Computer Aided Design of Mechanical Clutch.

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ABSTRACT

In this work, software was developed which accurately determined the torque, axial thrust, and mean radius of clutch discs. Comparison was made between a conventionally designed and Computer-Aided Designed (CAD) mechanical clutch using cast iron and bronze as clutch materials. This was done using a computer system with processor speed of 2.3 GHz and JAVA programming language. The platform for the software is a Graphic User Interface (GUI). The software package contains unit conversion and code. The code was used to design two clutch discs with respective external and internal radii of 150 and 75 mm, for cast iron and, 120 and 96 mm for bronze. The results showed that the measured values of mechanical clutches designed using computer-aid over the conventionally designed ones are more accurate. The degree of accuracy of uniform pressure are respectively 1.2965×10^{-4}, 2.8629×10^{-7} and 1.3025×10^{-3}, while the corresponding accuracy of axial wear are 1.2965×10^{-4}, 0 and 1.2965×10^{-4} for axial thrust, mean radius, and torque for cast Iron. For bronze, similar trend was observed. Accuracy in the design of mechanical clutch was achieved using the developed code.

(Keywords: clutch, computer aided design, CAD, conventional, mechanical, accuracy, develop)

INTRODUCTION

A clutch is a machine member used to connect driving shaft to the driven shaft so that the driven shaft may be started or stopped at will, without stopping the driving shaft (Khurmi and Gupta, 2006). There are three states in which clutch can be found. These states are disengaged, clutch slipping and engaged.

Clutches are useful in cars and other devices that have two rotating shafts. In these devices, one shaft is typically driven by a motor, and the other shaft drives another device like gearbox in case of cars (Karim, 2006). The function of an engaging friction clutch is to transmit torque gradually, to avoid high accelerations or jerks, when the engine is connected to the rest of the driveline. This torque is transferred from the engine through the pressure plate onto one or more friction plates connected to the transmission input shaft. These plates are pushed apart by a diaphragm springs. When the clutch is fully disengaged the clutch plates are not in mechanical contact and no torque is transmitted.

When the clutch is engaged a normal force on the pressure plate pushes the clutch plates towards each other. The clutch now starts slipping and an increasing amount of torque can be transmitted. The velocities of the plates will become equal and the plates stick. The clutch is now fully engaged and can transmit torque from the engine up to the maximum static friction torque (Dassen and Serrarens, 2003).

A clutch consists of a plate whose both sides are faced with a frictional material. It is mounted on the hub which is free to move axially along the splines of the driven shaft. The pressure plate is mounted inside the clutch which is bolted to the flywheel. Both the pressure plate and the flywheel rotate with the engine crankshaft or the driving shaft. The pressure plate pushes the clutch towards the flywheel by a set of strong springs which are arranged radially inside the body. The three levers are carried on pivots suspended from the case of the body; these are arranged in such a manner so that pressure plate moves away from the flywheel by the inward movement of a thrust bearing. The bearing is mounted upon a forked shaft and moves forward when the clutch pedal is pressed. When the clutch is pedal is pressed down, its linkage forces the thrust release to move in towards the flywheel and pressing the longer ends of the lever inwards. The levers are forced to turn on their suspended pivot and the pressure plate moves away from the flywheel by the knife edges, thereby compressing the clutch springs. This action removes the pressure from the clutch plate and thus moves the pressure from the clutch plate and thus moves back from the flywheel and the driven shaft becomes stationary.

On the other hand, when the foot is taken off from the clutch pedal, the thrust bearing moves back via the levers. This allows the springs to extend and thus the pressure plate pushes the clutch plate back towards the flywheel. The axial pressure exerted by the spring provides a fractional force in the circumferential direction when the relative motion between the driving and the driven members tends to take place. If the torque due to this frictional force exceeds the torque to be transmitted, then no slipping takes place the power is transmitted from the driving shaft to the driven shaft (Khurmi and Gupta, 2006).

The clutch is subjected to massive loads and intense heat due to its position and mode of operation of clutch. The concept and system of automobile production has generally remained the same since the first motorized vehicle appeared on the road about a hundred years ago. After about a century, basic changes are taking place in the very concept of the automobile and its system of production. Automobile production now is quite different from that of the last hundred years (Amin, 1990).

Some of the important features of the automobiles are: improved performance, increased creature comforts, and rapidly changing designs. To cater for this changing automobile demand characteristics, the use of computer was adopted in design and manufacturing processes. This has brought about many benefits into the manufacturing industries such as monitoring the progress of a problem solution and terminating the run or modifying the input data as required, reduction of the input data as required, drafting labor and number of drawings required, high accuracy, evaluation of alternatives to mention but a few. This innovation has greatly shortened the period between design and manufacture and greatly expanded the scope of production processes for which automated machinery could be economically used (Amin, 1990). The objective of this work is to use develop software that will design a mechanical clutch by accurately determining the torque, axial thrust, mean radius of clutch disc and compare the result of manually designed clutch and the computer designed clutch using the same parameters.

MATERIALS AND METHODS

This was done using the following materials:

- A computer system with window XP operating system and processor speed of 2.3 GHz for compiling programs.
- JAVA programming language was used to write and debug programs and publish a computer software application.
- Other software applications like Firefox and .Net bean were used.

The procedures for the CAD of the clutch system were grouped into three major stages. These were employed in developing the computer software application package that has been proposed in the objectives of this work. The three major stages are:

- Theoretical design process
- Software design process
- Software packaging

THEORETICAL DESIGN PROCESS

<u>Design of a disc clutch</u>

Considering two friction surfaces maintained in contact by an axial thrust (W) as shown in the Figure 1a.

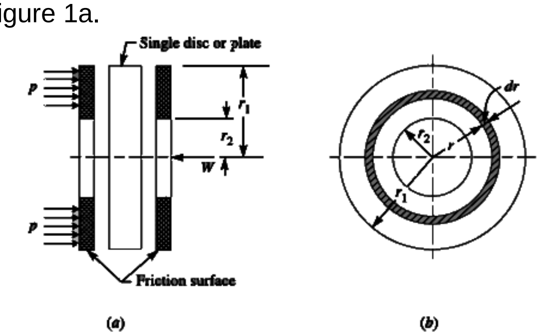

Figure1: Forces on a Disc. (Source: Khurmi and Gupta, 2006).

Let T = torque transmitted by the clutch

p = intensity of axial pressure with which contact surface are held together

r_1 and r_2 = external and internal radii of friction faces

R = mean radius of the frictional faces and

μ = coefficient of friction

Considering an elementary ring radius r and thickness dr as shown in the Figure1b we know that area of the contact surface or friction surface

$$= 2\pi r dr \qquad \textbf{(1)}$$

:. Normal or axial force on the ring:

$$\delta W = \text{Pressure x Area} = p \times 2\pi r dr \qquad \textbf{(2)}$$

and the frictional force on the ring acting tangentially at radius r:

$$F_r = \mu = \delta W = \mu p \times 2\pi r dr \qquad \textbf{(3)}$$

:. Frictional torque acting on the ring:

$$T_r = F_r \times r = \mu.p \times 2\pi r.dr \times r = 2\pi\mu p.r^2 dr \qquad \textbf{(4)}$$

We shall now consider the following two cases: When there is uniform pressure and when there is a uniform pressure axial wear.

Considering Uniform Pressure

When the pressure is uniformly distributed over the entire area of the friction face as shown in Figure 1a, then the intensity of pressure:

$$p = \frac{W}{\pi[(r_1)^2 - (r_2)^2]} \qquad \textbf{(5)}$$

Where,

W = Axial thrust with which the friction surfaces are held together

From Equation (4), The friction torque on the elementary ring of radius r and thickness dr is:

$$T_r = 2\pi\mu.p.r^2 dr \qquad \textbf{(6)}$$

Integrating the Equation (6) within the limits from r_1 to r_2 for the total friction torque.

$$T = \int_{r_2}^{r_1} 2\pi\mu.p.r^2$$

:

. Total frictional torque acting on the clutch

$$= 2\pi\mu.p\left[\frac{r^3}{3}\right]_{r_2}^{r_1} \qquad \textbf{(7)}$$

$$= 2\pi\mu.p\left[\frac{(r_1)^3 - (r_2)^3}{3}\right]$$

$$= 2\pi\mu \times \frac{W}{\pi[(r_1)^2 - (r_2)^2]} \times \left[\frac{(r_1)^3 - (r_2)^3}{3}\right] \qquad \textbf{(8)}$$

Substituting the value of p in Equation (5) from Equation (8), we have:

$$T = \frac{2}{3}\mu w\left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2}\right] = \mu wR \qquad \textbf{(9)}$$

Where $R = \frac{2}{3}\left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2}\right]$ = mean radius of the friction surface:

Considering Uniform Axial Wear

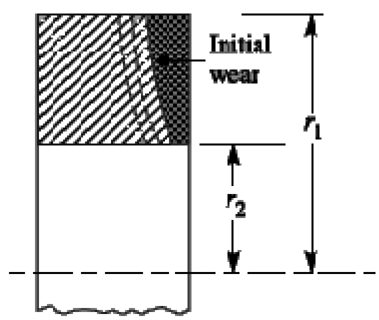

Figure 2: Uniform Axial Wear. (Source: Khurmi and Gupta, 2006)

The basic principle in designing machine parts that are subjected to wear due to sliding friction is that the normal wear is proportional to the work of friction the work of friction is proportional to the product of normal pressure (p) the sliding velocity (v) therefore, normal wear α work of friction α p .v

p. v = k (constant)

$$\text{Or} \quad p = \frac{k}{v} \qquad \textbf{(10)}$$

It may be noted that the friction surface is new, there is uniform pressure distribution one the entire contact surface. The pressure will wear most rapidly when the sliding velocity is maximum and this will reduce the pressure between the surfaces this wearing in process continues until the produced is uniform as in the Figure 2.

Let p be the normal intensity of pressure at a distance r from the axis of the clutch since the intensity of pressure varies inversely with the distance therefore:

$p\ v = C$ (a constant) **(11)**

Or $p = \frac{C}{V}$

And the normal force on the ring:

$\delta W = p.2\pi r.\ dr$

$= \frac{C}{r} \times 2\pi r.dr = \frac{C}{r} \times 2\pi r.\ dr = 2\pi c dr$ **(12)**

:. Total force acting on the friction surface

$W = \int_{r_2}^{r_1} 2\pi C dr = 2\pi C[r]_{r_2}^{r_1}$

$= 2\pi C\ (r_1 - r_2)$ **(13)**

Or $C = \frac{W}{2\pi(r_1 - r_2)}$ **(14)**

We know from Equation (6) that the frictional torque acting on the ring:

$T_r = 2\pi\mu p r^2 dr = 2\pi\mu \times \frac{C}{r} \times r^2 dr = 2\pi\mu c r dr$

(.: $P = c/r$) **(15)**

Integrating the eq. (xv) within the limits from r_1 to r_2 for the total friction torque:

$T = \int_{r_2}^{r_1} 2\pi\mu c r dr$ **(16)**

:. Total frictional torque acting on the friction surface (or on the clutch):

$= 2\pi\mu c[\frac{r^2}{2}]_{r_2}^{r_1}$ **(17)**

$= 2\pi\mu c[\frac{(r_1)^2 - (r_2)^2}{2}] = \pi\mu c[(r_1)^2 - (r_2)^2]$ **(18)**

$= \pi\mu \times \frac{W}{2\pi(r_1 - r_2)}[(r_1)^2 - (r_2)^2]$ **(19)**

$= \frac{1}{2} \times \mu w\ (r_1 + r_2) = \mu w R$ **(20)**

Where $R = \frac{r_1 + r_2}{2}$ = mean radius of the friction surface.

SOFTWARE DESIGN PROCESS

The software design process was divided into four parts which are:

- Analysis
- Algorithm design
- Coding
- Testing (Adejuyigbe, 2002)

They are considered broadly below.

ANALYSIS

A proper identification of objective was possible through analysis. The specification of the software and select the appropriate data structure was clearly examined. The software package has the following characteristics. It produced the assembly view of the product in 2D. It displayed parameters needed for the clutch. It is user friendly and easily accessible. The software worked based on the input of certain parameters. The software accurately manipulated the input parameters through the written codes (which are the design equations) to determine various results.

Algorithm Design: An Algorithm is an unambiguous set of instructive or executable actions or steps that must be taken in order to solve a particular problem. The design involves development of instructions in a logical manner so that execution of the instruction results in the solution of the problem. The use of flowchart made it simpler during the programming stage. Flow chart was used in other to avoid algorithmic ambiguity.

Below is the flowchart for the Computer Aided Design of the clutch:

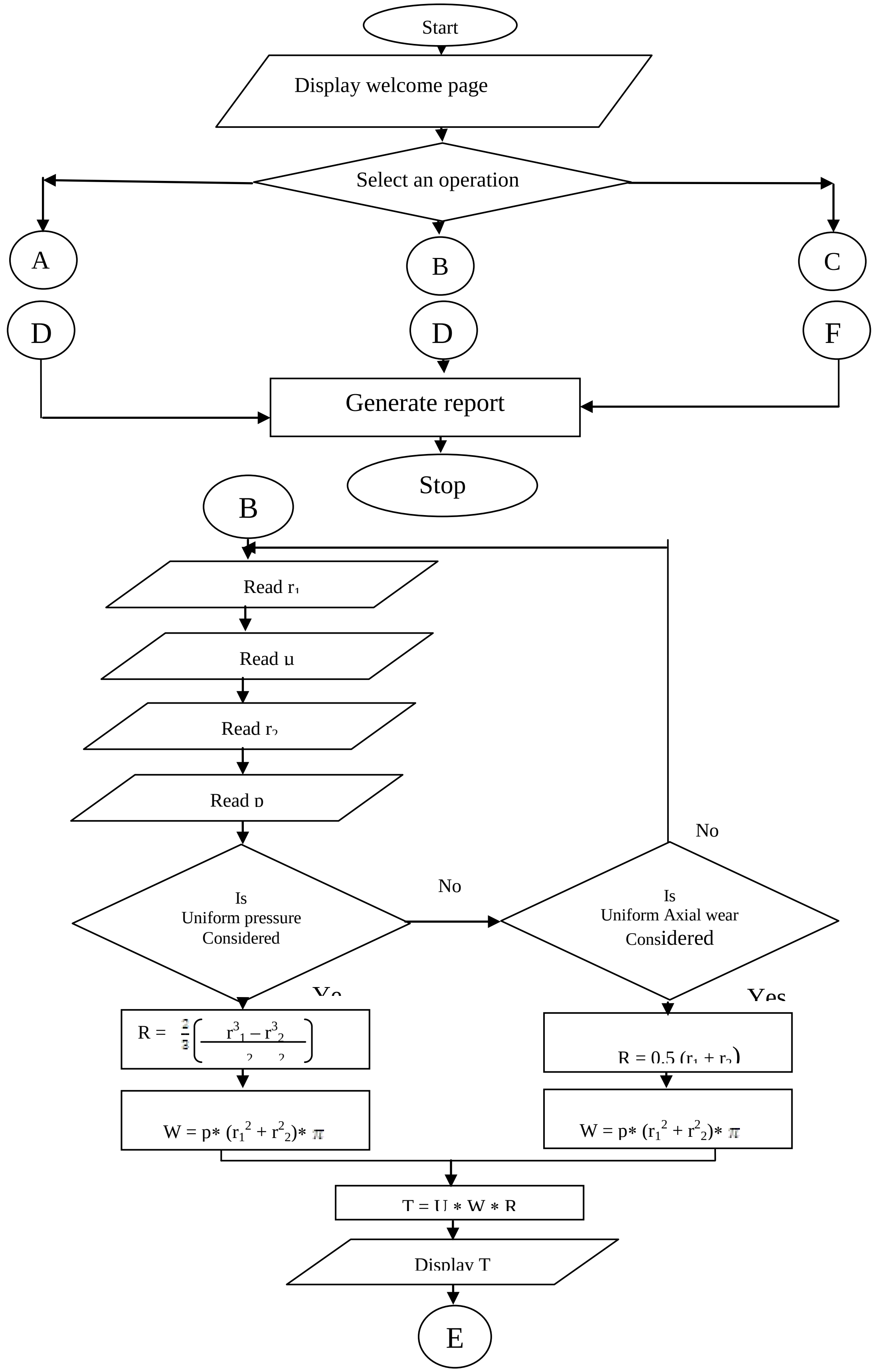

Figure 4: Flowchart of the Design of the Clutch.

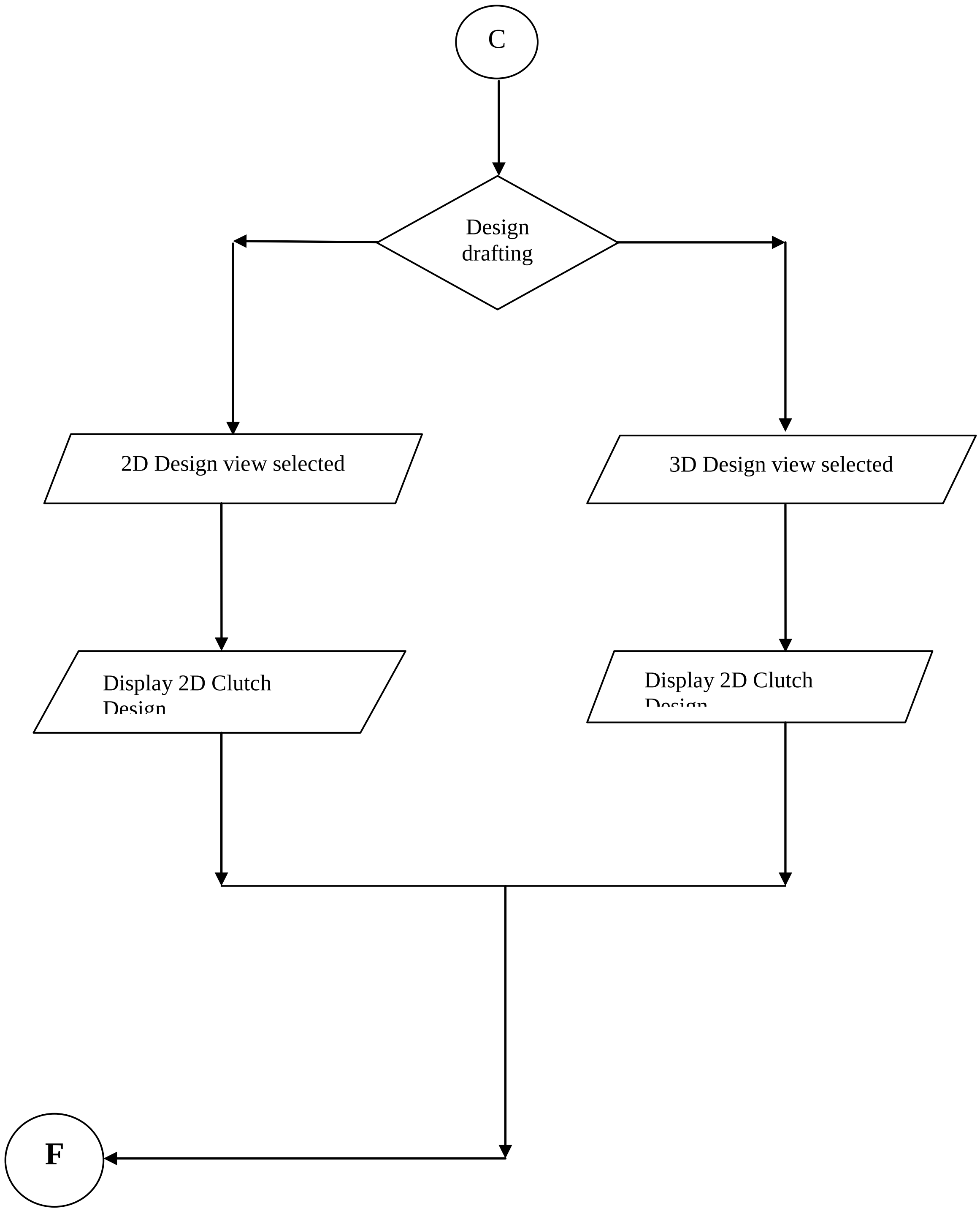

Figure 5: Flowchart of the Design Drafting of the Clutch.

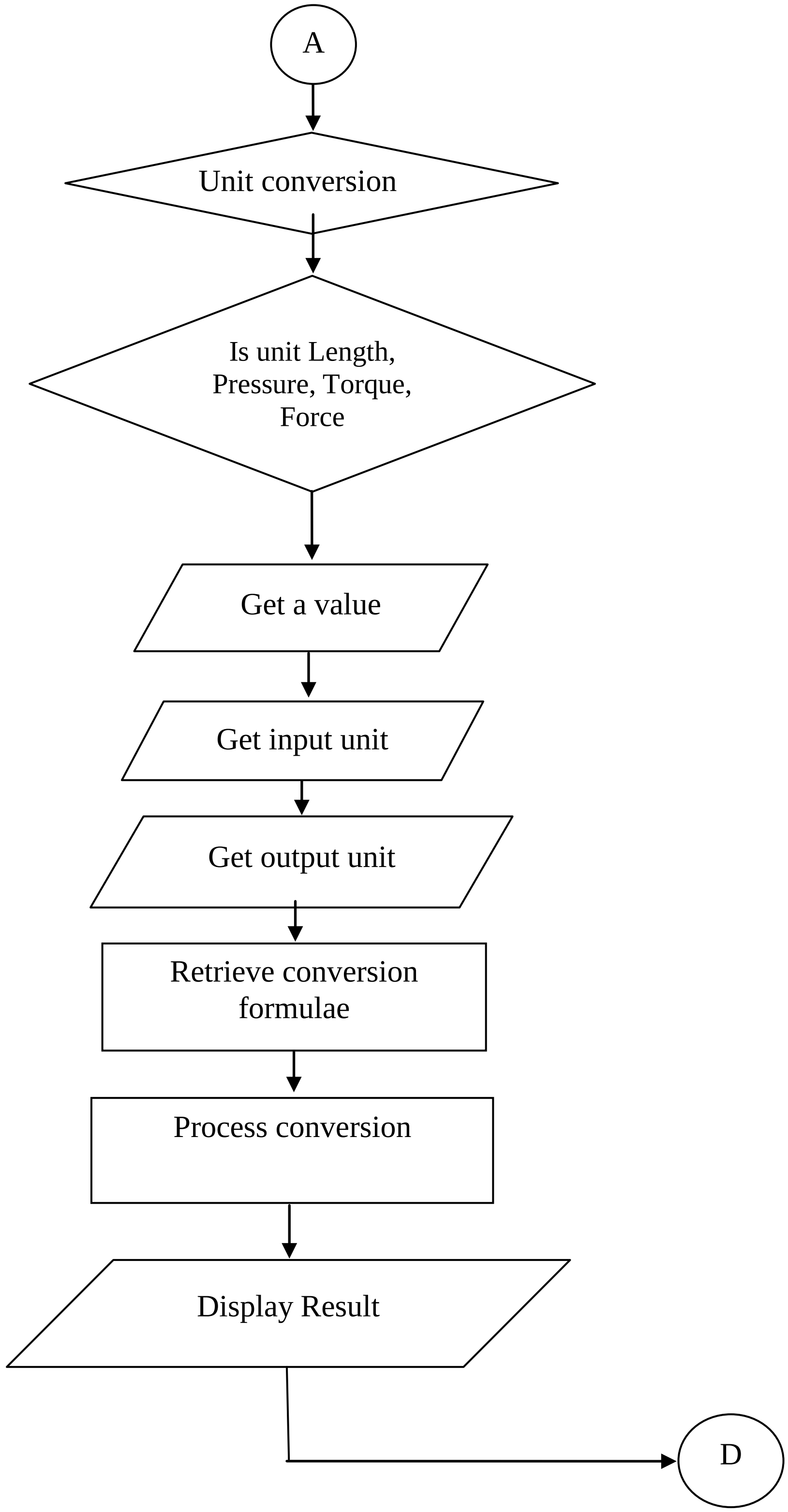

Figure 6: Flowchart of the Clutch Design Unit Conversion.

Table 1: The Nomenclature of Input and Output Data used in the Flow Chart of Computer-Aided Design of Mechanical Clutch.

Symbol	Meaning
T	Torque transmitted by the clutch
p	Intensity of axial pressure with which contact surface are held together
r_2	Internal radii of friction faces
r_1	External radii of friction faces
R	Mean radius of the frictional faces
μ	Coefficient of friction

Coding

This is the program writing phase of the software design. In any Computer Aided Design where a software application is to be developed the coding stage of design is the major and delicate aspect since an accurate and efficient coding system will give rise to the software working properly (Ejiro 2010). Codes were written in this phase of the software design. This was the major and delicate aspect of software application development since an accurate and efficient coding system gave rise to proper working of the software. While making use of the IDE to compile the program, it was checked for errors by debugging each stage of the code. Debugging helped to avoid too many untraceable errors.

Testing

Testing was used to determine if the software was working properly. In testing the clutch design software, a practical design case was executed by the software and result was compared with that of the practical design since that of the practical design has already been accepted as being correct.

SOFTWARE PACKAGING

The software was converted from a program code to an executable file extension ".exe", all applications and software we use on our computers always have an executable file. This file helps the normal computer interface to run the software instead of an IDE.

CAD OF CLUTCH

All parts are built up on the same principle. There is the schematic part; each part comprises of points, lines and planes, describing all clutch-specific points for the definition of the entire clutch geometry.

INTERFACE

The interface was designed with JAVA programming language because it does not interact directly with a computer's central processing unit (CPU) or operating system therefore enabled the software to run on any type of personal computer. The Interface showed the design of all the components and their labels

RESULTS AND DISCUSSIONS

The program was design to have a graphic user interface (GUI) which means that it contains graphical features such as windows, menus dialog boxes, and features that make the application easy to use. After a successful packaging of the software, which succeeded the software design process, the software application was then be analyzed. Analysis of the clutch design software is highlighted as follows starting with the major design windows.

Welcome Screen: It shows the title of the project and it has a button "**Next**", when this button is clicked software begins to run fully (Plate 1).

Plate 1: Welcome Screen.

Main Design Window: It is a multi-document window capable of housing more than one window at a time, where you can maximize and minimize any one of your choice. The multi document window has various menus; file, design consideration, unit conversion and design drafting (Plate 2).

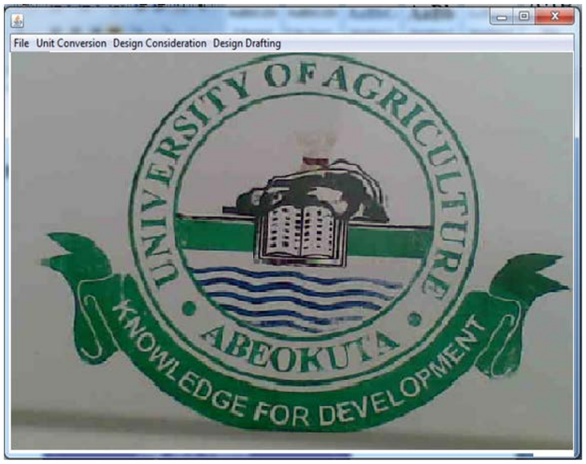

Plate 2: Main Design Window.

Unit Conversion Window: When you click the unit conversion menu a drop down menu opens showing pressure, force, length and torque (Plate 3).

Plate 3: Unit Conversion Menu Window.

Length Conversion Window: It opens after clicking length in the unit conversion menu of the multi document window (Plate 4). This contains millimeter, centimeter, meter, inches and feet units. The user inputs the quantity he/she wants to convert in the space, "convert what quantity?", and then click on the parameter he/she is changing from (Plate 5), as well do the same to the parameter he/she is changing to (Plate 6); and then the "convert" button. The parameter converts to the desired parameter in the space, "result" There is also a "reset" button that is used to clear the input field.

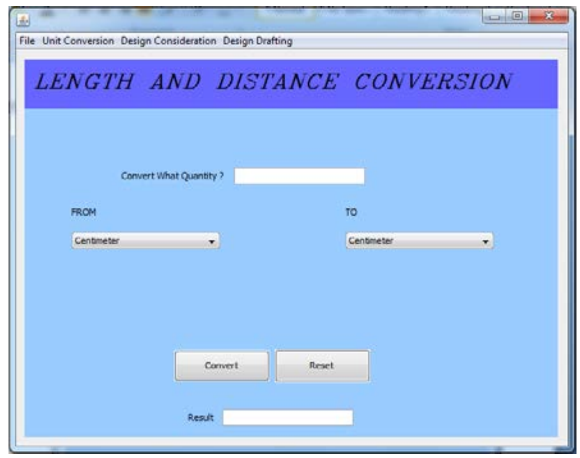

Plate 4: Length Conversion Weight.

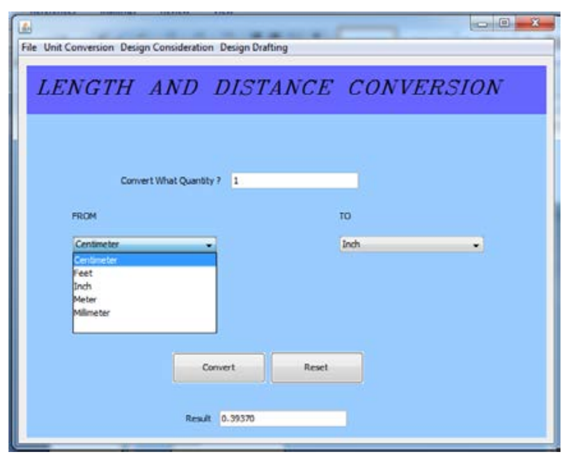

Plate 5: Input Units for Length Conversion.

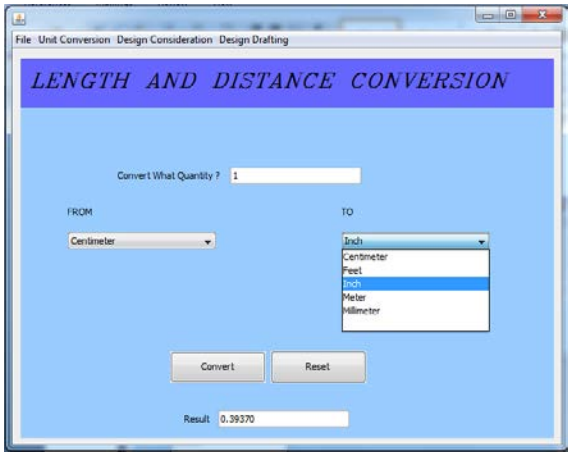

Plate 6: Output Units for Length Conversion.

Pressure Conversion Window: It opens after clicking pressure in the unit conversion menu of the multi document window (Plate 7). This contains atmosphere, bar, Newton/square millimeter, megapascal, kilogram-force/square meter, kilonewton/square meter, kilopascal, Pascal, millimeter of mercury [0°C] and pounds/square inch units. The user inputs the quantity he/she wants to convert in the space, "convert what quantity?" and then click on the parameter he/she has already or is changing from (Plate 8) as well do the same to the parameter he/she is changing to (Plate 9); and then click on the 'convert' button the parameter converts to the desired parameter in the space, "result". There is also a "reset" button that is used to clear the input field.

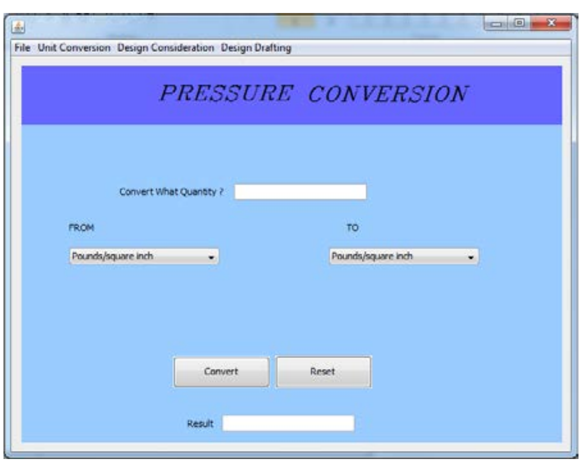

Plate 7: Pressure Conversion Window.

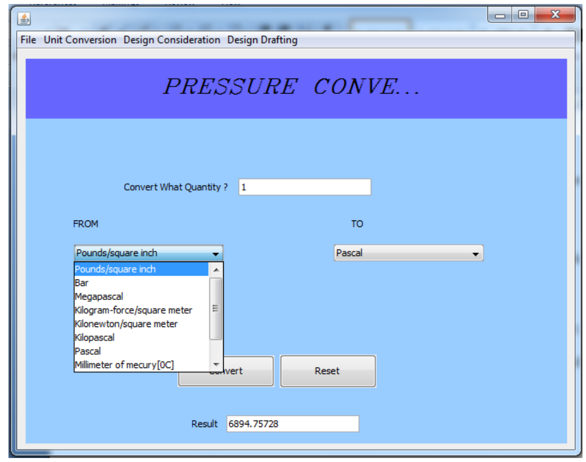

Plate 8: Input Units for Pressure Conversion.

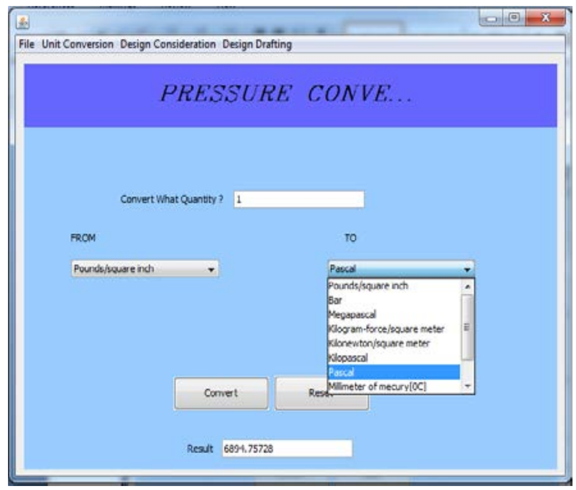

Plate 9: Output Units for Pressure Conversion.

Torque Conversion Window: It opens after clicking torque in the unit conversion menu of the multi document window (Plate 10). This contains Newton meter, Newton millimeter, pounds inch, pounds feet, ounce inch and ounce feet units. The user inputs the quantity he/she wants to convert in the space, "convert what quantity?" and then click on the parameter he/she is changing from (Plate 11) and as well do the same to the parameter he/she is changing to (Plate 12); and clicking on the "convert" button the parameter converts to the desired parameter in the space, 'result'. There is also a 'reset' button that is used to clear the input field.

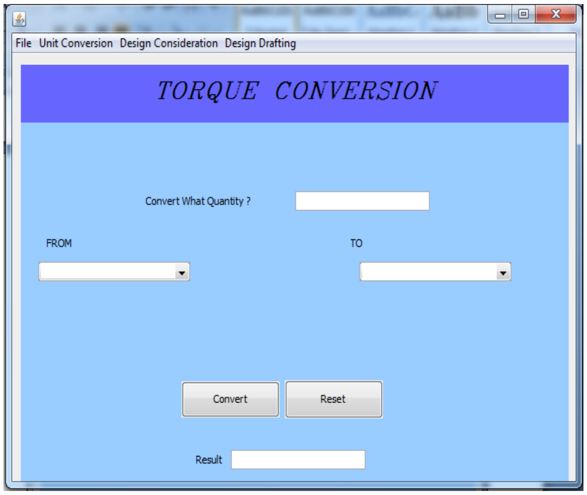

Plate 10: Torque Conversion Window.

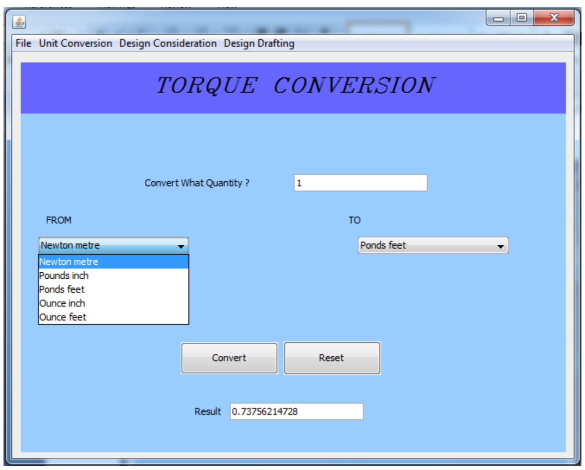

Plate 11: Input Units for Torque Conversion.

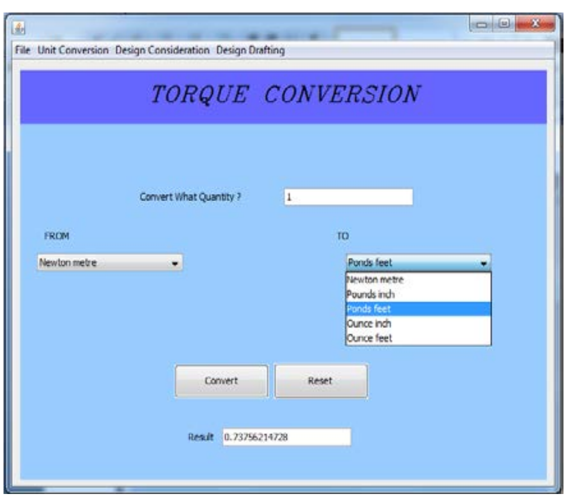

Plate 12: Output Units for Torque Conversion.

Force Conversion Window: It opens after clicking force in the unit conversion menu of the multi document window (Plate 13). This contains joule/meter, Newton, ounce-force, kilonewton, kilogram-force and pounds units.

The user inputs the quantity he/she wants to convert in the space, "convert what quantity?" and clicking on the parameter he/she is changing from (Plate 14) and as well do the same to the parameter he/she is changing to (Plate 15); and then click on the "convert" button the parameter converts to the desired parameter in the space, "result". There is also a "reset" button that is used to clear the input field.

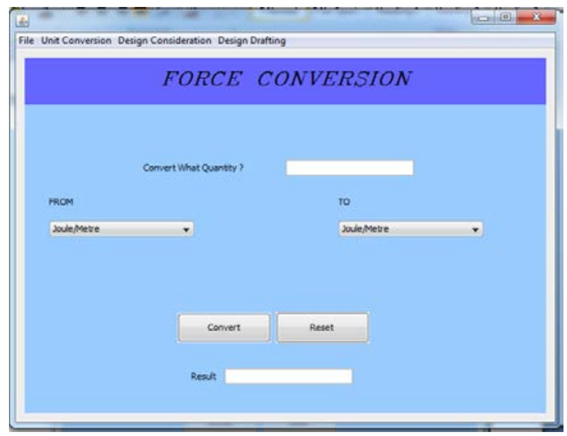

Plate 13: Force Conversion Window.

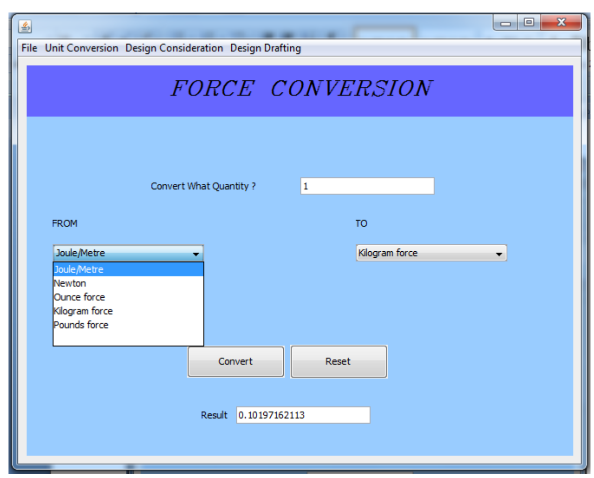

Plate 14: Input units for Force Conversion.

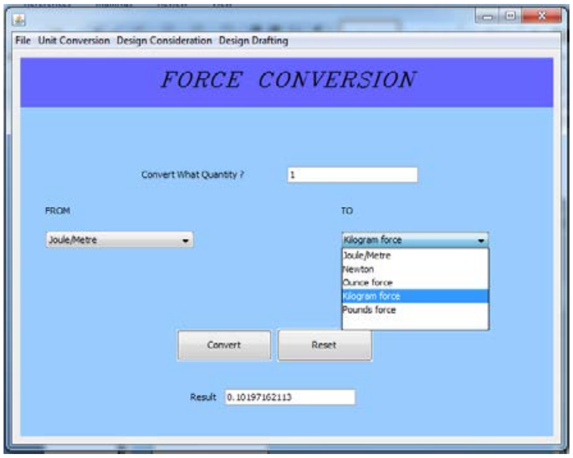

Plate 15: Output Units for Force Conversion.

Design Consideration Window: When you click on design consideration a drop down menu opens showing uniform pressure and uniform axial wear (Plate 16). When you click on either uniform pressure or uniform axial wear, suggestions for clutch materials you can choose from will open (Plate 17). You may choose to ignore the suggested materials. If either be the case one can click next to continue to the design window.

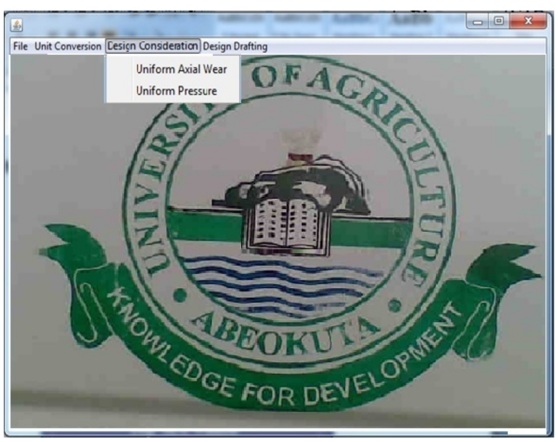

Plate 16: Design Consideration Menu Window.

Clutch material window: When you click the material of your choice, and then "Next" button; as stated earlier you may decide to ignore those materials and go on (Plate 17). Depending on what you clicked before material window opened, either uniform pressure or uniform axial wear, the window will now come up.

For each of the design considerations you have chosen, spaces for inputting design parameters will show where the values for r_1, r_2, μ and p which stand for external radius of friction face, internal radius of friction face, coefficient of friction and intensity of axial pressure with which contact surface are held together respectively will be typed in. Also a button "calculate" which when clicked it will display the result for axial thrust, mean radius and torque for uniform pressure and uniform axial wear respectively and a reset button for clearing the input field (plates 18 and 19).

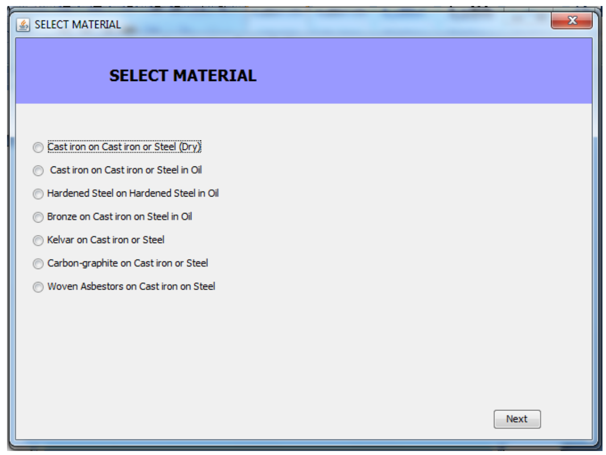

Plate 17: Clutch Materials Window.

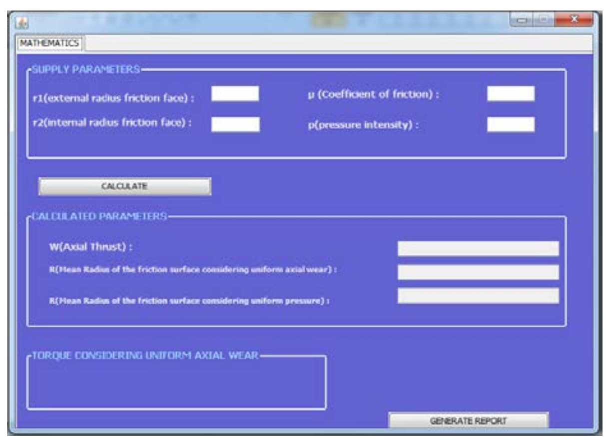

Plate 18: Design of Clutch when Uniform Axial Wear is Considered.

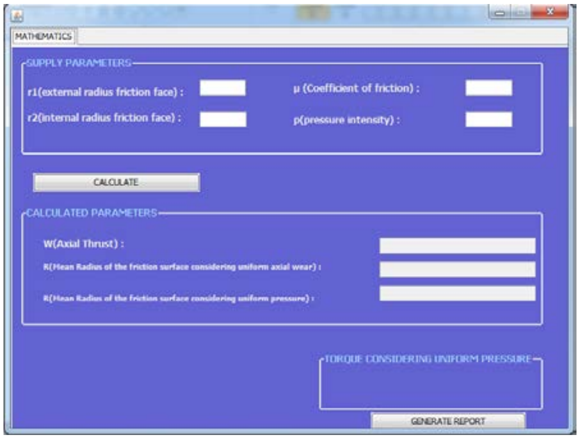

Plate 19: Design of Clutch when Uniform Pressure is Considered.

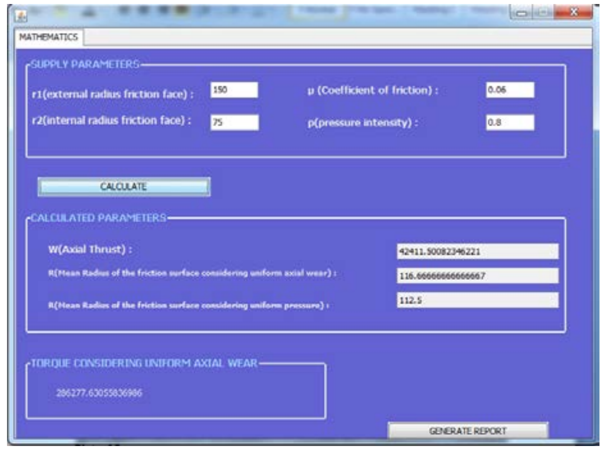

Plate 22: Shows the Second Test of Design of Mechanical Clutch Software using Cast Iron on Cast Iron when Uniform Axial Wear is Considered.

TESTING

Firstly the software was tested with a practical design to check for its validity and accuracy using cast iron on cast iron (dry) and bronze on cast iron for the second test. The clutch design was made under two considerations; uniform pressure and uniform axial wear. The clutch software design results for different dimensions are shown on plates 22 to 23. The detailed output is shown in Tables 2 and 3. The conventional design results for different dimensions are shown in Tables 4 and 5. The results for the design done conventionally were compared with the result obtained with software design. The difference in their results is shown in Tables 6 and 7. The unit of conversion for length, force, pressure and torque were also tested and tabulated.

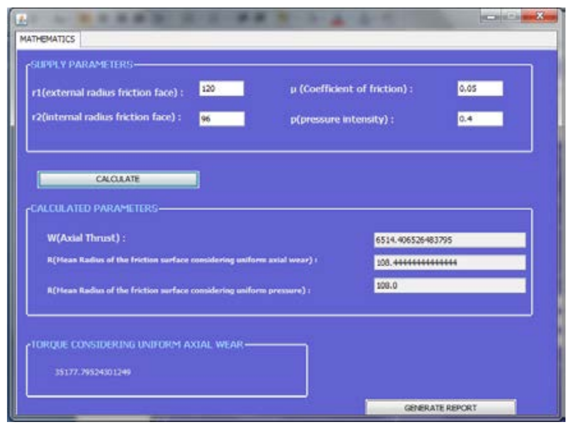

Plate 23: Second Test of Design of Mechanical Clutch Software using Bronze Iron on Cast Iron when Uniform Pressure is Considered

Table 2: First Test Result of Design of Mechanical Clutch Software using Cast Iron on Cast Iron.

Using cast iron on cast iron (dry) plate.	Result
Internal radius	150 mm
External radius	75 mm
Coefficient of friction	0.06
Pressure intensity	0.8N/mm²
Axial thrust	42411.50082346221 N
Mean radius (uniform pressure)	116.66666666666667 mm
Mean radius (uniform axial wear)	112.5 mm
Torque (uniform pressure)	296880.50576423545 N-mm
Torque (uniform axial wear)	286277.630558366986 N-mm

Source: Output from the mechanical clutch software.

Table 3: Second Test Result of Design of Mechanical Clutch Software using Bronze on Cast Iron.

Using bronze on cast iron	Result
Internal radius	120 mm
External radius	96 mm
Coefficient of friction	0.05
Pressure intensity	0.4 N/mm²
Axial thrust	6514.406526483795 N
Mean radius (uniform pressure)	108.4444444444444 mm
Mean radius (uniform axial wear)	108 mm
Torque (uniform pressure)	35322.55983248991 N-mm
Torque (uniform axial wear)	35177.79524301249 N-mm

Source: output from the mechanical clutch software

Table 4: Result of Design of Mechanical Clutch done Conventionally using Cast Iron on Cast Iron.

Using cast iron on cast iron (dry) plate.	Result
Internal radius	150 mm
External radius	75 mm
Coefficient of friction	0.06
Pressure intensity	0.8 N/mm²
Axial thrust	42417 N
Mean radius (uniform pressure)	116.6667 mm
Mean radius (uniform axial wear)	112.5 mm
Torque (uniform pressure)	296919.0848 N-mm
Torque (uniform axial wear)	286314.75 N-mm

Source: Result of conventional design of clutch.

Table 5: Result of Design of Mechanical Clutch Done Conventionally using Bronze on Cast Iron.

Using bronze on cast iron	Result
Internal radius	120 mm
External radius	96 mm
Coefficient of friction	0.05
Pressure intensity	0.4 N/mm²
Axial thrust	6515.2512N
Mean radius (uniform pressure)	108.4444 mm
Mean radius (uniform axial wear)	108 mm
Torque (uniform pressure)	35327.1254 N-mm
Torque (uniform axial wear)	35182.3565 N-mm

Source: Result of conventional design of clutch.

Table 6: Difference in Results of Design of Mechanical Clutch done Conventionally and the Developed Clutch Software (using cast iron on cast iron).

Using cast iron on cast iron (dry) plate.	Software Result (SR)	Conventional Result (CR)	Difference between software result and conventional result	Percentage error incurred by conventional design $\frac{SR-CR}{CR} X\ 100\%$
Internal radius	150 mm	150 mm	0.0	0.0
External radius	75 mm	75 mm	0.0	0.0
Coefficient of friction	0.06	0.06	0.0	0.0
Pressure intensity	0.8 N/mm²	0.8 N/mm²	0.0	0.0
Axial thrust	42411.50082346221 N	42417 N	5.49918	1.2965×10^{-4}
Mean radius (uniform pressure)	116.66666666666667 mm	116.6667 mm	3.34×10^{-5}	2.8629×10^{-7}
Mean radius (uniform axial wear)	112.5 mm	112.5 mm	0.0	0.0
Torque (uniform pressure)	296880.50576423545 N-mm	296919.0848 N-mm	38.5791	1.3025×10^{-3}
Torque (uniform axial wear)	286277.63055836986 N-mm	286314.75 N-mm	37.1195	1.2965×10^{-4}

Table 7: Difference in Results of Design of Mechanical Clutch done Conventionally and the Developed Clutch Software (using bronze on cast iron).

Using bronze on cast iron	Software Result	Conventional Result	Difference between software result and conventional result	Percentage error incurred by conventional design $\frac{SR - CR}{CR} X\ 100\%$
Internal radius	120 mm	120 mm	0.0	0.0
External radius	96 mm	96 mm	0.0	0.0
Coefficient of friction	0.05	0.05	0.0	0.0
Pressure intensity	0.4 N/mm²	0.4 N/mm²	0.0	0.0
Axial thrust	6514.406526483795 N	6515.2512N	0.844674	1.2965×10^{-4}
Mean radius (uniform pressure)	108.4444444444444 mm	108.4444 mm	4.44×10^{-5}	4.0943×10^{-7}
Mean radius (uniform axial wear)	108 mm	108 mm	0.0	0.0
Torque (uniform pressure)	35322.55983248991 N-mm	35327.1254 N-mm	4.56557	1.2924×10^{-4}
Torque (uniform axial wear)	35177.79524301249 N-mm	35182.3565 N-mm	4.56126	1.2965×10^{-4}

The steps to design the above clutch disc considering both uniform pressure and uniform wear with the software are:

1. Start the program and the welcome screen shows after which; click the begin button

2. A multi – document window opens and then click on design consideration

3. When the design consideration window opens check the button for the clutch materials that you wish to use for the design

4. After clicking the "Generate report" button, the result is shown on a new window (This can be seen on plate 16), on this window there is

5. Generate report button again which when clicked will take the final report to c:/output document after it has shown "Report written to C:/output doc. (This also is on Plate 17) the results obtained were compared with the values obtained in the convectional design, and it was ascertained correct. Also the software should be capable of stating some conditions under which the clutch will operate.

6. The output of the design will be seen in the c:/output doc.; below is the sample of design made with cast iron on cast iron

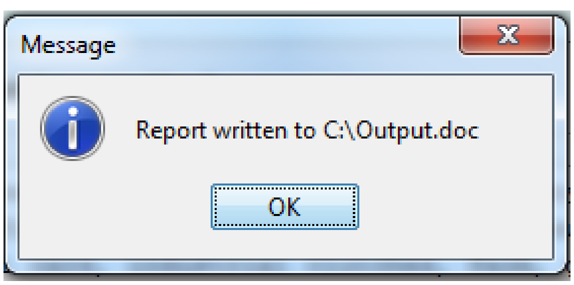

Plate 24: Directive Message for Output of the Design.

The steps to design the above unit conversion for unit conversion are:

1. Start the program and the welcome screen shows after which; click the begin button;

2. A multi – document window opens and then click on unit conversion;

3. A drop down menu opens showing length, pressure, torque and force;

4. Click on length, a window opens; millimeter, centimeter, meter, inches and feet units. Inputs the dimension you have in the space, "convert what quantity?" and then click on the parameter you are changing from and as well do the same to the parameter you are changing to; and then click on "convert" button the parameter converts to the desired parameter in the space, "result" . There is also a "reset" button that is used to clear the input field. This can be repeated for pressure, torque and force following the same process.

DESIGN CONSTRAINTS

Design constraint was introduced to the software one if the internal radius of the clutch is greater than the external radius i.e. $r_2>r_1$ what this means is that the clutch disc has no thickness. When the software notices that the value of the internal radius entered is greater than that of external radius, it shows an error message warning the user. This is shown in Plate 25.

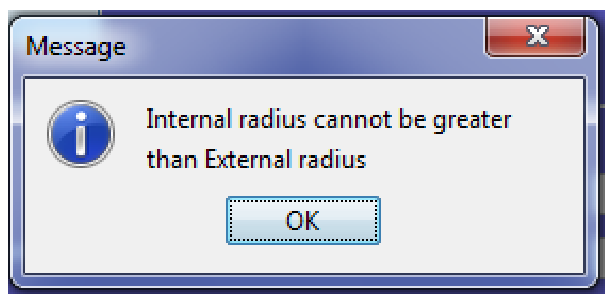

Plate 25: Error Message.

DRAWING THE CLUTCH ASSEMBLY AUTOMATICALLY WITH THE CLUTCH SOFTWARE

The software is capable of drafting in 2D and 3D the assembly diagram of clutch automatically by just click of a button. This is done from the software by clicking on the design drafting menu; the dropdown menu will open showing 2D design and 3D design, when either of them us clicked the software will produce the drawing. The output for these designs in shown in Plates 26 - 28.

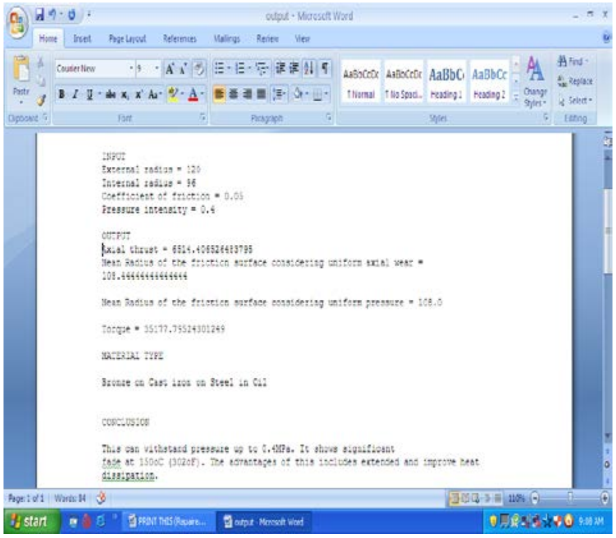

Plate 25: Output of the Clutch Software when Bronze was Considered.

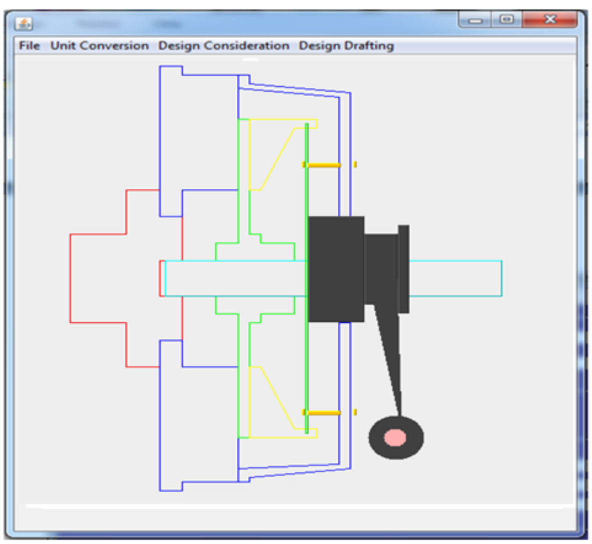

Plate 26: 2D Design Draft.

The main objective of this work was mainly to derive a method of using computer in the design process of automobile industries mainly in the design of clutches. This study successfully created a computer software application that designed a clutch according to a well-known standard code. After designing and testing the clutch software, the outputs of the clutch software were measured against the conventionally designed clutches. This showed fractional difference between the clutch software outputs and conventionally designed clutches result. The measured values of mechanical clutches designed using computer aid over the conventionally designed ones are more accurate.

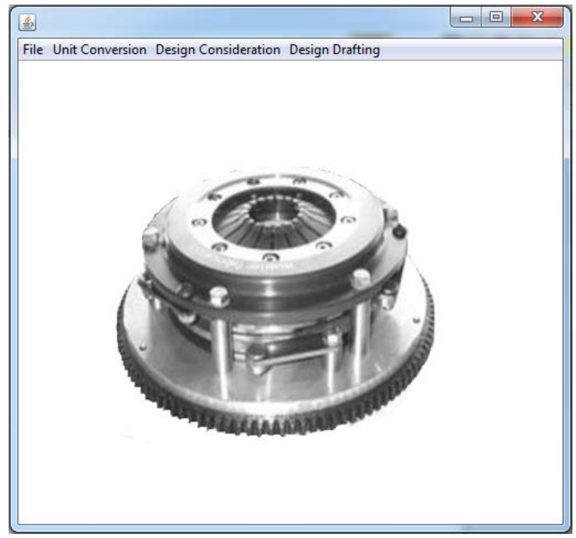

Plate 29: 3D Design Draft.

For cast iron, the degree of accuracy of uniform pressure were respectively 1.2965 x 10^{-4}, 2.8629 x10^{-7} and 1.3025 x 10^{-3} percent, while the corresponding accuracy of axial wear were 1.2965 x10^{-4}, 0 and 1.2965 x10^{-4} percent for axial thrust, mean radius, and torque. For bronze, it was the degree of accuracy of uniform pressure were respectively 1.2965 x10^{-4}, 4.0943 x 10^{-7} and 1.2924 x 10^{-4} percent, while the corresponding accuracy of axial wear were 1.2965 x10^{-4}, 0 and 1.2965 x10^{-4} percent for axial thrust, mean radius, and torque. In the case of unit conversion the software got the exact values as the standard unit conversions.

This project has not only proven to have improved degree of accuracy based on the obtained results, but has also shown great speed of drafting of the clutch both in 2D and 3D. Furthermore, a characteristic of good software was attained by this software. Portability; the packaged software was transferred from the system in where it was design to five other system and the functionality was not lost. The owners of the system were allowed to test the software, none of the software transferred crashed owing to error made by different user as entry data error warned for wrong input. This is recoverability of software (recovery from error).

The simplicity of the software made it easy user friendly. Style and aesthetics adopted gave the various parts of the program readability features as it was not difficult for one to comprehend the logic behind the software.

CONCLUSION

Accuracy in the design of mechanical clutch was achieved using the developed code. The comparison made between a conventionally designed and Computer-Aided Designed mechanical clutch using cast iron and bronze as clutch materials proved that the CAD of mechanical clutch is more accurate. Being multi-functional application software other functions such as conversion of clutch design quantities from one unit to another and design drafting of the mechanical clutches in 2D and 3D view were also achieved using this software.

REFERENCES

1. Adejuyigbe, S.B. 2002. *CAD/CAM for Manufacturing.* Topfun Publications: Akure, Nigeria. 1 – 135.

2. Amin, K. 1990. *Automobile Production - Future Trends Economic Review*. Farlex, Inc.: Pakistan.

3. Dassen, M.H.M and A.F.A. Serrarens. 2003. *Modelling and Control of Automotive Clutch Systems*. Eindhoven. 8

4. Karim, N. 2006. "How Clutches Work". Retrieved 2012 March 11 from: http://www.niumotorsports.com/formula/learn/engine/clutch.pdf

5. Khurmi, R.S. and J.K. Gupta. 2006. *A Textbook of Machine Design*. S Chand Publishers: New Delhi, India. 885-891.

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