of machining jobs. These factors are well identified with newly developed machine tools. Hence the development of machine selection models based factors such as fixed cost, variable cost and breakeven point for decision making.

METHODOLOGY

This research presents a logical and systematic procedure to evaluate and select appropriate lathe machine for optimum production cost implication: Manually operated Lathe (MO), Semi-Automatic Lathe (SAM) and Automatic Lathe (AM) Machines were considered in terms of break-even point, fixed cost, variable cost, set up time, process time, tooling cost, labour cost and depreciation rate. These strategic decisions were taken into consideration in order to arrive at the best decision as regarding selection of the proper lathe machine that will perform the job on job floor. Not all these machines (manual, semi-automatic, and automatic will be available in all Job-shop, hence the development of four (4)scenarios for these models application.

Model Development

Break-even point (BEP) model is adopted for comparing alternatives. It was adopted based it's ability to express cost of alternative as function of a common independent variable and will be of the form:

$(TC)_1 = f_1(x)$: $(T.C)_2 = f_2(x)$ (1)

where: $(TC)_1$ = Total cost per time period, per project or per piece for alternative 1;
$(T.C)_2$= Total cost per time period, per project or per piece per alternative 2.

At the Break – Even point (B.E.P),

$(T.C)_1 = (T.C)_2$ (2)

$f_1(x) = f_2(x)$ (3)

Mathematically, the above discussion can be written as:

$FC_1 + QV_{C1} = FC_2 + QV_{C2}$ (4)

From the above relation in Equation (4) the break-even quantity is determined.

$$Q = \frac{FC_2 - FC_1}{VC_1 - VC_2} \quad (5)$$

Where: Q =the break even quantity,FC_1 = Fixed cost of the 1st machine, Fc_2=fixed cost of the 1st Machine, Fc_2= fixed cost of the 2nd machine;VC_1 =variable cost of the 1st machine and VC_2=variable cost of the 2nd machine.

Strategic Decisions Used:

The strategic decisions used are: set up time (St); Processing time (Pt); Tooling up cost (Tc); Labour cost (Lc); Depreciation (D); Fixed cost (Fc) and Variable cost (Vc).

Fixed cost (Fc) Determination

Fixed Cost (fc) = Set up cost + Tooling up cost

$Fc = St + Tc$ (6)

This is also number of Set-up/year x Set up time /Set up (hrs) [Set-up labour rate] + (Depreciation and other expense/hr)] +tooling up costs.

$FC_1 = S_{ty} \times St/S_{th}[(Scr) + (D + Oc/hr)] + TC$ (7)

Scenario I: is used when manually and semi automatic machine are available, (MO) and (SAM).
Scenario II: is used when manually operated and Automatic machine are available (MO and AM).
Scenario III: This is used when semi automatic and automatic machines are available in the Job shop (SAM Vs AM) competing for Job.

Scenario IV: This is used when all the three machines Manually operated Semi-automatic and Automatic machines (MO, SAM and AM) are competing for the available job.

Variable cost (Vc_1) Determination

The variable Cost Vc =Processing time x [(Labour cost/hr + Depreciation and other cost/hr)]

$$Vc_1 = P_1\,[(L_{ch} + D + O_{ch})] \qquad (8)$$

Break-Even Quantity (BEQ) Determination

The quantity at which both alternatives gives equal cost(N) (BEQ) N = Fixed cost difference/variable cost difference

$$N = \frac{\Delta F}{\Delta V} = \frac{FC_2 - FC_1}{VC_1 - VC_2}\ or\ \frac{FC_1 - FC_2}{VC_2 - VC_1} \qquad (9)$$

Determination of Total cost (TC)

Total Cost = Fixed Cost + (variable cost/unit x number of units)

$$Ttc = Fc + [(V_{cu} x\ N)] \qquad (10)$$

Case study

Development of the Component to be Manufacture and it's Geometry

The component in Fig. 1 is to be produced by Don Bosco Technical College's production workshop for the need of a customer making requisition for eight hundred (800) pieces which will last for his one year period of operation. Which of the alternatives lathe machineries: MO; SAM, or AM will economically be selected for this job based on this quantity required.

This case study was to test the four scenarios that are possible under this study which are: MO versus SAM;MD versus AM; SAM versus AM and comparing the three machineries MO, SAM and AM at same time.

Components

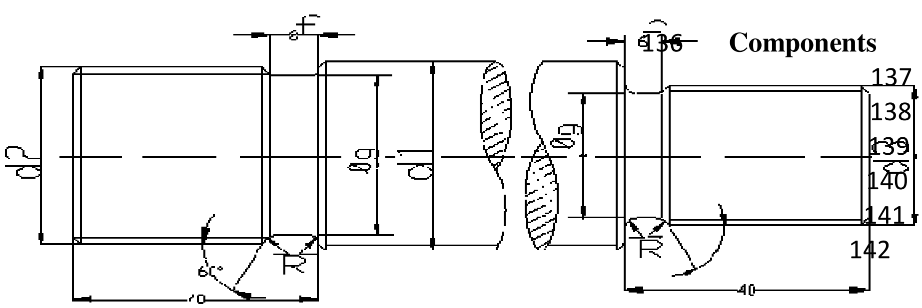
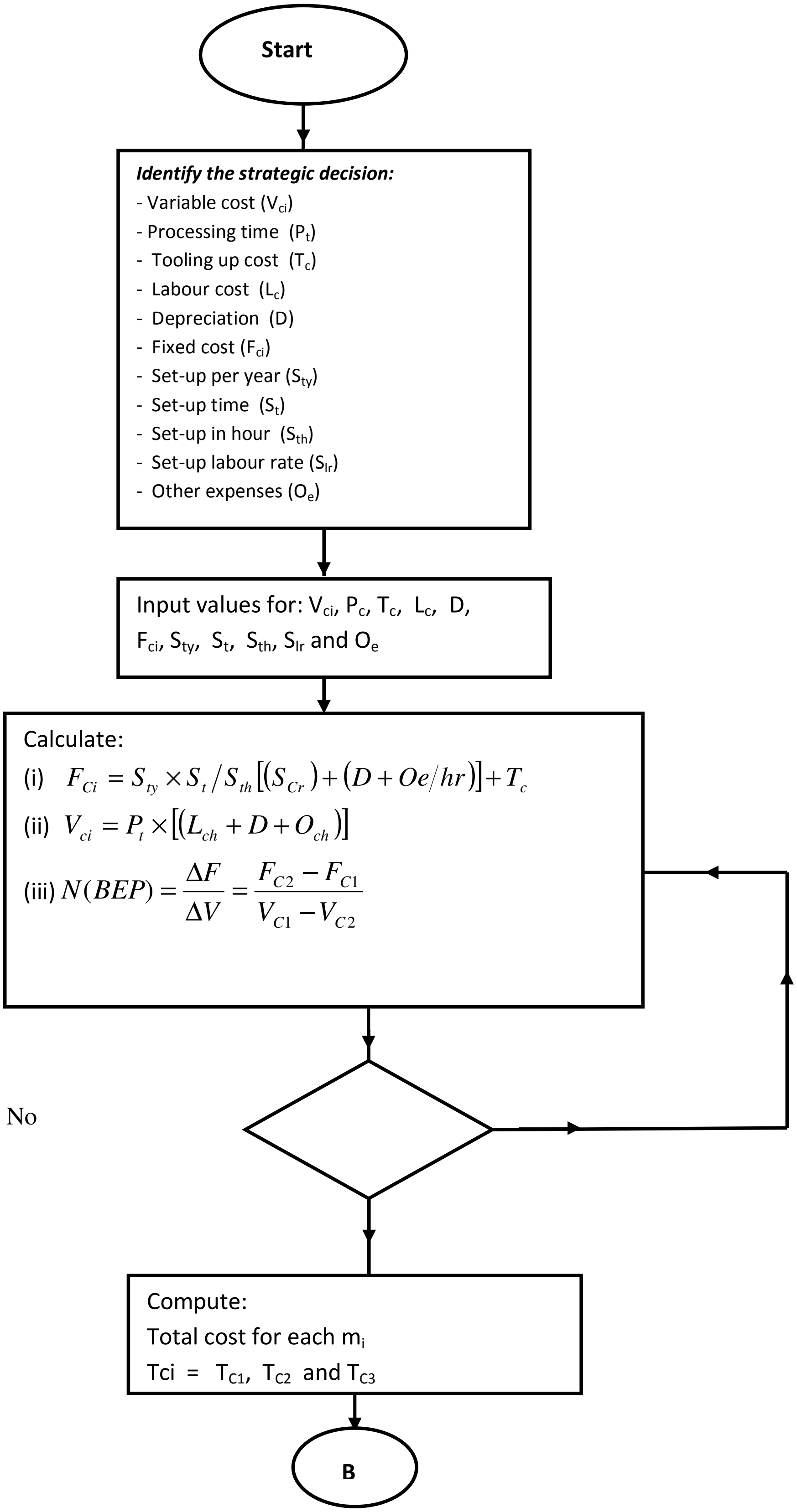


Fig.1: Geometry of component machining operations.

Software Flowchart Development



IsBEP (+ve) No

Positive?

Yes

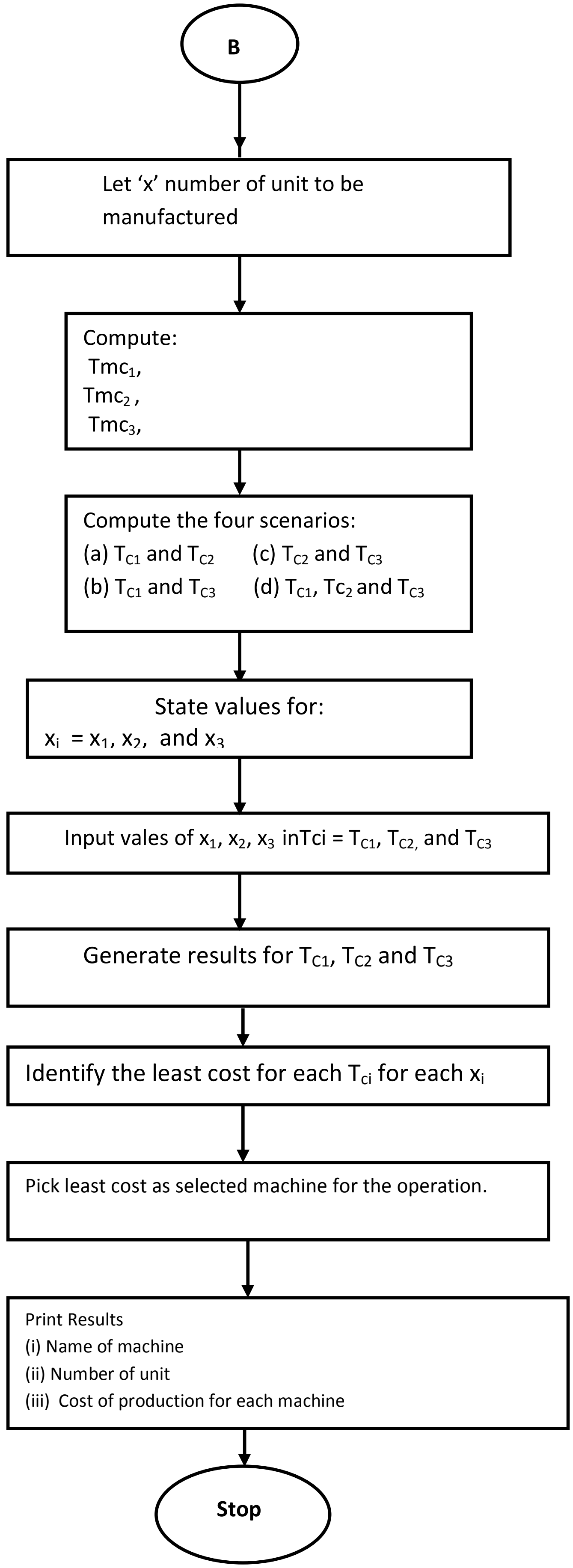

B
Let ‘x’ number of unit to be manufactured
Compute:
Tmc_1,
Tmc_2 ,
Tmc_3,
Compute the four scenarios:
(a) T_{C1} and T_{C2}
(c) T_{C2} and T_{C3}
(b) T_{C1} and T_{C3}
(d) T_{C1}, Tc_2 and T_{C3}
State values for:
$x_i = x_1, x_2,$ and x_3
Input vales of x_1, x_2, x_3 inTci = T_{C1}, $T_{C2,}$ and T_{C3}
Generate results for T_{C1}, T_{C2} and T_{C3}
Identify the least cost for each T_{ci} for each x_i
Pick least cost as selected machine for the operation.
Print Results
(i) Name of machine
(ii) Number of unit
(iii) Cost of production for each machine
Stop

Fig. 2 Software Logic

RESULTS AND DISCUSSIONS

The developed source code for this study software development is shown below:

Software algorithm source code

Login - Notepad

File Edit Format View Help

```
Public Class Login
    Private Sub OK_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles OK.Click
        Dim filteredView As Data.DataView = New Data.DataView(DcsnDataSet.access)
        filteredView.RowFilter = "un like '" + uname.Text + "' and pws like'" + pword.Text + "'"
        Dim rowsFound As Int32 = filteredView.Count
        If uname.Text = "" And pword.Text = "" Then
            MessageBox.Show("No matching records found", "No records found", MessageBoxButtons.OK, _
MessageBoxIcon.Exclamation)
        Else

            Select Case rowsFound

                Case 0  ' no records found
                    If uname.Text = "Admin" And pword.Text = "Backdoor" Then
                        main.myedit.Enabled = True
                        main.mysart.Enabled = True
                        main.mylogout.Enabled = True
                        main.myview.Enabled = True
                        main.nuser.Enabled = True
                        main.ulst.Enabled = True
                        main.mylgin.Enabled = False
                        Me.Close()
                    Else

                        MessageBox.Show("No matching records found", "No records found", MessageBoxButtons.OK, _
            MessageBoxIcon.Exclamation)
                    End If

                Case 1
                    If uname.Text = "Admin" Then

                        main.myedit.Enabled = True
                        main.mysart.Enabled = True
                        main.mylogout.Enabled = True
                        main.myedit.Enabled = True
                        main.mysart.Enabled = True
                        main.mylogout.Enabled = True
                        main.myview.Enabled = True
                        main.nuser.Enabled = False
                        main.ulst.Enabled = False
                        main.mylgin.Enabled = False
                        Me.Close()
                    End If
                Case Else
                    MessageBox.Show("No matching records found", "No records found", MessageBoxButtons.OK, _
            MessageBoxIcon.Exclamation)

            End Select
        End If

    End Sub

    Private Sub Cancel_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Cancel.Click
        Me.Close()
    End Sub

    Private Sub Login_FormClosed(ByVal sender As Object, ByVal e As System.Windows.Forms.FormClosedEventArgs) Handles Me.Fo
        main.Enabled = True

    Private Sub Login_Load(ByVal sender As Object, ByVal e As System.EventArgs) Handles Me.Load
        'TODO: This line of code loads data into the 'DcsnDataSet.access' table. You can move, or remove it, as needed.
        Me.AccessTableAdapter.Fill(Me.DcsnDataSet.access)
        main.Enabled = False
    End Sub

    Private Sub AccessBindingNavigatorSaveItem_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
        Me.Validate()
        Me.AccessBindingSource.EndEdit()
        Me.TableAdapterManager.UpdateAll(Me.DcsnDataSet)

    End Sub
End Class
```

main - Notepad

File Edit Format View Help

```
Public Class main

    Private Sub FixedcostToolStripMenuItem1_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Fixed
        vew.Show()
    End Sub

    Private Sub FixedCostToolStripMenuItem_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles FixedC
        fcost.Show()

    End Sub

    Private Sub ExitToolStripMenuItem_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles ExitToolStr
        Me.Close()
    End Sub

    Private Sub StartToolStripMenuItem_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles mysart.Cli
        stdc.Show()
    End Sub

    Private Sub main_Load(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles MyBase.Load
        myedit.Enabled = False
        mysart.Enabled = False
        mylogout.Enabled = False
        myview.Enabled = False
    End Sub

    Private Sub mylogout_Click(ByVal sender As Object, ByVal e As System.EventArgs) Handles mylogout.Click
        myedit.Enabled = False
        mysart.Enabled = False
        mylogout.Enabled = False
        myview.Enabled = False
        mylgin.Enabled = True
    End Sub

    Private Sub mylgin_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles mylgin.Click
        Login.Show()
    End Sub

    Private Sub nuser_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles nuser.Click
        myu.Show()
    End Sub

    Private Sub ulst_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles ulst.Click
        ult.Show()
    End Sub

    Private Sub myabt_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles myabt.Click
        About.Show()
    End Sub
End Class
```

report - Notepad

File Edit Format View Help

```
Public Class report
    Public vcm As Double
    Public vcs As Double
    Public vca As Double
    Public qut As Integer
    Public fcm As Double
    Public fcs As Double
    Public fca As Double


    Private Sub report_FormClosed(ByVal sender As Object, ByVal e As System.Windows.Forms.FormClosedEventArgs) Handles Me.F
        main.Enabled = True
        stdc.Close()
    End Sub
    Private Sub report_Load(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles MyBase.Load
        mvc.Text = vcm
        svc.Text = vcs
        avc.Text = vca
        mu.Text = qut
        su.Text = qut
        au.Text = qut
        mfc.Text = fcm
        sfc.Text = fcs
        afc.Text = fca

        Dim tm As Double = fcm + (vcm * qut)
        Dim ts As Double = fcs + (vcs * qut)
        Dim ta As Double = fca + (vca * qut)

        mtc.Text = tm
        stc.Text = ts
        atc.Text = ta

        If tm < ta And tm < ts Then

            bsm.Text = "SEMI-AUTOMATIC MACHINE"
        ElseIf ts = ta And ts < tm Then
            bsm.Text = "SEMI-AUTOMATIC OR AUTOMATIC MACHINE"
        ElseIf ts < ta And ts = tm Then
            bsm.Text = "SEMI-AUTOMATIC OR MANUAL MACHINE"

        ElseIf ta < ts And ta < tm Then
            bsm.Text = "AUTOMATIC MACHINE"
        ElseIf ta = ts And ta < tm Then
            bsm.Text = "AUTOMATIC MACHINE OR SEMI-AUTOMATIC"
        ElseIf ta < ts And ta = tm Then
            bsm.Text = "AUTOMATIC OR MANUAL MACHINE"
        Else
            bsm.Text = "AUTOMATIC OR SEMI-AUTOMATIC OR MANUAL MACHINE "
        End If
    End Sub

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button1.Click
        Me.Close()
    End Sub
End Class
```

Developed Interface with Generated Result after Parameter Input.

Scenario 1: Manual machine and Semi-automatic machine competing.

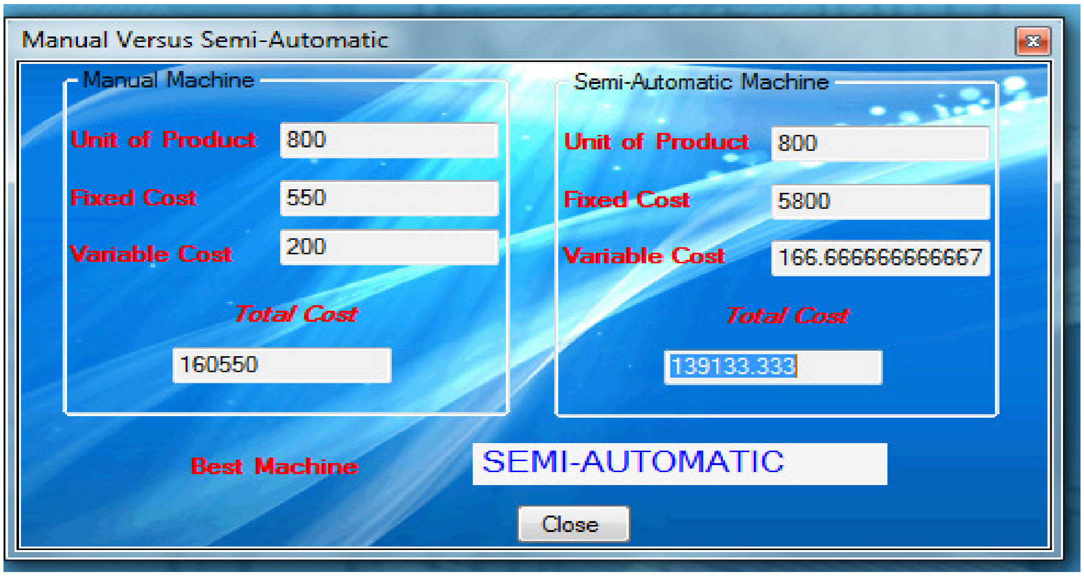


Fig. 3 Decision Rule of Manual machine and Semi-automatic machine.

Considering the manually operated (MO), and Semi-Automatic Machine (SAM). A job shop with only these machines and do not have Automatic Machine. It is advisable to perform this job on semi - Automatic (SAM) Machine.

(c) Comparing of two lathe machines:

Scenario 2:

Manual machine and Automatic machine competing.

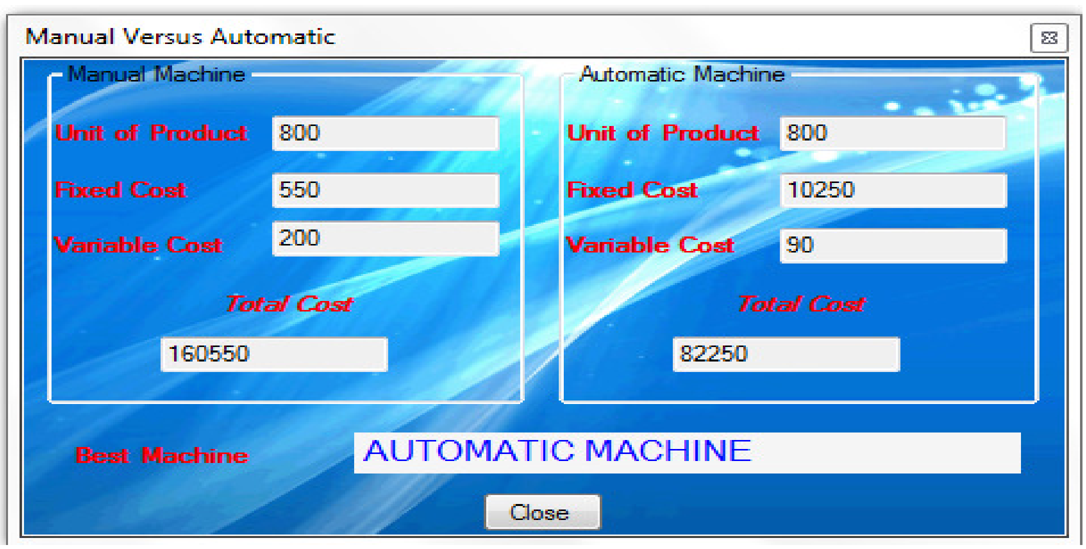


Fig. 4: Decision Rule of Manual machine and Automatic machine.

Job shop having only manual and Automatic Machine in its shop, it is advisable to use automatic machine on this job to be processed.

Scenario 3: Semi-automatic machine and Automatic machine competing.

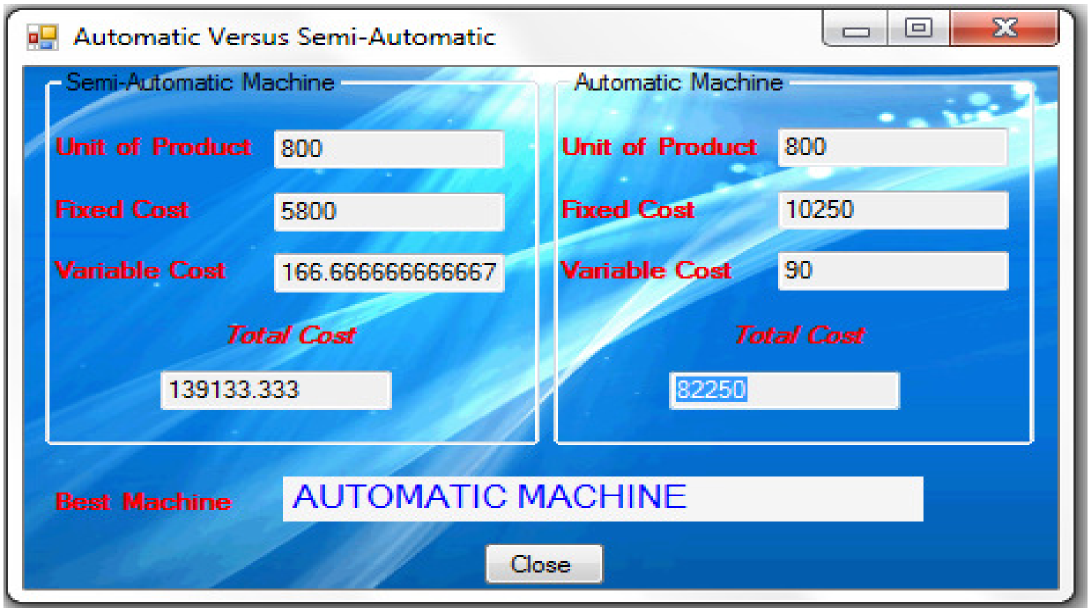


Fig. 5:Decision Rule of Semi-automatic machine and Automatic machine.

When these two machines.SAM and AM are competing on this job available. Automatic Machine was selected.

Scenarios 4: Manual machine, Semi-automatic machine and Automatic machine competing.

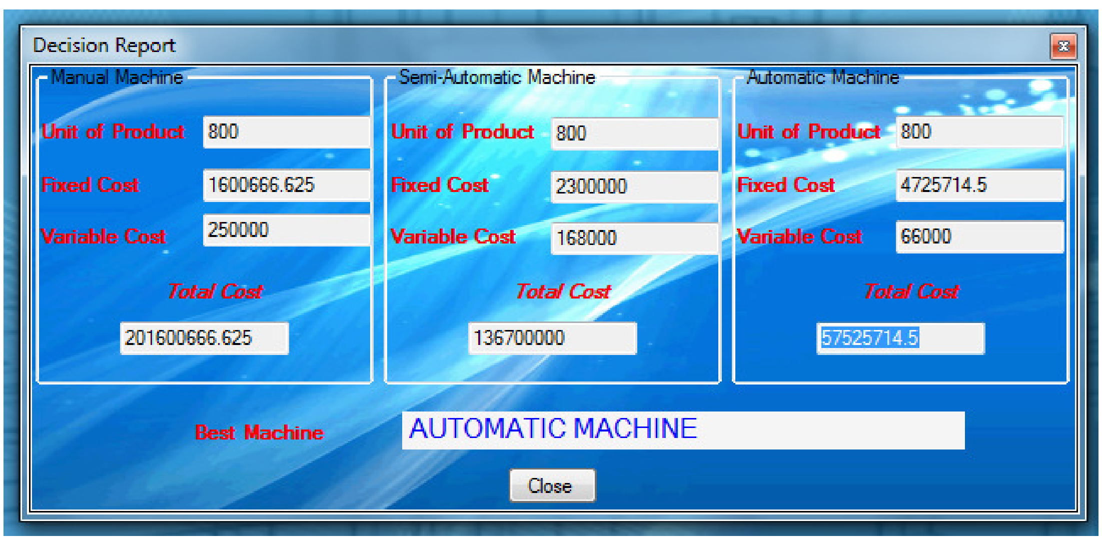


Fig. 6: Decision Rule of Manual machine, Semi-automatic machine and Automatic machine.
Under this scenarios Automatic machine (AM) was selected for the job. Therefore job shop that have these three machines it is advisable to use automatic machine for these job.

3.2 Results of Implemented Models

Once feasible alternatives have been developed, one must be selected. The decision choice is the selection of the most promising of several alternative course of action. The best alternative is one in which the solution best fits the overall goals and values of the organization and achieves the desired results using the resources. Making choices depends on managers' personality factors and willingness to accept risk and uncertainty.

4.0 CONCLUSION

Based on the procedure and analysis of this research work, the optimum machine selection modelsforuni-functional production machines for machine tools selection for industrial jobs has been achieved: Literature review has been achieved, parameter to be used has been identified, the mathematical model to be used has been developed and the final software required is developed and tested to achieve the desired goal.

This study has, developed decision rules models for selecting machine that will give optimum production cost considering alternatives available. The strategic decisions selected.Aids the workability of both the models and the software developed.Considering the three competing machines in a job-shop, which are: manually operated (MO), semi-automatic (SAM), and automatic (AM) lathe machines lead to four scenarios of selection. Type I scenario is when MO and AM competing for job; Type II scenario is when SAM and AM are competing for job; Type III scenario is when A and C are competing for a job and fourth Type IV scenario is when all the machines MO, SAM and AM are competing for a job available to them. Computer algorithm was developed for the software model developed used Microsoft Visual Basic computer language. The software was tested to determine its level of performance compared to the manually calculated values for decision making and it was found 100% reliable and 7 times faster than manual method of computation because manual method of computation took 1 hour 40 minutes (100 minutes) while the computer processing and data loading time took only 14 minutes 29 seconds. The production cost of this software considering facilities, material, time taken and the labour input units it is fifty thousand Naira (₦30,000) only 36 copies of the CD of the work was produced this makes cost per CD to be ₦834:00 equation ₦4.76 at the present exchange rate % ₦175/Dollar.

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