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DEVELOPMENT OF AUTOMATED LEATHER CUTTING MACHINE

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Abstract- Leather cutting serves a crucial role in modifying the shape. Nowadays, there is a clear difference in cutting technologies applied to leather. Industrial leather processing serves the purpose of mass production of leather items in order to satisfy the demand of essential products like clothes, shoes, bags, etc. these demands from technology to be economically efficient, fast, adaptive and to provide maximum possible results with minimum possible cost. Manual cutting with use of scissors and special knifes is used in leather crafting. This allows producing individual unique items whose value is not determined by functionality but based more on visual effects and design features. Currently technologies which are applied for leather cutting include slitting knifes, manual cutting, die press techniques and Laser Cutting. Use of Die Cutting in collaboration electro-mechanical technology has grown significantly during recent years due to number of advantages over conventional cutting methods; flexibility, high production speed, possibility to cut complex geometries, easier cutting of customized parts, and less leftovers of leather makes Die Cutting more and more economically attractive to apply for leather cutting. This paper studies the leather cutting operations through various research works and provides the theoretical data for Design calculations, fabricate & automate the leather blanking machine in such a way that the required length of leather blank of size **200mm X 200mm** can be cut with keeping cost minimum for a sponsored company.
Keywords- Die Cutting, Laser Cutting, Leather, Die press techniques, Automate

I. INTRODUCTION

Die cutting is the process of using a die to shear webs of low-strength materials, such as rubber, fiber, foil, cloth, corrugated fiberboard, paperboard, plastics, pressure-sensitive adhesive tapes, foam and sheet metal. In the metalworking and leather industries, the process is known as clicking and the machine may be referred to as a clicking machine. When a dinking die or dinking machine is used, the process is known as dinking.

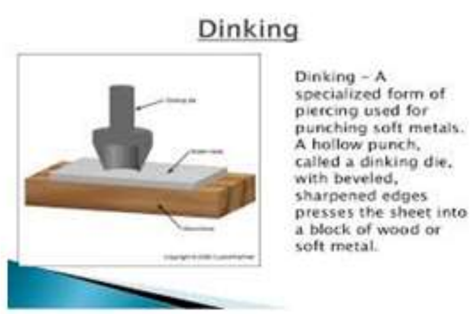

Figure 1. Dinking Process

In its most basic form, die cutting can be defined as a process whereby shapes are cut from sheets of plastic (a similar process to cookie cutting) by using a shaped knife and pressing the edge into one (or a number) of layers of sheeting. The dies that are used in this process are most often referred to as steel rule dies. After the cutting is complete, pressure is applied by the use of hydraulic or mechanical presses. Die cutting sometimes goes by the names dinking or blanking.

There are a few types of die cutting but the most well-known are rotary die cutting (also known as gasket die cutting) and flatbed die cutting. Let's take a closer look at both types.

1.1 Rotary die cutting involves the unwinding of material that is then put through a hydraulic press. Afterwards a precision engraved steel cylinder die is used to first roll over and then cut a variety of shapes and sizes out of the material. This material is very manageable at this point in time. It can be carried by a release liner and rolled onto a new core or if preferred, the sheets can be made into pads. The rotary dies can do one of two things. They can cut completely through the material and its corresponding release liner (called metal to metal die-cut) or it can cut through the material and down to (but not right through) the release liner (known as a kiss-cut or a butt-cut).

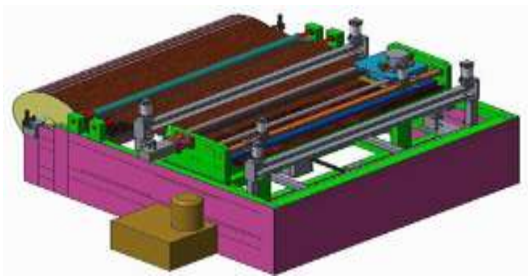

Figure 2. CAD (CREO) Model Showing Conceptual Design of Leather cutting machine.

1.2 Flatbed die cutting is the other most popular of this important process. In this case, material shapes are stamped out utilizing steel rule dies that are adjusted accordingly to varying degrees of hydraulic presses. One of the biggest advantages of flatbed die cutting is tooling costs are kept to a minimum. The reason for this is simple- when quantity is not at its highest, then the sizes of the die-cuts are bigger and/or a number of shapes are needed therefore the less costly flatbed dies provide definite value over rotary tooling. Another plus is that on materials over 1/8" in thickness, the vertical cut allows a much tighter tolerance.

II. MATERIAL SELECTION FOR LEATHER CUTTING MACHINE

Mechanical components have mass, they carry loads, they conduct heat and electricity, they are exposed to wear and to corrosion, they are made of one or more materials; they have shape; and they must be manufactured. We need to understand how these activities are related. Materials have limited design since man first build shelters, made clothes and undertook human conflict. Today the number of materials available to the designer is vast, more than 50,000 are available. While some materials are standardized, removing some close options, new materials are developed that expands the list.

Figure 3. Actual Leather Cutting Machine Fabricated

The process for the selection of the material depends on the stage of the design, with initial design suggesting the consideration of a wide range of material, but final design requiring more accurate information to choose between a few materials and to make the final accurate design. The prehistoric ages were named for the chief materials that man employed: the Stone Age, the Bronze Age and the Iron

Age. The evolution is shown schematically in Figure 4 in which the time scale is not linear. We see the early history of materials was dominated by the development of metals – usually produced by metallurgical processes, which replaced the naturally occurring materials like wood, skins and flint.

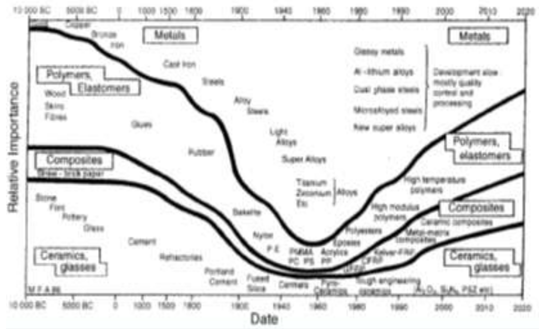

Figure 4. The evolution of engineering materials with time. 'Relative importance' in the stone and bronze ages is based on assessments of archaeologists; that in 1960 is based on allocated teaching hours in UK and US universities; that in 2020 on predictions of materials usage in automobiles by manufacturers. The time scale is non-linear. The rate of change is far faster today than at any previous time in history.

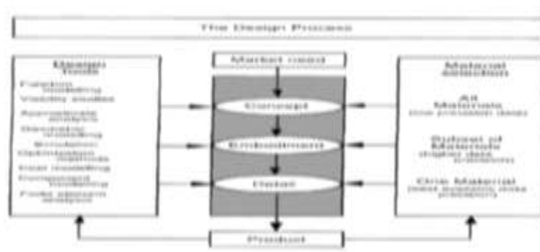

Figure 5. The design flow chart, showing how design tools and materials selection enter the procedure. Information about materials is needed at each stage.

Following Materials we have selected for different parts of machine as per our research work considering their Properties, Chemical Composition & Application in Various Study works,

1. Tool Materials:

Cutting tools must be made of a material harder than the material which is to be cut, and the tool must be able to withstand the heat generated in the cutting process.

Produce quality product, a cutting tool must have three characteristics:

- ✓ Hardness: hardness and strength at high temperatures.
- ✓ Toughness: so that tools do not chip or fracture.
- ✓ Wear resistance: having acceptable tool life before needing to be replaced

In our work it is found the cutting materials & the geometry materials of Tool should possess the hardness value ranging from 40 to 62 HRC, on the basis of the these hardness and the properties required for our application we have considered following materials in our machine for tool,

a. D2, b. WPS, c. OHNS.

2. Stress Components

Components such as Spacer, Stopper Plate, guide plate, etc. where there is relative movements between components, due to this they are under continuous stress which results in wear & tear of parts. For these we have selected following materials having higher value of strength & hardness,

a. EN31, b. EN8, c. EN35, d. EN36A, e. OHNS

3. Structural Materials

Machine Structure (i.e. bed, table, etc.) require more compressive strength then tensile strength also it should possess stability, durability and vibrational damping properties for that the materials can be used in casting and fabrication form. The following materials having good compressive strength, a. Cast Iron (Grey Cast Iron), b. Low carbon steel (AS3679 grade 300), etc.

4. Case Hardened Steel

A tough core and a hard case are the desired attributes of case-hardened steel components. Components such as Shafts, Bushes, Ball Screw, Nuts, etc., requires tough core & hard case for there applications. Case Hardened Steels we have used are - a. SAE8620, b. SAE5120, etc.

III. CUTTING FORCE CALCULATIONS FOR LEATHER BLANK CUTTING (Tonnage)

Formula for calculating the cutting force for 200mm X 200 mm Leather Blank:

$$\textbf{Cutting Force} = L \times S \times T_{Max}$$

L = Length of periphery to be cut in ‘mm’,
S = Sheet thickness in ‘mm’,
T max = Shear strength in N/mm2

The bellow figure 6 represents the typical load curve of cutting force of blanking or piercing punch.

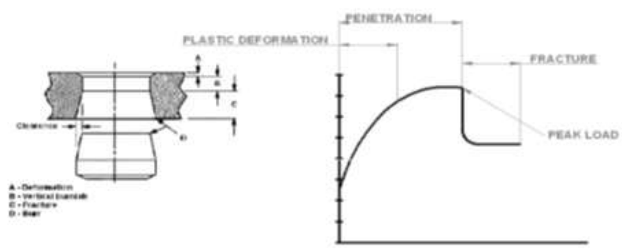

Figure 6. Load curve of cutting force of blanking or piercing punch

The bellow given table gives the shear strength (T max = 0.2 for tensile strength σ max) of several materials.

Table 1. Shear Strength of Different Materials

Material	**T max in N/mm2**
Steel with 0.1% carbon	240 - 300
Steel with 0.2% carbon content	320 - 400
(deep draw steel)	360 - 420
Steel with 0.9% carbon	450 - 550
Silicon steel	350 - 450
Stainless steel	200 - 400
Copper	350 - 400
Brass	360 - 450
Bronze	300 - 20
German silver (2 - 20% Ni, 45 - 75% Cu)	30 - 40
Tin	100 - 120
Zinc	20 - 30
Lead	20 - 120
Alluminium 99% pure	150 - 320
Alluminium manganese alloy	120 - 250

Alluminium silicon alloy	20 - 50
Paper & card board	70 - 90
Laminated paper or rosin impregnated paper	90 - 120
Laminated fabrics	50 - 20
Mica	20 - 40
Plywood	7
Leather	48-90
Soft rubber	20 - 60
Hard rubber	40 - 60

CALCULATING THE PRESS CAPACITY

Press force = Cutting force + Stripping force

As, Striping force = 10% to 20% of cutting force

Material – Leather, Sheet thickness (S) – 0.7 mm, Blank Size – 200X200 (L=800mm),
Shear Strength T_{Max} (Leather) – 58 N/mm^2

Now, Cutting Force = L X S X T_{Max}

=800 X .7 X 48= 26880 N =2688 kgf ………….. (As 1 N = 10 kgf)

Cutting Force = 2.688 Ton

Press force = Cutting force + Stripping force

=26880 + 20 % 26880 = 32256 N =3.2256 Ton

Taking FOS = 1.5, Press Capacity = FOS X 3.2256 =1.5 X 3.2256=4.8384 Ton

Taking, Press Capacity = 5000 N

Press Capacity = 5 Tonnage

IV. MANUFACTURING CONSIDERATION IN DEVELOPMENT OF LEATHER CUTTING MACHINE

The study of manufacturing reveals those parameters which can be most efficiently being influenced to increase production and raise its accuracy. Advance manufacturing engineering involves the following concepts- 1 Process planning, 2 Process sheets, 3 Route sheets, 4 tooling, 5 Cutting tools, machine tools, 6 Jigs and Fixtures, 7 Dies and Moulds, 8 Manufacturing Information Generation, 9 CNC part programs, 10 Robot programmers, 11 Flexible Manufacturing Systems (FMS), Group Technology (GT) and Computer integrated manufacturing (CIM).

4.1 PRODUCTION PROCESS

Generally there are three basic types of production system that are given as under.
1. Job production, 2. Batch production, 3. Mass production

4.2 Classification of Manufacturing Processes

These are discussed as under

4.2.1. Primary Shaping Processes: The parts produced through these processes may or may not require undergoing further operations. Some important primary shaping processes are(1) Casting, (2) Powder metallurgy, (3) Plastic technology,(4) Gas cutting,(5) Bending and (6) Forging.

4.2.2. Secondary or Machining Processes: (1) Turning, (2) Threading, (3) Knurling, (4) Milling, (5) Drilling, (6) Boring, (7) Planning, (8) Shaping, (9) Slotting, (10) Sawing, (11) Broaching, (12) Hobbing,

(13) Grinding, (14) Gear cutting, (15) Thread cutting & (16) Unconventional machining processes ECM, LBM, AJM etc.

Surface Finishing Processes

Processes Effecting Change in Properties:

A few such commonly used processes are given as under: (1) Annealing, (2) Normalising, (3) Hardening, (4) Case hardening, (5) Flame hardening, (6) Tempering, (7) Shot peeing, (8) Grain refining and (9) Age hardening.

4.3 Machine Tools

Following Machine Tools we have used for Manufacturing of Leather Cutting Machine as per the Conceptual Design;

1) Lathe Machine (Manual), 2) Surface Grinder, 3) Vertical Machining Centre (VMC), 4) Cylindrical Grinding Machine, 5) CNC Flame Cutting, 6) CNC Wire Cut EDM

4.4 Process Sequence

The manufacturing process selected must be an economical balance of materials, manpower, product design, tooling and equipment, plant space, and many other factors influencing cost and practicality. Following Process Sequence we have selected considering all above factors which will give a quality product,

Raw Material Form

A) Bright & Black (Blocks, Bars,etc.)

B) Cylindrical (Shaft, Bars,etc.)

4.4.1. Process Sequence Plan for Bright & Black form Raw Material

1) Sizing by Turning on Lathe Machine within 500µ (0.5 mm) of finish tolerances. (Only for Black form)

2) Surface Grinding within required finish tolerances (0-10µ max.) as per Design.

3) Machining on Programmable Controlled Vertical Machining Centre (VMC) with the help of CAM Software Del CAM/NCG CAM as per required tolerances.

4) Drilling Holes on DRO Drilling machine for Bolting & positioning applications at low cost & time.

5) Manual Tapping done with 3 sets of tap in Drilled holes.

6) Hardening Process – Annealing. Normalizing, Case Hardening, etc. as per achieving the required properties (Hardness, Softness, Stress relieving, etc.) in material (only for Hardened Material)

7) Wire cut is required for keyway cut, Splines, etc.

8) Finishing Process Blackodising is done for Corrosion resistance, Appearance, etc. (Only for soft material)

4.4.2. Process Sequence Plan for Cylindrical form Raw Material

1) Sizing by Turning on Lathe Machine within 500µ (0.5 mm) of finish tolerances.

2) Machining on Programmable Controlled Vertical Machining Centre (VMC) with the help of CAM Software Del CAM/NCG CAM as per required tolerances.

3) Drilling Holes on DRO Drilling machine for Bolting & positioning applications at low cost & time.

4) Manual Tapping done with 3 sets of tap in Drilled holes.

5) Hardening Process – Annealing. Normalizing, Case Hardening, etc. as per achieving the required properties (Hardness, Softness, Stress relieving, etc.) in material (only for Hardened Material)

6) Wire cut is required for keyway cut, Splines, etc.

7) Cylindrical Grinding is done as per required fits (Press fit, slide fit, transition fit, etc.) depending upon the application (as per tolerances).

8) Finishing Process Blackodising is done for Corrosion resistance, Appearance, etc. (Only for soft material)

V. RESULTS AND DISCUSSIONS

- For cutting a Leather blank of Size 200 mm X 200 mm & 0.7 mm thick a Hydraulic System with Capacity 5 ton should be designed.
- Flatbed die cutting machines are efficient for low volume orders, projects involving many different kinds of shapes, or applications in which no material curvature is needed. These are constructed using a pre-hard/pre-sharp Steel Rule Die blade. Blades can range from 2pt (.028 inch) to 8pt. (.112 inch) thick and have heights from .750 inch to 4.00 inches
- The performance of an engineering component is limited by the properties of the material of which it is made, and by the shapes to which this material can be formed. Under some circumstances a material can be selected satisfactorily by specifying ranges for individual properties. More often, however, performance depends on a combination of properties, and then the best material is selected by maximizing one or more ‘performance indices’.
- Decisions for optimal selection of processes, optimal sequencing of the selected processes and optimal order of processing parts have been found to be interrelated thereby requiring a stochastic technique like genetic algorithms to search for an optimal solution.

VI. CONCLUSION

Conventional leather cutting Machines available in market are manual not automatic, having larger cycle time, with more man power requirements and are not economical. Therefore to overcome these problems advanced Leather Cutting machine with automation is needed to be developed. Design, fabrication and automation of this advanced Leather Cutting machine can be done with minimum cost by considering proper process for leather cutting, developing efficient hydraulic system for cutting, proper material selection, by designing the machine components & testing for its failure, Proper Structure design, servo motor selection, and with the help of Electromechanical controls (PLC Controller) which will results in increase in production rate, reduce cycle time, less skill operator and reduce man power.

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