Analysis and Design of Engraving Machine Movement

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Abstract—— **CNC routers play a significant role in several markets such as furniture design, circuit board manufacturing, plastic and foam fabrication. It can allow to complete projects in few hours that used to take several days CNC routers can work on sheets of woods, plastic, rubber, acrylics, and non-ferrous metal and CNC router machine moves and cuts in three directions using computer aided design software.**

A computer program has been established to design the power screws of any engraving machine. The power required to cut material was calculated by the program. The resisting force was analyzed and all stresses act on the power screws. The power screws were designed by using the main common theory of failures. The buckling and maximum deflection was checked in this program.

An example of the output results was designed and drawn in Advanced Centre of Technology using solid works software. The nut connected to the screws was also drawn. The parts of engraving machine have been manufactured and tested in Advanced Centre Technology A.C.T in Libya.

Index Terms: **engraving machine, Power Screw, Fortran program.**

I. INTRODUCTION

Professional craftsmen can carve and shape high-quality products using hand tools such as circular saws, hand routers, and planers. However, manual production is too labour-intensive and prone to errors for many modern business applications. Computer numerically Controlled (CNC) routers can help drill, carve, rout, and cut materials with incredible accuracy and speed to increase productivity without sacrificing quality.

While old CNC routers operated using punch tape, modern CNC routers use computers to tell the control system and motors how far to move and how to cut. A CNC router can turn raw industrial material such as wood or aluminium into finished products based on detailed designs you create using accompanying software.

CNC routers play a significant role in several markets such as furniture design, circuit board manufacturing, plastic and foam fabrication. It can allow designer to complete projects in a few hours that used to take several days.

CNC routers can work on sheets of wood, plastic, rubber, acrylics, and non-ferrous metal like aluminium. The design possibilities are endless. The designer can cut slabs of wood for a chair or cabinet, make three-dimensional architectural mouldings for furniture, and create custom –made guitars [1].

The main benefit of CNC routers is automation. It can be feed in a sheet of material and the router precisely cuts the material based on the design created. Unlike manual machinery, The worker does not have to supervise each and every step. It can simply set up the function of router to perform, walk away, and it will complete the job with accuracy up to ten thousandths of a percent – results could not get with a hand router.

A CNC router machine moves and cuts in three directions at once. The X-axis runs front to back and is the longest distance the machine can travel. The Y-axis goes from left to right, and the Z-axis is up and down. Since the CNC router can move in several directions at once, it can create patterns and shapes quickly [2].

Where it begins the work starts with the attached computer that controls the motion, design, and cutting. Either can work directly at this controller, or work from your desktop and transfer the design when it's ready. Also can set up the CNC router machine to work on a new design while it is in use.

The computer aided design (CAD) software is the focal point for every move CNC router machine will make. Operating on a Windows-based interface, the CAD software helps design the product. It will then output instructions, called tool path files, onto the PC controller to tell the router exactly what to do. The controller sends direction signals to the motor drivers and the router moves in the requisite directions to create the finished design.

The motors control the very precise motion of the CNC router machine's drive system.

This moves the axes back and forth on a separate device called a gantry to make cuts in different directions. The drive system determines the quality and accuracy of the cut and therefore how well parts fit together later [3].

CNC machining additional considerations Drive systems the motors of CNC machining are connected to one of two different drive systems to drive the machine's axes:

- Ball screw: Large screw drives with ball bearings that run around the gantry

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- Lead screw: Similar to a ball screw drive but without ball bearings.

The drive system will affect the cut quality and accuracy. For detailed cuts that need to fit together perfectly or for fine engraving, ball screw drives are the best. The ball screw can cut perfectly round circles without leaving flat sections on curves. However, ball screws are more expensive. Lead screw drives are much less expensive, but may provide a lower cut quality because of backlash when the motor changes direction. Usually due to lose or poor mechanisms, backlash will negatively impact the quality of your cuts: circles may be imperfect or inlays may not fit [4].

II. THEORETICAL ANALYSIS

The machine design is the creation of new and better machines and improving the existing ones. A new or better machine is one which is more economical in the overall cost of production and operation. The process of design is a long and time consuming one. From the study of existing ideas, a new idea has to be conceived. The idea is then studied keeping in mind its commercial success and given shape and form in the form of drawings. In the preparation of these drawings, care must be taken of the availability of resources in money, in men and in materials required for the successful completion of the new idea into an actual reality. In designing a machine component, it is necessary to have good knowledge of many subjects such as mathematics, engineering mechanics, strength of materials, and theory of machines, workshop processes and engineering drawing [5].

A. Classifications of Machine Design

The machine design may be classified as follows:

1. Adaptive design. In most cases, the designer's work is concerned with adaptation of existing design. This type of design needs no special knowledge or skill and can be attempted by designers of ordinary technical training. The designer only makes minor alternation or modification in the existing designs of the product.
2. Development design. This type of design needs considerable scientific training and design ability in order to modify the existing design into a new idea by adopting a new material or different method of manufacture. In this case, though the designer starts from the existing design, but the final product may differ quite markedly from the original product.
3. New design. This type of design needs lot of research, technical ability and creative thinking. Only those designers who have personal qualities of a sufficiently high order can take up the work of a new design.

B. General Consideration in Machine Design

Following are the general considerations in designing a machine component:

1. Type of load and stresses caused by the load. The load, on a machine component, may act in several ways due to which the internal stresses are set up.
2. Motion of the parts or kinematics of the machine. The successful operation of any machine depends largely upon the simplest arrangement of the parts which will give the motion required.

The motion of the parts may be Rectilinear motion which includes unidirectional and reciprocating motions, Curvilinear motion which includes rotary or oscillatory or simple harmonic.

-Constant velocity.

-Constant or variable acceleration.

3. Selection of materials. It is essential that a designer should have a thorough knowledge of the properties of the materials and their behaviour under working conditions. Some of the important characteristics of materials are: strength, durability, flexibility, weight, resistance to heat and corrosion, machinability, etc.
4. Form and size of the parts. The form and size are based on judgment. The smallest practicable cross-section may be used, but it may be checked that the stresses induced in the designed cross-section are reasonably safe. In order to design any machine part for form and size, it is necessary to know the forces which the part must sustain. It is also important to anticipate any suddenly applied or impact load which may cause failure.
5. Frictional resistance and lubrication. There is always a loss of power due to Frictional resistance and it should be noted that the friction of starting is higher than that of running friction. It is, therefore, essential that a careful attention must be given to the matter of lubrication of all surfaces which move in contact with others, whether in rotating, sliding, or rolling bearings.
6. Convenient and economical features. In designing, the operating features of the machine should be carefully studied. The starting, controlling and stopping levers should be located on the basis of convenient handling.
7. Use of standard parts. The use of standard parts is closely related to cost, because the cost of standard parts is only a fraction of the cost of similar parts made to order. The standard parts should be used whenever possible; parts for which patterns are already in existence such as gears, pulleys, and bearings.
8. Safety of operation. Some machines are dangerous to operate, especially those which are speeded up to insure production at a maximum rate.

Therefore that, a designer should always provide safety devices for the safety of the operator. The safety appliances should in no way interfere with operation of the machine.

9. Workshop facilities. A design engineer should be familiar with the limitations of his employer's workshop, in order to avoid the necessity of having work done in some other workshop.

Comp

10. Number of machines to be manufactured. The number of articles or machines to be manufactured affects the design in number of ways.

11. Cost of construction. The cost of construction of an article is the most important consideration involved in design. In some cases, it is quite possible that the high cost of an article may immediately bar it from further considerations. The aim of design engineer under all conditions should be to reduce the manufacturing cost to the minimum.

12. Assembling every machine or structure must be assembled as a unit before it can function. Large units must often be assembled in the shop, tested and then taken to be transported to their place of service. The final location of any machine is important and the design engineer must anticipate the exact location and the local facilities for erection [6].

C. Reverse Engineering

Reverse engineering is the general process of analyzing a technology specifically to ascertain how it was designed or how it operates. This kind of inquiry engages individuals in a constructive learning process about the operation of systems and products. Reverse engineering as a method is not confined to any particular purpose, but is often an important part of the scientific method and technological development. The process of taking something apart and revealing the way in which it works is often an effective way to learn how to build a technology or make improvements to it [7].

Through reverse engineering, a researcher gathers the technical data necessary for the documentation of the operation of a technology or component of a system. In "black box" reverse engineering, systems are observed without examining internal structure, while in "white box" reverse engineering the inner workings of the system are inspected.

When reverse engineering software, researchers are able to examine the strength of systems and identify their weaknesses in terms of performance, security, and interoperability.

The reverse engineering process allows researchers to understand both how a program works and also what aspects of the program contribute to its not working. Independent manufacturers can participate in a competitive market that rewards the improvements made on dominant products. For example, security audits, which allow users of software to better protect their systems and networks by revealing security flaws, require reverse engineering. The creation of better designs and the interoperability of existing products often begin with reverse engineering [8].

The most traditional method of the development of a technology is referred to as "forward engineering". In the construction of a technology, manufacturers develop a product by implementing engineering concepts and abstractions.

By contrast, reverse engineering begins with final product, and works backward to recreate the engineering concepts by analyzing the design of the system and the interrelationships of its components [9].

Value engineering refers to the creation of an improved system or product to the one originally analyzed. While there is often overlap between the methods of value engineering and reverse engineering, the goal of reverse engineering itself is the improved documentation of how the original product works by uncovering the underlying design. The working product that results from a reverse engineering effort is more like a duplicate of the original system, without necessarily adding modifications or improvements to the original design.

Since the reverse engineering process can be time-consuming and expensive, reverse engineers generally consider whether the financial risk of such an endeavour is preferable to purchasing or licensing the information from the original manufacturer, if possible.

In order to reverse engineer a product or component of a system, engineers and researchers generally follow the following four-stage process:

- Identifying the product or component which will be reverse engineered.
- Observing or disassembling the information documenting how the original product works.
- Implementing the technical data generated by reverse engineering in a replica or modified version of the original.
- Creating a new product (and, perhaps, introducing it into the market).

In the first stage in the process, sometimes called "pre-screening", reverse engineers determine the candidate product for their project. Potential candidates for such a project include singular items, parts, components, units, subassemblies, some of which may contain many smaller parts sold as a single entity [10].

The second stage, disassembly of the original product, is the most time-consuming aspect of the project. In this stage, reverse engineers attempt to construct a characterization of the system by accumulating all of the technical data and instructions of how the product works.

In the third stage of reverse engineering, reverse engineers try to verify that the data generated by disassembly is an accurate reconstruction the original system. Engineers verify the accuracy and validity of their designs by testing the system, creating prototypes, and experimenting with the results.

The final stage of the reverse engineering process is the introduction of a new product into the marketplace. These new products are often innovations of the original product with competitive designs, features, or capabilities. These products may also be adaptations of the original product for use with other integrated systems, such as different platforms of computer operating systems.

Often different groups of engineers perform each step separately, using only documents to exchange the information learned at each step. This is to prevent duplication of the original technology, which may violate copyright. By contrast, reverse engineering creates a different implementation with the same functionality [11].

D. Power Screws

Power screws, (also known as translation screws), convert the input rotation of an applied torque to the output translation of an axial force. For example, in the case of the lead screw of engraving machine, the rotary motion is available but the tool has to be advanced in the direction of the cut against the cutting resistance of the material. In case of screw jack, a small force applied in the horizontal plane is used to raise or lower a large load.

In most of the power screws, the nut has axial motion against the resisting axial force while the screw rotates in its bearings. In some screws, the screw rotates and moves axially against the resisting force while the nut is stationary and in others the nut rotates while the screw moves axially with no rotation.

Power screws use in production machines, and among many other applications such as universal tensile testing machines, machine tools, automotive jacks, vises, micrometers, and C-clamps. The mechanical advantage inherent in the screw is exploited to produce large axial forces in response to small torques. Typical design considerations, discussed in the following sections, include buckling and deflection, and stresses.

Two principal categories of power screws are machine screws and ball screws, The screw threads are typically formed by thread rolling, which results in high surface hardness, high strength, and superior surface finish. Since high thread friction can cause self-locking when the applied torque is removed, protective brakes or stops to hold the load are usually not required.

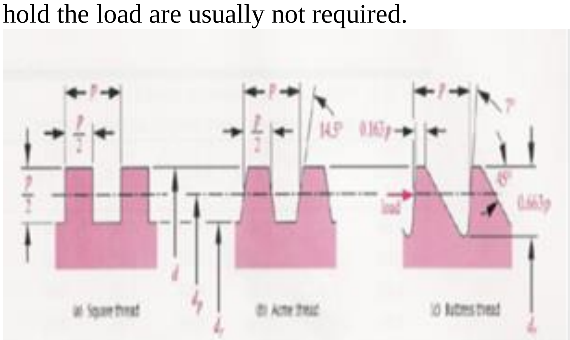


Figure (1) Types of Screw threads

The applications of power screws are in linear actuators, which operate on the same principle, but either motorize the nut rotation to translate the screw or motorize the screw rotation to translate the nut. These devices are used in machine tools to move the table and workpiece under the cutting tool, as used in engraving machine to convert rotation to linear motion and in assembly machines to position parts, and in aircraft to move the control surfaces, as well as in many other applications, if the rotating input is provided by servomotor or stepping motor in combination with a precision lead screw, very accurate positioning can be obtained, Figure(2) shows one possible arrangement of a power screw used as a jack to lift a load. The nut is turned by an applied torque T and the screw translates up to lift the load P or down to lower it.

There needs to be some friction at the load surface to prevent the screw from turning with the nut. Once the load P is engaged, this is not a problem. Alternatively, the screw could be turned against a fixed nut to lift the load. In either case there will be significant friction between the screw and the nut as well as friction between the nut and base, requiring that a thrust bearing be provided as shown. If a plain (i.e., none rolling) thrust bearing is used, it is possible for the bearing interface to generate larger friction torque than the threads. Ball-thrust bearings are often used in this application to reduce these losses.

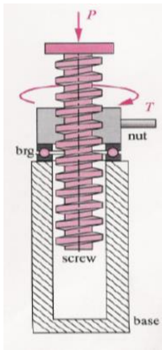


Figure (2) An Acme Thread Power Screw Jack

The total torque T_u to lift the load with a square thread is calculated by the equation (1).

$$T_d = T_{sd} + Tc = (p\, d_p /2) \times \{(\mu\pi d_p - L)/((\pi d_p + \mu L)\} + \mu_c p(d_c/2) \quad \ldots\ldots\ldots 1$$

E. Machining Power

E.1 Estimating Machining Power

Knowledge of the power required to perform machining operations is useful when planning new machining operation, for optimizing existing machining operations, and to develop specifications for new machine tools that are to be acquired. The available power on any machine tool places a limit on the size of the cut that it can take.

When much metal must be removed from the workpiece, it is advisable to estimate the cutting conditions that will utilize the maximum power on the machine. Many machining operations require only light cuts to be taken for which the machine obviously has power; in this event, estimating the power required is a wasteful effort. Conditions in different shops may vary and machine tools are not all designed alike, so some variations between the estimated results and those obtained on the job are to be expected.

However, by using the methods provided in this section reasonable estimate of the power required can be made, which will suffice in most practical situations. The measure of power in SI metric units it is the kilowatt, which is used for both mechanical and electrical power.

The power required to cut a material depends upon the rate at which the material is being cut and upon an experimentally determined power constant, K_P, which is also called the unit power, or specific power consumption. The power constant is equal to the power in kilowatts required to cut a material at a rate of one cubic centimetre per second.

Values of the power constant in table (1) can be used for all machining operations expect drilling and grinding. Values given are for sharp tools [12].

Table (1) Shows Power Constant for Ferrous Cast Metal

Material	Brinell hardness number(BHN)	Kp (metric unit)
Gray cast iron	120-140	0.96
	140-160	1.04
	160-180	1.42
	180-200	1.64
	200-220	1.94
	220-240	2.48
Alloy cast iron	150-175	0.82
	175-200	1.72
	200-250	2.51
Malleable Iron ferritic	150-175	1.15
Malleable Iron pearlitic	175-200	1.56
	200-250	2.24
	250-300	3.22
Cast steel	175-200	2.13
	200-250	2.35

The value of the power constant is essentially unaffected by the cutting speed, the depth of cut, and the cutting tool material. Factors that do affect the value of the power constant, and thereby the power required to cut a material, include the hardness and microstructure of the work material, the feed rate, the rake angle of the cutting tool, and whether the cutting edge of the tool is sharp or dull. Values are given in the power constant tables for different material hardness levels, whenever this information is available. Feed factors for the power constant are given in table (2). All metal cutting tools wear but a worn cutting edge requires more power to cut than a sharp cutting edge.

Table (2) Shows Feed Factors for Power Constant

Feed (mm/tooth)	Feed factor C	Feed (mm/tooth)	Feed factor C
0.02	1.70	0.35	0.97
0.05	1.40	0.38	0.95
0.07	1.30	0.40	0.94
0.10	1.25	0.45	0.92
0.12	1.20	0.50	0.90
0.15	1.15	0.55	0.88
0.18	1.11	0.60	0.87
0.20	1.08	0.70	0.84
0.22	1.06	0.75	0.83
0.25	1.04	0.80	0.82
0.28	1.01	0.90	0.80
0.30	1.00	1.0	0.78
0.33	0.98	1.50	0.72

Factors to provide tool wear given in table (3). In this table, the extra-heavy-duty category or milling and turning occurs only on operations where the tool is allowed to wear more than a normal amount before it is replaced, such as roll turning. The effect of the rake angle usually can be disregarded. The rake angle for which most of the data in the power constant tables are given is positive 14 degrees. Only when the deviation from this angle is large is it necessary to make an adjustment. Using rake angle that is more positive reduces the power required approximately one percent per degree; Using rake angle that is more negative increases the power required; again approximately one percent per degree.

Many index able insert cutting tools are formed with an integral chip breaker or other cutting edge modifications, which have the effect of reducing the power, required cutting a material. The extent of this effect cannot be predicted without a test of each design. Cutting fluids will also usually reduce the power required, when operating in the lower range of cutting speeds. Again, the extent of this effect cannot be predicted because each cutting fluid exhibits its own characteristics [13].

Table (3) shows Tool Wear Factors, *W*

Type of operation(Milling)	*W*(Tool wear factor)
Slab milling	1.10
End milling	1.10
Light & medium face milling	1.10-1.25
Extra-heavy-duty face milling	1.30-1.60

The machine tool transmits the power from the driving motor to the workpiece, where it is used to cut the material. The effectiveness of this transmission is measured by the machine tool efficiency factor (E). Average values of this factor are given in table (4).

Table (4) Shows Machine Tool Efficiency Factors E

Type of Drive	E(Tool Efficiency Factor)
Direct Belt Drive	0.90
Back Gear Drive	0.75
Geared Head Drive	0.70-0.80
Oil-Hydraulic Drive	0.60-0.90

The power at the cutting tool and the power at the motor can be calculated from equations (2), (3):

$$P_c = k_p \times C \times Q \times W \quad \ldots\ldots 2$$

$$P_m = P_c / E = (k_P \times c \times Q \times W) / E \quad \ldots\ldots 3$$

E.2 Strength of Material.

Strength of Materials focuses on the strength of materials and structural components subjected to different types of force and thermal loadings, the limiting strength criteria of structures, and the theory of strength of structures.

Consideration is given to actual operating conditions, problems of crack resistance and theories of failure, the theory of oscillations of real mechanical systems, and calculations of the stress-strain state of structural components:

-Uniaxial Stresses: stress is defined as force per unit with units of MPa. Stress is generally distributed as continuously varying function within the continuum of material.

-Axial tension: Axial loading in tension is one of the simplest types of loading that can be applied to an element.

$$\sigma = F / A \quad \ldots\ldots 4$$

Where: F is the applied force and A is the cross-sectional area at the point of interest. This is an applied normal stress. The principal normal stresses and the maximum shear stress can be found from equations.

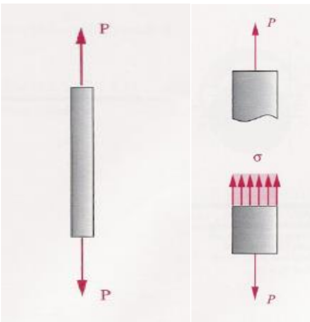


Figure (3) Stress Distribution across a Bar in Axial Tension

- Bending stress in straight beams, in engineering practice, the machine parts of structural members may be subjected to static or dynamic loads which cause bending stress in the sections besides other types of stresses such as tensile, compressive and shearing stresses.

- Torsional shear stress, when a machine member is subjected to the action of two equal and opposite couples acting in parallel planes (or torque or twisting moment), then the machine member is said to be subjected to torsion. The stress set up by torsion is known as torsional shear stress. It is zero at the centroid axis and maximum at the outer surface.

The strength of the shaft means the maximum torque transmitted by it. Therefore, in order to design a shaft for strength, the power transmitted by the shaft is given by equation 5.

$$P = (2 \pi N. T) / 60 = T . \omega \quad \ldots\ldots 5$$

- Combine stresses, in the discussion that follows the element is subjected to stresses lying in one plane; this is the case of plane stress, or two-dimensional stress.

- Simple stresses, defined as such by the flexure and torsion theories, lie in planes normal or parallel to the line of action of the forces. Normal, as well as shearing, stresses may, however, exist in other directions. A particle out of a loaded member will contain normal and shearing stresses. Note that the four shearing stresses must be of the same magnitude, if equilibrium is to be satisfied.

III. ENGINEERING MACHINE DESIGN

Engraver machine consists of four parts: mechanical systems: the cover, rails, base, reflecting the composition of frames and other mechanical parts., Transmission: four balanced by three high-precision imported linear guide rail, belts, two stepper motors and several gears. And Control system: high-speed control cards, power supply, stepper motor drives. The machine is designed in (A.C.T) to engrave soft materials as aluminum, brass and wood. with the dimensions Width of table= 1300 mm and Length of the table = 1750mm.

Some parts are manufactured in A.C.T as power screws, nuts, table. And the others as motors, chain, legs, spindle, cables used as standard parts. Figure(3) shows the machine which is collected and assembled in A.C.T.

Figure (3) EGRAVING MACHINE

The machine has been tested and operated to engrave the different shape as letter and maps. Figure (4) shows an example of the output of products of this machine

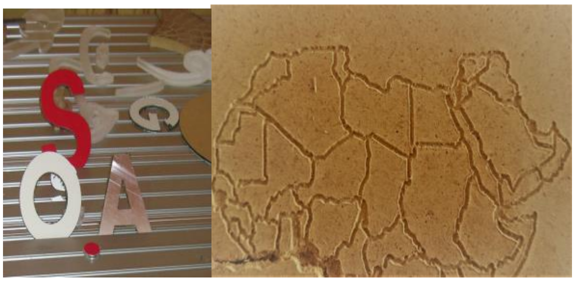


Figure (4) PRODUCTS

A .Force Analysis.

Due to cutting of materials, there will be a resistance force. This force will act x-y plane as shown in figure (4). The angle (θ) varies from 0° to 360°. There will a force in the third direction (z direction). This force responsible the depth of cut. A simple free body diagram of each screw can be shown in figure (5).

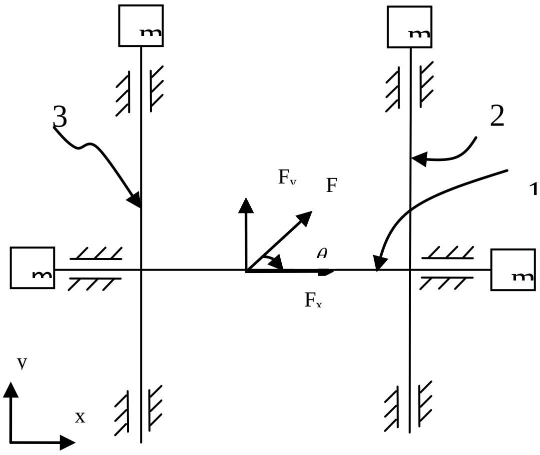


Figure (5) force acts on axis

Each screw is subjected to axial force, bending moment and twisting torque, this is shown in figure 5. For design it can be taken F_x = F , F_y =F at L/2.

B. Design Stresses and Factor of Safety

If a machine part is to safely transmit loads acting upon it, a permissible maximum stress must be established and used in the design. This is the allowable stress, the working stress, or preferably, the design stress. The design stress should not waste material, yet should be large enough to prevent failure in case loads exceed expected values, or other uncertainties react unfavourably.

C. Theories of Failure under Static Load

It has already been discussed in the previous chapter that strength of machine members is based upon the mechanical properties of the materials used. Since these properties are usually determined from simple tension or compression tests, therefore, predicting failure in members subjected to uniaxial stress is both simple and straight-forward. But the problem of predicting the failure stresses for members subjected to bi-axial or tri- straight-forward. But the problem of predicting the failure stresses for members subjected to bi-axial or tri-axial stresses is much more complicated. In fact, the problem is so complicated that a large number of different theories have been formulated. The principal theories of failure for a member subjected to bi-axial stress are as follows:

1. Maximum principal stress theory (Rankine's theory).
2. Maximum shear stress theory (Tresca's theory).
3. Maximum principal strain theory (Saint Venant theory).
4. Maximum strain energy theory (Haigh's theory).
5. Maximum distortion energy theory (Hencky and Von Mises theory).

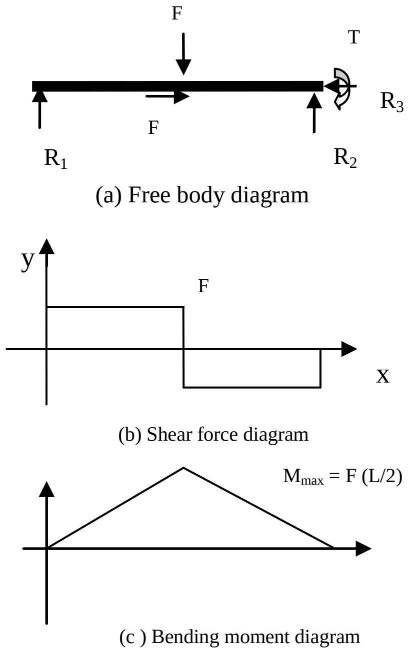


Figure (5) free body shear force and bending moment diagram of designed shafts

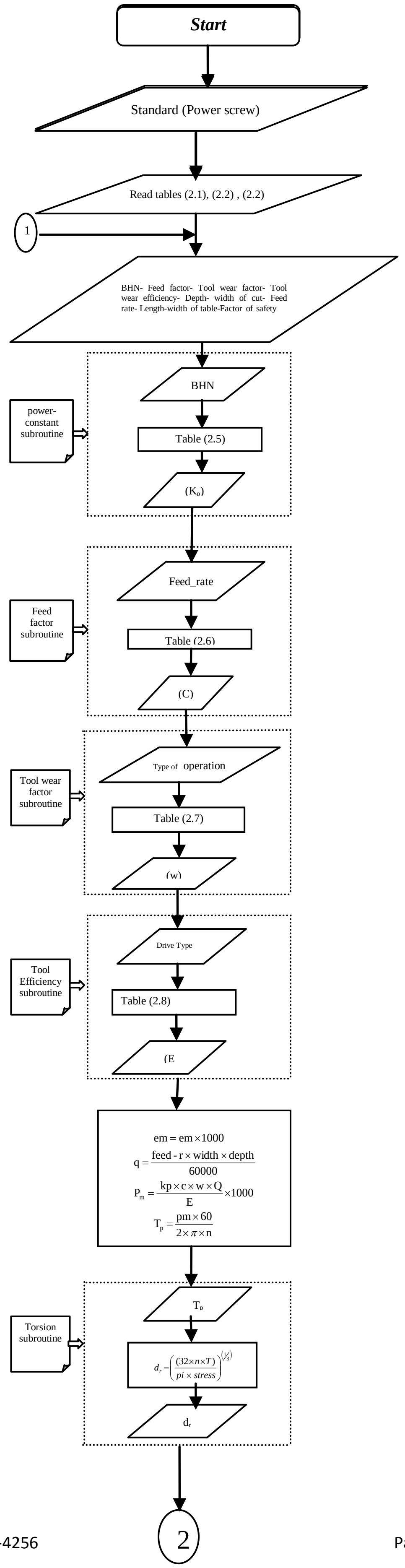
IV. MAIN PROGRAM

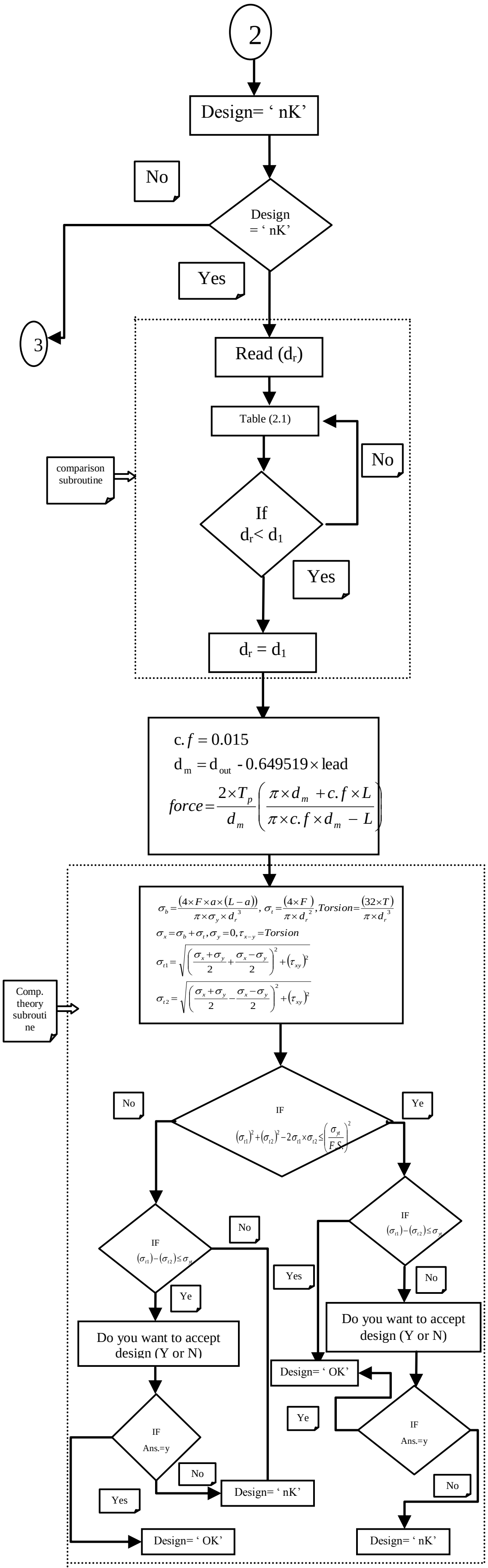
The main program is named as power screw designer. This program follows the next steps:

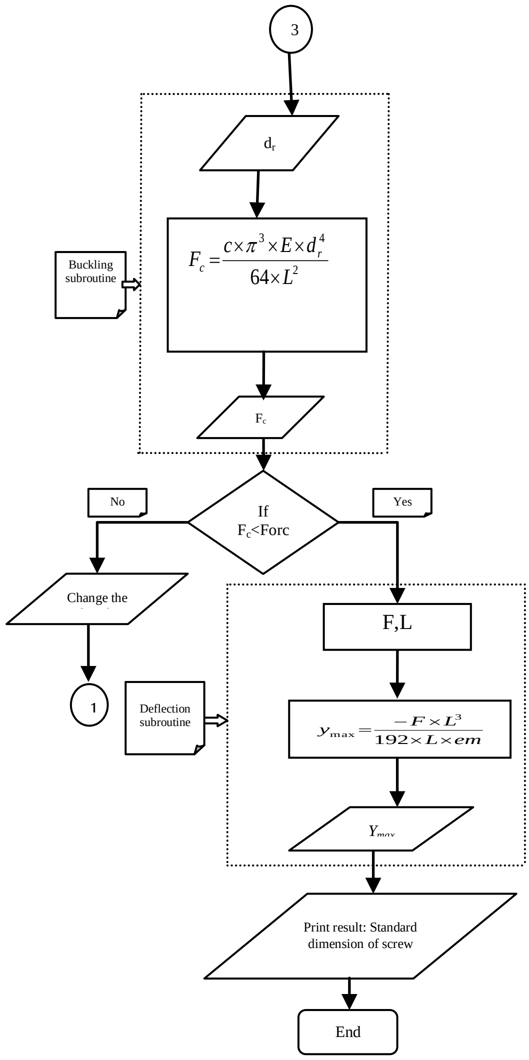
Reading all the input data, The maximum power (p_m), required for the machine is calculated using equation (3), The torque required (T) is calculated using equation (5), Calling subroutine torsion, Calling subroutine comparison, The maximum axial force is calculated using equation (1) and Calling comp. theory, if the design is suitable, then the program will continue.

If not, the program goes to step 5. Then, program calling buckling subroutine.

If the critical buckling force is less than the calculated axial force, the program will continue, else the length of the screw will be changed and the program goes to step 1.







A. Program Analysis

Engraving is one of the most important and sensitive machining work in all industry, to maintain its efficiency and achieve the specified design and high quality of the engraved product, a computer program was written using Fortran language in this research to design the power screw that to be used in the engraving machine.

The type of thread must be select carefully starting from material type, Major and minor diameter and all other properties that should be taken in consideration when designing the power screw.

Basically there are many types of standards and specifications describe the properties and dimensions for different types of threads.

In this work the specification in IS: 4694-1968(square and Acme thread) is selected. It will be loaded to the program as input data in order to compare its dimensions of the thread with the output results.

The input files are: Standard square thread, Standard Acme thread and Ball power screw.

The output describes the dimensions of the screw.

The factors which are affected the power required to cut material (such as hardness, feed rate, tool wear factor etc…) are given as input data to the program.

B. The Screen Input Data

The Standard square thread, standard acme thread and Ball Power screw, also the factors which affect the power required to cut material such as hardness, feed rate, tool wear factor are given as input data to the program.

Table .Shows the Input Data

Type	value	Type	Value
Hardness of the workable material	120	Yield stress of materials power screw	1770 MPa
Feed factor	0.12 mm/ tooth	Young modules of materials power screw	200GPa
Depth of cut	3.0mm	Length of the table	1750mm
Width of cut	5.0mm	Width of the table	1300 mm
Feed rate	250 mm/min	Factor of safety	1.2

VI. RESULTS AND DISCUSSION

The available engraving machine is imported using reverse engineering. In this work, the power screws of this machine are designed using the computer program. The materials for the power screws is choosing according the material available in the Advanced Centre of Technology (A.C.T), allows for manufacturing the power screws and use it in the imported machine.

The square power screw is conduced; it is possible to be manufacture in the centre. The ball screw is better and high accurate, but is not possible to manufacture in the centre.

The computer program will be calculated the required power of motor and dimensions of power screw that will be used in the imported engraving machine.

As a result of all this calculations a fully detailed drawing of power screws and their nuts should be made. Figure(6) shows a fully detailed drawing for the screws.

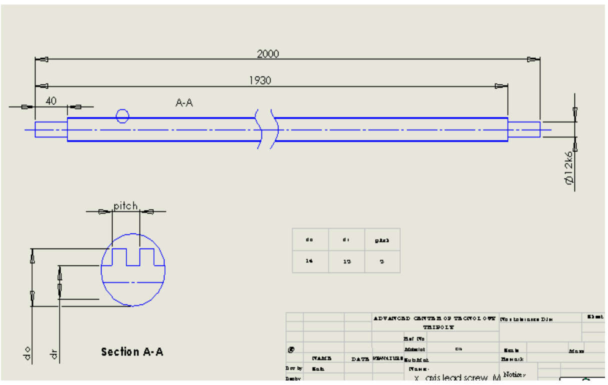


Figure 6. Detailed Drawings

A. Output results

This research is about analysis and design of the engraving machine driver elements using a computer program with (Fortran language). The motors of CNC machining are connected to one of two different drive systems used to drive systems used to drive the machine’s axes (Ball screws or lead screws).

The drive system will affect the cut quality and accuracy, thus this program calculates the motor power required the power screws dimensions for the standard types of power screws (square, Acme, and Ball power screws) inner diameter is 12 mm, out diameter is 14 mm and the pitch is 2 mm of the square thread and for the acme thread 13.5mm, 18mm and 4mm then for the ball power screw inner diameter is 13,2mm, out diameter is 16mm and the pitch is 5mm. The motor power required = 187.5 Watt.

VII. CONCLUSION

This research is to analysis and design of engraving machine driver elements using a computer program with (FORTRAN language).

The motors of CNC machining are connected to one of two different drive systems to drive the machine's axes (Ball screws or Lead screws).

The drive system will affect the cut quality and accuracy, so this program is to calculate the motor power required and the power screws dimensions for the standard types of power screws (square, Acme, and Ball power screws). Hence the speed of the drives is very low, therefore all the analysis are taken as a static analysis. Each screw is subjected to axial force, bending moment and twisting torque. For design, it is considered the critical case. This case occurs when the force in the middle of the screw.

Most of design parameters are used as variable in the program. This allows the user to change design according to the available cases. For example all the material properties (yield stress, hardness…etc) are used as input data.

The program uses the most common theories of failure (maximum normal theory, maximum shear theory, and von misses theory). In some cases, the design is accepted by one theory and not accepts by the other. In this case, the program will write message saying that and the user can accept or reject the design results. The buckling is checked in this program, and Maximum deflection is calculated. This will effect the bearing selection. An example is taken to see the output results from the available engraving machine. This machine is imported using the reverse engineering.

In this machine, Ball screws drives are the best for fine engraving. They can cut perfectly round circles, but they are more expensive, lead screws drives are much less expensive, and they are possible to manufacture in the centre. In this example a square power screws is chosen.

The square power screw is drawn using solid work software. The nut connected to the screw is also drawn; the parts are ready for manufacturing and tested in available machine.

With a small modification, this program can be used for designing power screws used in turning machine, and other similar application. It is planed to design all the mechanical parts of the imported engraving machine, such as bearings, Frames, etc……this can be achieved in another project as a future work

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