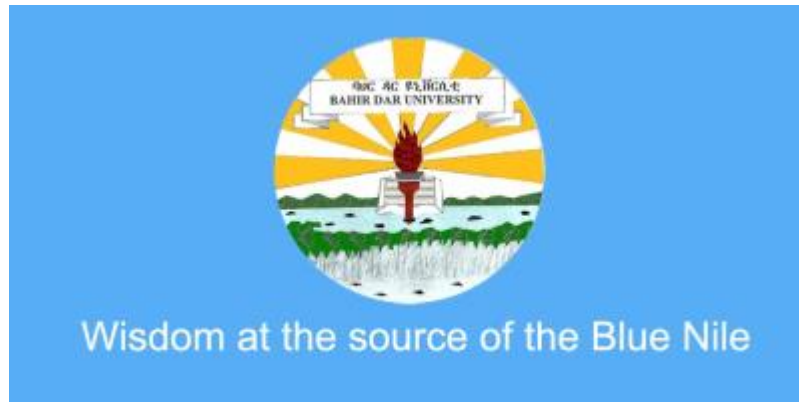


Re-design and simulation of Manually Operated Simple Interlocking Clay Brick Making Machine.



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Declaration

We the undersigned, declare that the thesis comprises our own work. In compliance with internationally accepted practices, we have acknowledged and refereed all materials used in this work. We understand that non-adherence to the principles of academic honesty and integrity, misrepresentation/fabrication of any idea/data/fact/source will constitute sufficient ground for disciplinary action by the University and can also evoke penal action from the sources which have not been properly cited or acknowledged.

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Acknowledgements

We would like to express our great appreciation to Bahir Dar institute of technology to comprise on its curriculum this final year project work. Because this helps us to develop our practical skill by giving a strength to the theoretical skill. Next we do have a great gratitude to our advisor Mr. Aragew Mulu for his continuous and sound advice as well as motivation in every aspect of the project work being responsible for it. He really provide its effort so as to inspire us for better work. Finally we would like to thank and appreciate to our friends those who helps us conceptually and motivate us as much as they can. We hope that our project team possess the study as per the schedule thanks to all individuals who guide and motivates us kindly.

Abstract

This project is mechanical engineering BSc program final year project with a title re-design and simulation of manually operated interlocking brick making machine its objective is to design and simulate manually operated interlocking brick making machine that can resolve the current housing problem by producing interlocking bricks that can easily assemble without the requirement of cement to clinch them together like concrete blocks and in turn minimize the cost of building construction. It benefits all individual or group of people engaged in construction activity and those who have low income and can't afford that much money for to construct home for themselves. The first phase of the project is to design which consists (literature review, analysis, cost estimation, part and assembly drawing and simulation).

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List of Abbreviation

W = the load applied on the brick.

P = the applied Effort on the lever arm.

R_F = Reaction at the fulcrum.

L_1 and L_2 = are length of the arm.

S = Compressive Strength (N/mm^2)

DP = Diameter of pin.

T = resisting torque.

P = Force applied at the handle,

σ_t = Permissible tensile stress.

L = Effective length of the lever,

τ = Permissible shear stress.

t_2 = Thickness of the boss.

l_2 = the length of the boss

t_1 = thickness of the lever arm.

h = height of the rectangular cross-section

Z = Section modulus for rectangular section

V = Material volume

ρ = Density of the material

A = is the cross-sectional area and

$r =$ radius of gyration.

$E =$ The modulus elasticity of the material

$\sigma_y =$ the yield strength of material

$I_x =$ second moment of inertia along x.

$I_y =$ second moment of inertia along y.

$t =$ throat thickness of the weld.

$S =$ leg or size of weld

$L =$ length of weld.

$V =$ Bolt length

$LT =$ Thread length

$L_d =$ Unthreaded length

$D =$ Major diameter

$H =$ Head height

$d =$ The major diameter is the largest diameter.

$d_r =$ The root diameter is the smallest diameter.

$d_p =$ The pitch diameter is a theoretical diameter between the major and minor diameters.

Chapter One

1.1. Introduction

Brick making has been practiced by human beings. Presently, bricks are easily made by using machines using new technologies. Generally two types of bricks are manufactured by using machines that are concrete block machines and clay brick machines. Different types of automatic machines use different techniques to make bricks. As a general the following raw materials used by the machines for making interlocking bricks. Fly ash, sand lime, iron oxide, lime sludge, quarry wastes etc. But for our machine we use specially clay, sand, cement and water.

The focus of this project is on the design & simulation of manual interlocking brick making machine which offer a speedier, cost effective, environmentally sound alternative to conventional walling materials. The technology has high potential in areas where raw materials are easily available. The new technique in producing this interlock brick can generate a highly profitable business for micro and small scale building material producers and construction companies.

Interlocking block production machine can be mechanically or manually operated. The former are normally incorporated with vibratory mechanism which enhances adequate compaction of the fresh stabilized mixture within the molds before hardening to achieve higher compressive strength after curing. The later does not achieve the compaction as in the former due to the fact that it is manually operated. Palettes are placed in the mold to form the grooves and protrusions for the top, middle and toe blocks. The production can be made in a small scale on site/laboratory or in a large unit in the industries.

The concepts or techniques of interlocking brick provide neat, fast and economical assembling of walls which is of great advantage over blocks laid with mortar. In the other hand, the dismantling is also very economical. Furthermore, interlocking blocks have reliable resistance to impact and penetration of sharp objects.

1.2 Background of Brick Making

Clay bricks were the first man-made artificial building material. They have been extensively used since the time of the Assyrians and Babylonians throughout all ages. It is an undisputed fact that shelter is one of the basic human necessities. Irrespective of the importance of shelter, most people do not have access to good shelter, most especially in developing countries. The poor are most adversely affected by this housing shortage. Among the many alternatives available for low-cost housing production are the compressed laterite soil blocks or bricks. Brick actually is the oldest man-made building material, invented almost ten thousand years ago. Its simplicity, strength and durability led to extensive use and gave it a dominant place in history alongside stone. Sun-dried bricks, reinforced with such diverse materials as straw and dung were so effective that fired bricks did not appear until the third millennium. In contemporary times machines have made it possible to produce higher quality bricks or blocks using soil as the basic ingredient. Sun dried uncompressed adobe bricks can be improved greatly by compressing the soil to higher densities. As we know the most important building materials for low-cost housing are blocks /bricks/, but conventional quality concrete blocks are too expensive for low-income communities. Due to high cost of Portland cement, a lot of block producer's use less than the recommended amount in the concrete mix making the block/brick to be substandard. This is one of the most dangerous factors for the frequent building collapse in the country recently example at Ledeta condominium Addis Ababa.

Bricks / Blocks are solid pieces of hard substances, usually with flat sides, used as construction units. They are sometimes referred to as masonry units (MU). A "brick is a masonry unit not exceeding 337.5mm in length, 225mm in width or 112.5mm in height". Units with more than these measurements to any of the sides are termed blocks. Block and brick masonry are strong, fire resistant, insect-proof building materials. They have a lot of thermal mass, which helps them retain heat and makes up for their relatively low insulation value. However, despite their similarities, block and brick have some major differences: Blocks are bigger in size as compared to bricks; blocks are usually made of concrete and hollow, while bricks, on the other hand, are smaller usually made of clay or other earthen materials and solid.

Compressed Earth Brick (CEB) is an alternative building material to concrete blocks which have been proved to be an excellent substitute. This project work is being done by Bahir Dar university

bachelor degree mechanical engineering program students as final year project on manually operated simple interlock brick making machine. which by its very character responds to the problems listed above and other quests that recently arise in the construction environment that are shortage in cement supply, high cost of cements, complexity in construction, and time needed to finish the construction. Therefore the above motive problem scenarios initiate this project that will address the above problems which are still existing in constructing residents by designing and fabricating manually operated simply interlock brick making machine. This project is not the peak advancement in the design and manufacturing of manually operated simply interlock brick making machine therefore it invites others who are interested to further modify the machine since success arise from the intelligence of knowing how to respond for failure to back on truck and by acknowledging others for their effort.

The advantages of interlocking Brick are:

- ✓ Construction with interlocking brick saves time and ample amount of mortar concrete compared to conventional masonry brick laid with mortar. Areas prone to earthquake uses hollow interlocking block with the strength improved with grout and reinforcement throughout the height of the wall to resist the effect of earthquake, thus, providing adequate structural stability against collapse. Having formed the base course, other course can be assembled by unskilled labor dismantling of the bricks in case of temporary structure does not incur much damages as in bricks laid with mortar. Cost of construction reduced or is relatively less.

Disadvantages of interlocking brick include:

- A standard skilled masonry labor is required to ensure proper horizontal and vertical alignment of the bricks, and that the corner and junction are right angled, especially at the base course. Due to wind and rain seepage effect the brick wall need be rendered. Consequently hamper the alignment and stability of the wall, if not adequately observed. It is difficult to maintain the required tight tolerances for accurate construction of large walls or other structures through the molding and cutting steps.

1.3. Significance of the study

It is helpful to improve the engineering properties such as strength, workability, plasticity, water absorption tightness and building bricks. Directly improves all the mechanical properties such as compressive strength, tensile strength, bending, flexural strength adhesion force of soil etc. To estimate the stability and durability of the brick. To reduce the plastering thick-ness and which will also helpful in reduction of the overall manufacturing cost of high strengthens building brick. After reviewing all above valuable point it is necessary that to produce an effective, feasible common solution for society and constructional industries which cover all the above point, manually operated interlocking brick making machine that operate by lever and linkage mechanism, which will helpful to manufacture wide range of bricks with cheap production cost, high production rate, easily accessible and easily handle by unskilled labor, easily transportable, eco-friendly technology to environment and satisfy all needs of industries and society. The other advantage is it avoids noise created by motor driven brick making machine which disturbs the people around the vicinity where brick manufacturing is performed since it is manually operated. The most commonly used interlocking bricks are the following:

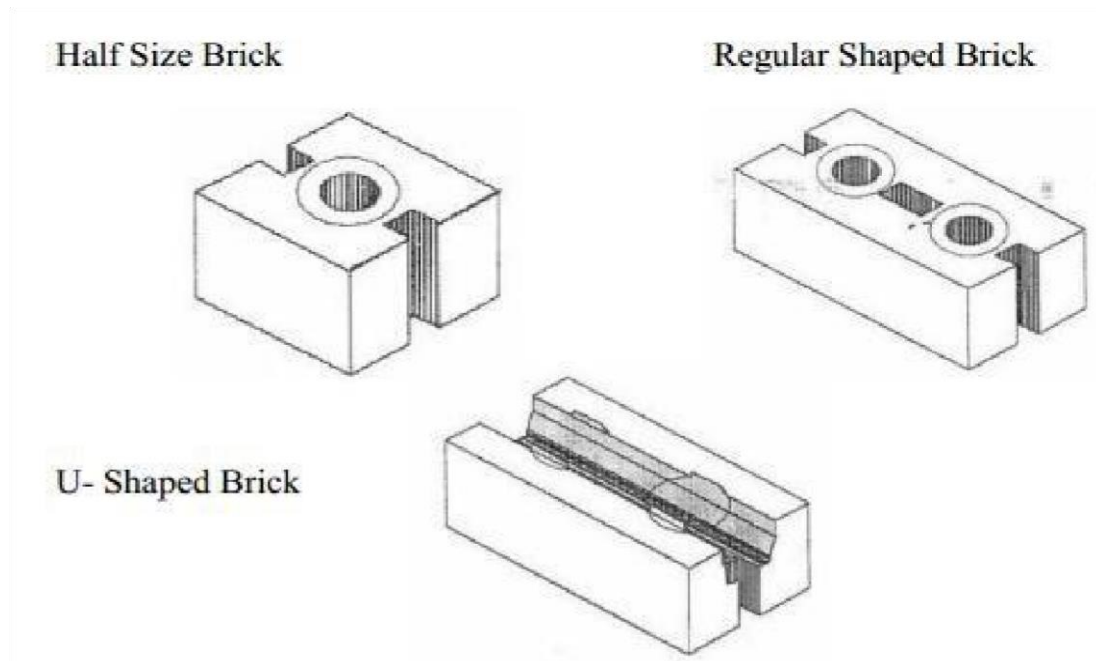


Figure 1. Different types of interlocking bricks.

1.4. Problem statement

The major problems detected around construction are high cost of cement which is not affordable by individuals that have low income. Even high cost for cement production therefore meeting the need of people in constructing their on shelter at low cost can be possible by this manually operated interlocking brick making machine. Even though there are other similar type of brick making machine they have some problem some are like producing only one shape of brick which is not favorable. Therefore in our design we ought to modify the machine and enable it to adapt dies of different shape or profile and produce bricks at least with two different profile the other problem is absence of electric power in most of the countryside since the machine is manually operated it also overcome this additional problem.

1.5. Objective

1.5.1. Major objective

The major objective of this project is to re-design and simulate manually operated simply interlock brick making machine

1.5.2. Specific objective

- Design each components of the machine.
- Simulation of each components of the machine.
- Modifying the mold to adapt at least two dies.
- Evaluate its effectiveness.
- Compare with concert making machine.

1.6. Scope of the study

This project work intended to solve the problem or the challenge observed on constructions. In this project we give more emphasis to solve the problem faced by designing a cost effective brick production. The team of this project aimed to re-design and manufacture a simply interlock brick making machine which can produce simply or easily interlocked bricks from clay soil and other soil substitutes based on the provided ratio.

1.7. Components of the machine

Hopper:-a component through which the sand cement and clay mixture is inserted to the machine.

Feeder feeds the mixture to the molding chamber by relative manual exited reciprocating motion

Molding chamber is the cavity in which various pattern plates are situated and the sand fed by the feeder is compressed to form a brick.

Pattern plates this is of different shape and can be interchangeable according to the desired shape.

Arm is through which the operator applies a pressing force to compress the mixture.

Linkages that connect the arm and the vertically sliding platform on which the bottom pattern plate.

Supporting base it support the overall components and stand firm while in operation.

Manual driven: - It uses solely the man power to actuate the machine.

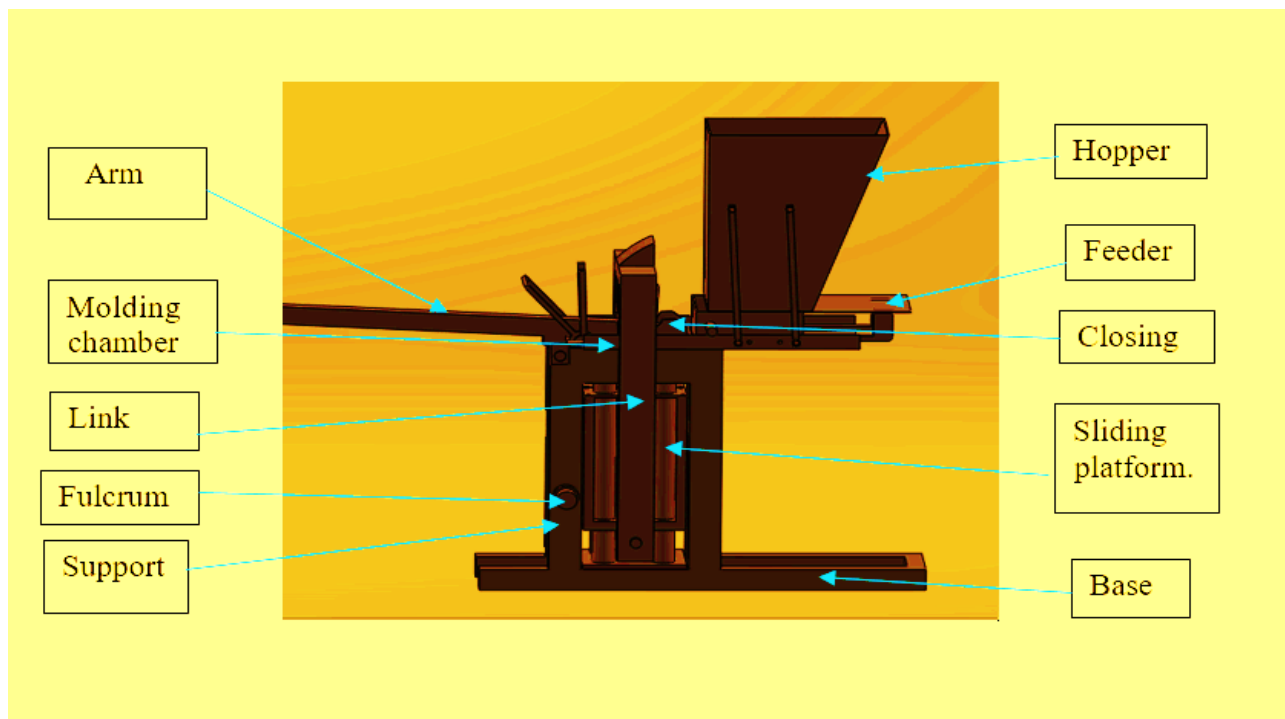


Figure 2 Components of the machine.

1.8. Working Principle

Once the sand cement clay or soil proportional mixture is prepared based on the required proportion, it will be imputed to the hopper so that the hopper bottom opens and passes the mixture to the feeder then add the mixture to the molding chamber. The top closing is open by linkage mechanism and the feeder is manually slide along the longitudinal direction the feeders protruding part locks the bottom of the hopper to avoid continuous flow of the mixture. Simultaneously the feeder feeds the mixture to the mold chamber where it is compressed to form the brick after the mixture is inserted to the chamber. The top closing is closed and the arm is pulled down in some angular rotation pressing the mixture by the upward movement of the base platform. While the arm is move down ward the then by the reverse motion of the arm the top closing is opened and same downward motion the compressed brick will be detached from the pattern plate.

1.9. Methodology

The study process uses different steps to come up with the desired outcomes. This includes data collection, analysis and design and workout of the machine model.

Data collection

- ✓ Necessary data required for analytical and model design will be collected from different sources. These includes collecting data from secondary sources like literature review on the design and processing aspects of the small scale boat from previous studies, websites and published books and scientific journals.
- ✓ Data collection by proper gathering of data has to be executed regarding the problem of bricks so that the information obtained from the local communities. Problem identification, evaluations & Material selection for each components;

Data analysis

The data analysis work will be done using descriptive statistic tools, concept analysis and software supported techniques. The analytical mission includes:

- ✓ Analyze data from the earlier kinematic and dynamic analysis.
- ✓ Studying & understanding its operational mechanisms and outputs,
- ✓ Undertake detail analysis of the data gathered from the specified source.

Design analysis

- Under taking a stress analysis of each machine component on the design
- Parameter analysis of each components
- Interpret working principles of design of each components.

Drawing works:

- Develop drawings using **solid work** Software
- Part drawing of each component by using solid work software after design each component realized the 3-D modeling of the brick components.
- Simulation, assemble drawing, Drafting and documentation of the project;

Cost analysis

- Study the cost of each components
- Analysis the cost respect to cement's cost and Calculate total cost.

Chapter Two

2. Literature review

2.1. History of Interlocking Bricks

Conventional concrete block/bricks walls are laid up by a time-consuming difficult procedure which involves making a layer of concrete mortar onto a level concrete or stone base or the like, on the top of a course of previously laid blocks and then setting blocks one at a time on the mortar layer, in each instance also applying mortar between the blocks and to the end course/walls to ensure proper binding of the blocks together. Few people have the skill to carry out such a procedure in a competent manner; therefore the cost of such construction is always high. Various types of interlocking blocks have been devised in the past to facilitate the construction of block walls and other structures. Most such blocks have been very expensive to produce since the interlocking portions, usually grooves or protrusions, are normally cut into the blocks after they have been formed by molding. Moreover, it is difficult to maintain the required tight tolerance for accurate construction of large walls or other structures through the molding and cutting steps. The prior blocks often required additional finishing or grinding steps to meet the required tolerance. Interlocking mortar less building blocks overcoming many of these deficiencies are described in U.S. [1]

Mortar less technology is directly associated with interlocking bricks. So the two terms will be used interchangeably. In this work we are going to deal with use of interlocking bricks, stacked dry to build a wall while observing building construction rules of proper bonding. Bonding's the arrangement of bricks in an interlocking pattern that result in a stable wall. The stretcher bond was the only (main) such pattern used in interlocking brick work before this research. The history of interlocking bricks started in the early 1900s with the construction of toys for children's. From the beginning most toy mechanisms were designed to teach the principles of creativity and were a tool for learning scientific, engineering and architectural principles. The original materials used for toy construction were tin, metal, wood and clay, though now most toys are made from plastic. Of these various systems, Lego has the most similarity to walling. [2]

The 1958 version of interlocking bricks with stubby cylinders and matching studs molded into the surface allowed the Lego bricks to be firmly attached to one another. In 1967 a simplified version called “Duplo” bricks was launched: is the latest version available in variety of sizes, shapes and colors that form the basis for mortar less technology using interlocking bricks/blocks the interlocking mortar less bricks/blocks for house construction, made from Sand-cement, stabilized soil and burnt/baked soil, have been pioneered in Africa, Canada, the Middle East and India. Those blocks have been used successfully for many years. These blocks are assembled in courses, with the block joints staggered and continuous vertical open cells into which reinforcing bars and wet (fresh) concrete can be inserted. While highly effective, these blocks require that the reinforcing bar be inserted in lower courses, with blocks in later courses lifted over an end of the reinforcing bar as the structure advances and wet concrete is periodically poured into the cells containing the reinforce. [3]

From compressed mixtures of Portland cement, stone dust and water. The interlocking blocks also follow the same pattern to have tongues and grooves on the top and bottom surfaces of the blocks respectively to restrain horizontal movement when laying interlocking block on top of one another without the use of mortar joints. Installing some reinforcement and grouting mortar in the grout holes increases the wall strength. [4].

We can characterize bricks in terms of their solidity as follows: -

- ✓ The more solid the brick the more material required and the more powerful the press needed to attain enough brick density, but less binder will be needed for satisfactory Brick strength.
- ✓ The more perforations, increasing up to 50%, the more binder will be required in the mix to achieve the higher strength needed for thin membranes formed onto a hollow block.
- ✓ The two solidity characteristics of blocks above, have extreme conditions that increase cost of blocks. The best percentage of perforation is that which minimize some combination of weight, material and the power requirement. To reduce the cement/sand ratio in the mix for hollow blocks, the size of perforations should be reduced.

Interlocking requires a variety of shapes/parts to construct different wall joints. The existing interlock designs have different configurations and thus vary the number of part bricks. Great care must be taken to keep each course perfectly horizontal and or vertical and straight.

Those blocks have been used successfully for many years and are assembled in courses, with the bricks joints staggered and continuous vertical open cells into which reinforcing bars and wet concrete can be inserted. While highly effective, these bricks require that the reinforcing bar be inserted in lower courses, with blocks over an end of the reinforcing bar as the structure advances and wet concrete is periodically poured into the cells.

However installing blocks over the reinforcing bar can be a significant problem with tall structures. Therefore, continuous need for improvements in mortar less building block systems to permit lower cost of block manufacture, and lower cost and more rapid structure assembly from the blocks became necessary. The design of the block should be such that it can be readily molded and released from the forming mold with full detail preserved, obviating any subsequent reshaping, finishing, etc.

Comparison between Previous clay brick machine and our design of clay brick machine.

Table 1. Comparison between Previous clay brick machine and our design of clay brick machine.

Previous clay brick machine.	Our design of clay brick machine.
✓ Because they doesn't have the interlocking shape, it requires a binding agent (cement)	✓ Interlocking requires a variety of shapes or parts to construct different wall joints.
✓ The prior bricks often required additional finishing or grinding steps to meet the required tolerance.	✓ To meet the required tolerance, the size, dimensions and surface finish of the molding chamber is perfectly designed.
✓ The die or pattern plate is rigid or fixed.	✓ We adopt the detachable or variable die or pattern plate.
✓ The machines are manual and mostly.	

Interlocking Brick Specification

The interlocking bricks are different from other normal bricks as it requires no mortar or cement for masonry work. This bricks interlocked with each other by means of positives and negative frogs on the top and bottom of the bricks which disallow the horizontal movement of bricks. There are various application of this bricks namely: load bearing wall, sills (bottom), Lintels (top support), Wall corners etc. The specifications and the characteristics of this brick depend on the machine used to manufacture it. The most common size of brick is 300x150x120mm. The basic raw material is cement, fine aggregate and coarse aggregate. Very little water is used. This is possible only with mechanized compaction and vibration and gives the block high quality in spite of the lean mix, which uses very little cement. Weight of this brick is about 4 - 7 Kg.

2.2. Materials required for interlocking brick production:

When looking for the right soil type, we should use soil from the subsoil, so as to avoid any organic matter. The best soil type is sandy loam (more sand than clay). Your optimum ration is 70% sand to 30% clay silt content. The reason for this is too much sand causes difficulties in handling, and too much clay causes the brick to shrink and in doing so they crack. If your soil has too much clay you can add sand to get the right ratio.

Soils are made up of varying proportions of materials such as gravels, sands, fine (silts and clays). Each of these have different characteristic, for example, when they are exposed to variations in humidity, some will change in volume, while others will not. The first two of these materials are stable, the other two are unstable. Stability is the ability of the material to withstand alternating of humidity and dryness without its properties changing. This is a fundamental importance property for a building material.

Gravels: - Are made up of pieces of rock of varying hardness, and their size ranges between approximately 2 and 20 mm. They form a stable constituent of the soil. Their mechanical properties undergo no detectable change in the presence of water.

Sands: - Are made up of mineral particles, and their size ranges between approximately 0.06 and 2 mm. They also form stable constituents of the soil. They lack cohesion when dry, but have a very high degree of internal friction between the particles which make them up.

Silts: - Are made up of particles the size of which range between approximately 0.002 and 0.06 mm. They have little cohesion when dry. Since their resistance to movement is generally lower than that of sands. However, they display cohesion when wet.

Clays: - Form the finest fraction of soils 0.002mm, and have completely different characteristics than those of the other particle types. They consist mainly of microscopic clay mineral particles. Clay particles are coated in a film of absorbed water. Classification by plasticity (Fine content):

Soil plasticity is the ability of a soil to undergo irreversible deformation when it is subjected to an increasing load. It is indicated by the plasticity index. The plasticity index is the amount of water required for a soil to pass from a plastic to a liquid state. In addition, soil is a mixture of irregularly shaped mineral particles of various sizes containing voids between particles. These voids may:

- ✓ Contain water if the soil is saturated,
- ✓ Contain water and air if partly saturated,
- ✓ Contain air if it is dry.

Cohesive soil: - Cohesive soils are fine-grained materials consisting of silts, clays, and organic material. These soils exhibit from low to high strength when the air is dried in the voids.

Cohesion less Soil: - Cohesion less soil is composed of granular or coarse-grained materials with visually detectable particle sizes with little cohesion/adhesion between particles. These soils have little or no strength when they dry and little or no cohesion when they submerged under water.

Generally:- A more useful range of particle sizes suitable for building with stabilized brick is from 40 - 75% sand and from 25 - 60% fine (silt and clay). Gravel is not usually used in soil-cement mixture production, as the large particle size may lead to a poor (rough) surface finish. A suitable soil for building construction contains a mixture of sand and fine (silt and clay) particles. The properties of each of these fractions influence the properties of the brick. There is no need of gravel particles in soil which is used for stabilized earth block productions. Therefore, the sieve that is used for filtering or screening the soil should have a diameter the same as the minimum diameter of the gravel particle size (i.e. 2mm).

Manually operated simple interlock brick making machine

Preparation of the raw material.

In the manufacturing, the clay rock is crashed and reduced in to smaller particles, and then the material produced is screen through an inclined vibrating screening machine to control the particle sizes prior to water being added. During the screening, manufactures adjust and compensate the different variations in chemical composition and physical properties by blending clays from the different locations and sources to fit their standard of the end product. Consequently, to fulfil the requirements of perfect clay for bricks making, or for the composition of the raw material to fulfil their standard, the different mixes and proportions of clay and chemical are blended together, prior to add water, as which of them affect the working properties of clays causing them to vary in their behavior affecting the properties of the final product. At the same time, manufacturing section has standardized their end product and their manufacturing processes to limit variations in the processing and the inconsistency in end product.

Example: Clay containing from 5 to 8 % of oxide of iron will, under ordinary conditions of firing, produce a red brick; but if the clay contains 3 to 4% of alkalis, or the brick is fired too hard, the color will be darker and purple. An excess of Alumina compound tending to make the color lighter and brighter.

Exploitation

Usable layers of soil are rarely found at the surface of the ground (except in dry areas), because at the surface soils contain too much organic matter. This organic top soil is rarely used for stabilized soil bricks and it is mostly found in the first 0.5 m depth of the soil layers. In addition, usable soil is rarely found at great depths, where there are too many stones, or even solid rock. Therefore, the depth of usable layers of soil varies greatly, from a range of few centimeters to several meters.

Cement: - Cement is a fine grey powder which is mainly composed of Lime (CaO) and Silica (SiO₂). The minimum amount of cement required to stabilize a brick depends on the type of soil, the degree of compaction force and the final application of the bricks. The range of cement content needed for good stabilization is between 3% and 5% by weight according to soil type. The cement to soil ratio can be anywhere from 5% to 12% cement. Once you have determined what ratio you are going to use, you can then start your mass mixing. The easiest method for preparing your mixture is to have a container that holds the same amount as a bag of cement.

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The cement must come level with the top of the container so that measuring one part cement will be the same as one part soil. We also want water supply at a place of mixing and curing.

Here are some examples of different mixing ratios:

- ✓ 5% Mix = 1 bag Cement: 20 parts Soil
- ✓ 8% Mix = 1 bag Cement: 12 Parts Soil
- ✓ 10% Mix = 1 bag Cement: 10 parts Soil
- ✓ 12% Mix = 1 bag Cement: 8 parts Soil.

3. Mixing: When mixing it is advisable to only mix one bag of cement at a time so you get an even mixture. Start by mixing your soil and cement until mixed thoroughly. Then add water – this must be done slowly and evenly, ideally using a watering can. You need to make sure you add the right amount of water to your mixture. Too dry mixture will make your brick crumble when handled and too wet will make your brick lose shape and crack. Ideally you want a mixture which when you squeeze it in your hand it sticks together and when you push your thumb into it, it will break into a few pieces.

WATER

The amount of water add in to mixture must be known in stabilized earth block production. The quality and quantity of the water plays a significant role in brick production. Impurities in water may interfere with the setting of the mixture, may adversely affect the strength of the brick. Less water in the soil paste will yield a stronger and more durable brick, whereas more water will give a free-flowing brick with a higher slump. Because adding more water to the mixer make easier to work, however the brick will have a poorer quality. The excess water can also cause the brick to crack due to shrinkage and break during drying. Adding the correct amount of water during brick preparation is critical for making good quality bricks.

Manually operated simple interlock brick making machine

The less water used, the better the quality. If the amount of water is too much in the mixture, the brick will:

- Deform easily under its own weight after molding;
- Deform when placed on uneven or bumpy ground;
- Results shrinkage crack during drying;
- Take much more time to dry.

The following is a simple example of estimating the volume of water for production and curing, based on author's practical experience with stabilized-soil brick production in Tanzania. Knowing the average ratio of cement to soil (1:16) and assuming a water/cement ratio of 0.5:1, one bag of cement (50kg) requires on average three buckets of water (60 liters) to produce 100 bricks. With one brick press, three laborers can comfortably produce 500 bricks a day, namely a batch, and to cure one batch we require two buckets (40 liters of water) per day for 7 days.

Washing of three laborers and tools requires five buckets of water (100 liters) per batch. Manual molds that require hand tamping, a mobile semi-mechanized and fully mechanized system that combines compression and manual concrete filling in mold. The machine also compacts and consolidates the mix so that the blocks are uniform in size and attain desired physical properties. The bricks are cured for a minimum period of 14 days, before they are ready to use. On an average 600-800 bricks can be in 8 hours by 1 skilled and 6-8 semiskilled workers.

Chapter Three

3.1. Conceptual design

Conceptual design is the part of the design process where by identifying the essential problems through abstraction, establishing function structures, searching for appropriate working principles and combining these into a working structure the basic solution path is laid down through the elaboration of a solution principle. Conceptual design specifies the principle of solution.

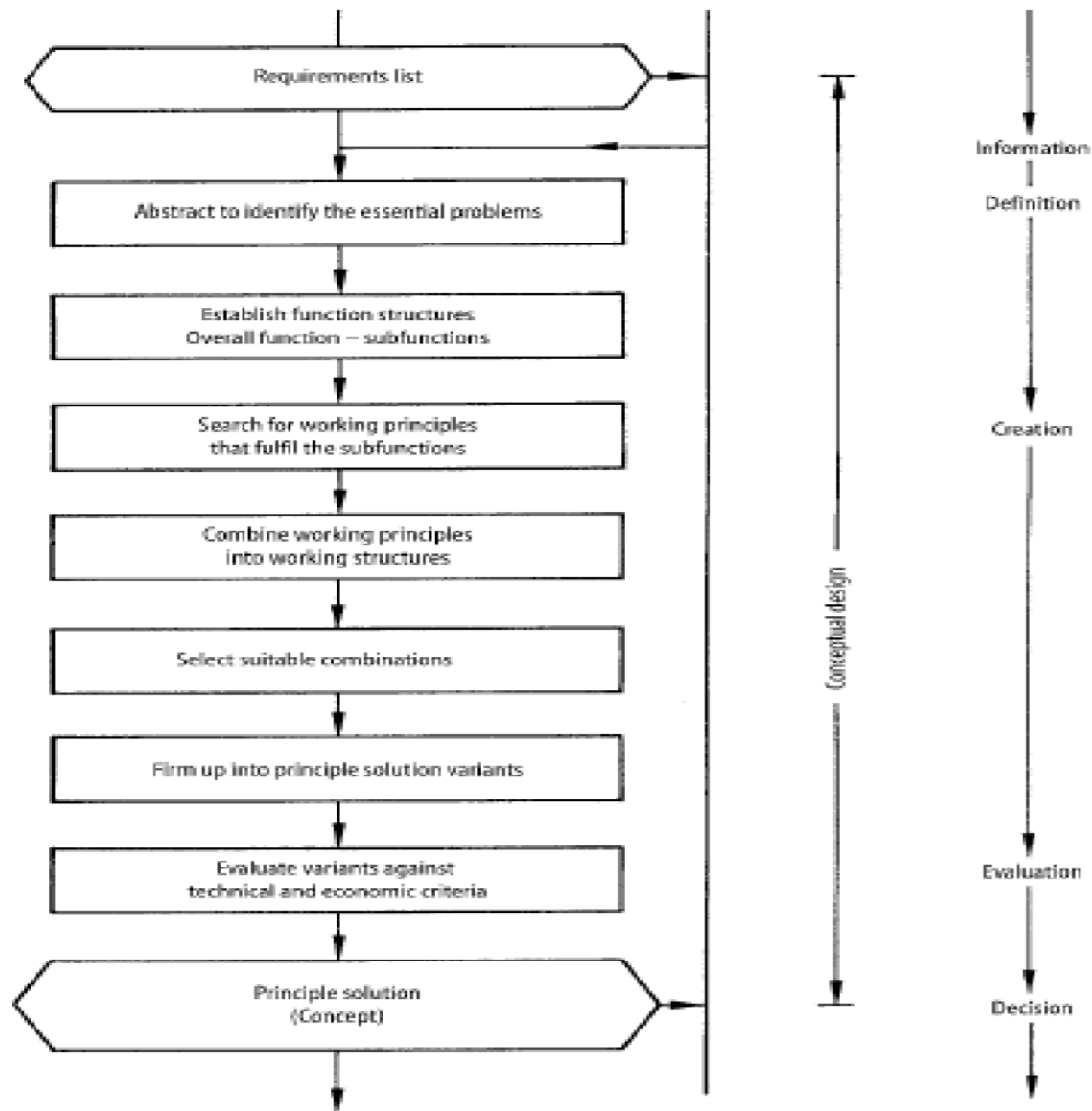


Figure 3 Steps of conceptual design.

Manually operated simple interlock brick making machine

- ✓ This is a machine able to made bricks to build different buildings. The Need of these machine:-
- ✓ The machine shall be easy to operate and Efficient
- ✓ It should have high performance and must be reliable and do the desired task.
- ✓ The machine is to be light in weight
- ✓ Small number of components, low complexity & low space requirement, no special problem with layout or form design.
- ✓ Easy to move and portable
- ✓ Safe operation to human being

Problem definition

- ✓ High cost of cement for building
- ✓ Only one dies of shape or profile clamping
- ✓ Old once make single brick at a time
- ✓ Absence of electric power in rural area

Existing solution

- ✓ Produce different shape of bricks
- ✓ Work in the absence of electrical power or manually
- ✓ Provide bricks for shelter at lower cost
- ✓ adapt dies of different shape or profile

Engineering characteristics

- Speed & Force
- Vibration resistance & Weight,
- Strength & Size
- Cost and Life time.
- **Product design specification**

✓ **Product identification**

Mechanical operate Function

- Produce varies shape of bricks
- The bricks produced shall be interlocking bricks to each other.

Manually operated simple interlock brick making machine

- ✓ Special features
 - To produce manual operated simple interlocking brick making machine
 - To minimize the cost due to manual operation
 - The mechanism is manual drive
- ✓ **Key performance targets**
 - Use full life of working.
 - Cost of installation and operation
 - Maintenance schedules and location
- ✓ to achieve the objectives, the design uses the following steps.
 - The fundamental concepts of engineering design and conceptual design among others were viewed. A list of target-specifications for the design was formulated.
 - There are several types of brick-making-machines. The stabilized brick-making-machines can either be manual, partially-manual or automated, therefore different local brick-making work shops were visited to evaluate the different machinery utilized.
 - Design problem was formulated (design factors involved such as block sizes/mold sizes, calculation of forces involved, variation in material use, failure modes, cost, etc.
 - Three free-hand sketches of various ways the machine might be constructed were made, at the same time making any preliminary calculations which might be required to substantiate ideas and to establish approximate sizes.
 - The design-alternatives were brainstormed to choose the most feasible and effective alternative to best satisfy the customer needs. Selection of the best-alternative was done by the use of the engineering design weighted-score-matrix.
 - The materials selection was done. The properties for consideration were limited to: technical properties of materials (density, conductivity, strength), manufacturing of materials (easy to manufacture with existing manufacturing facilities), economic properties of materials (Cost for material and production, availability) and ecological properties of materials (recycle-ability, sustainability).
 - The best-alternative-design was then optimized based on simulations and calculations. The layout was analyzed for forces, stresses, etc., and calculations necessary were made to be certain that the parts can perform satisfactorily.

3.2. Establishing Function Structures

3.2.1. Overall Function

The requirements determine the function that represents the intended overall relationship between the inputs and the outputs of a plant, machine or assembly. Hence, once the crux of the overall problem has been formulated, it is possible to indicate an overall function, based on the flow of energy, material and signals, with the use of a block diagram, express the solution-neutral relationship between inputs and output.

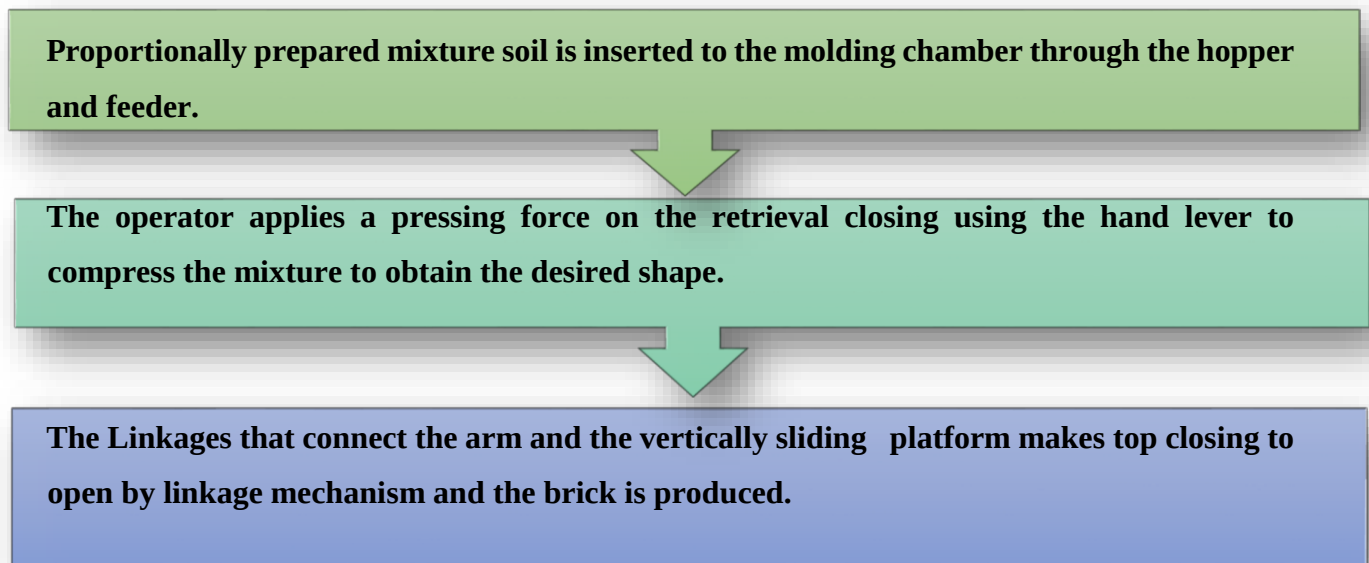


Figure 4 main function.

3.2.1. Breaking a Function Down into Sub functions

Just as a technical system can be divided into subsystems and elements, so a complex or overall function can be broken down into sub functions of lower complexity. The combination of individual sub functions results in a function structure representing the overall function.

The aims of breaking down complex functions are to determine sub functions that facilitate the subsequent search for solutions. Combine these sub functions into a simple and unambiguous function structure.

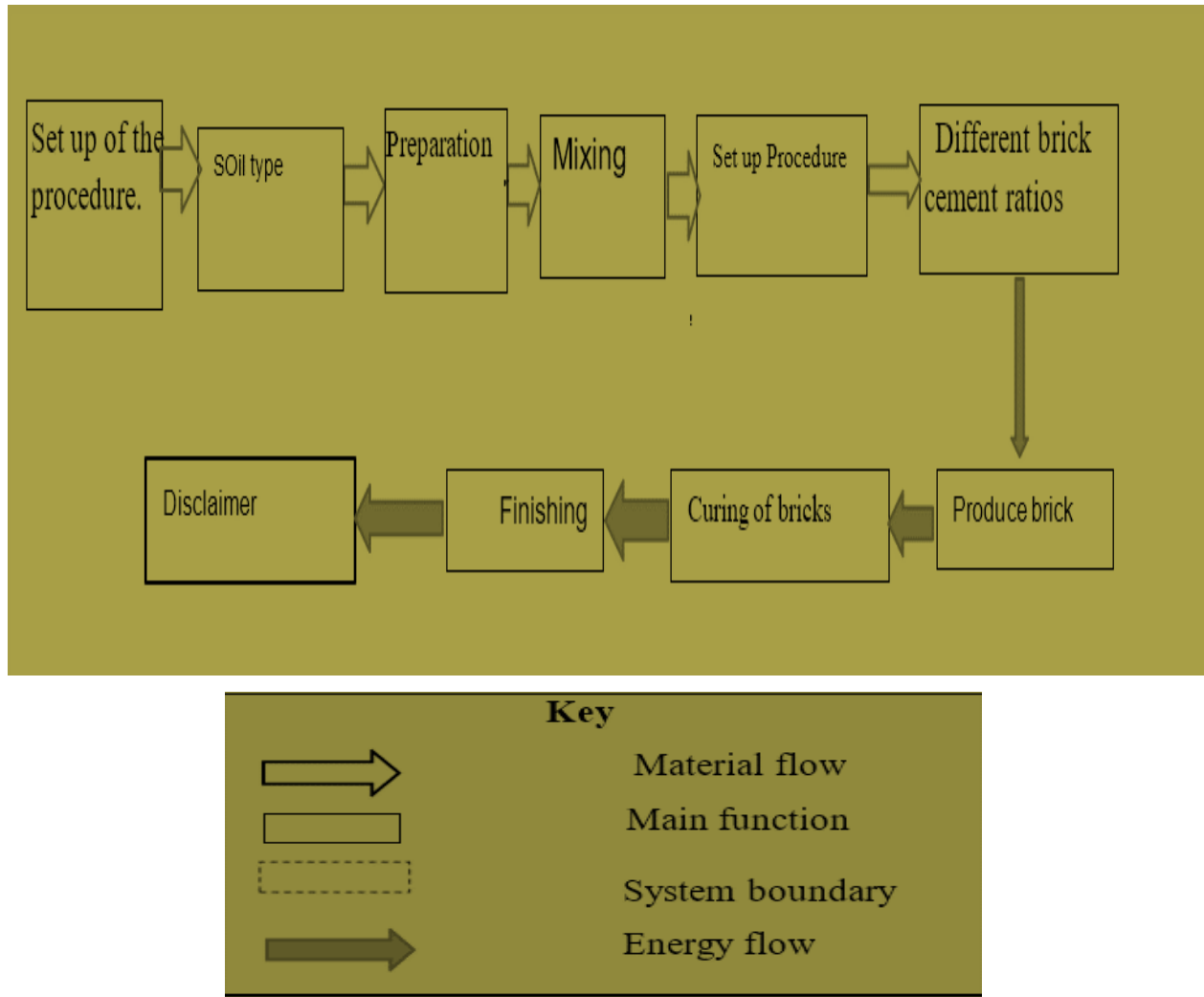


Figure 5. Sub function of main function

3.3. Expanding sub function

3.3.1 Setup of production line

Once you have established where you are going to make your bricks, it is a good idea to set up your Production site in such a way as to have a free flowing production line in order to minimize labor, time and cost. It is a good idea to have your machine and mixing area all under some water tank shade. You also want your water supply at your place of mixing and curing.

The following are the sub function of producing bricks.

Manually operated simple interlock brick making machine

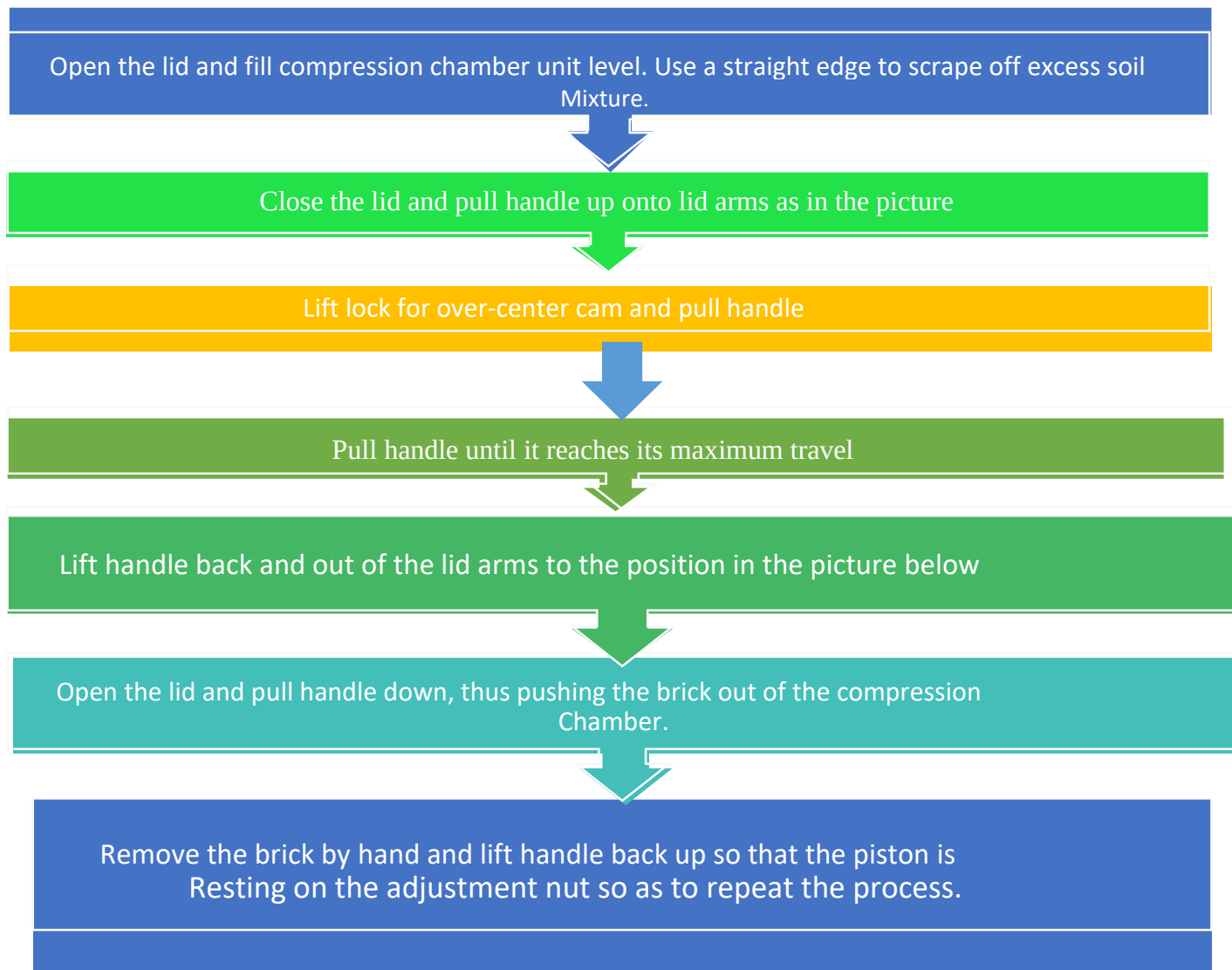


Figure 6. The sub function of producing bricks.

3.4. Searching for working principles

First, a range of possible solutions for the given task has to be generated. The function structure also provides the functional interrelationship between the subtasks, by describing the relationship between the inputs and outputs of each sub function with respect to the flows of material, energy and signals.

In a second step, one or more possible physical effects are assigned to each of these solution neutral sub functions in order to realize them. This is done in accordance with the task-specific

Manually operated simple interlock brick making machine

requirements. Brainstorming is even useful in the solution of sub problems arising in known or existing systems.

To sum up: the search for working principles for sub functions should be based on the following guidelines:

- Preference should be given to the main sub functions that determine the principle of the overall solution and for which no solution principle has yet been discovered.
- Classifying criteria and associated parameters should be derived from identifiable relationships between the energy, material and signal flows, or from associated systems.
- If the working principle is unknown, it should be derived from the physical effects and, for instance, from the type of energy. If the physical effect has been determined, appropriate form design features (working geometry, motions and materials) should be chosen and varied.

Table 2. Alternatives working principles with different criteria.

Sub function	1	2	3
Source of energy	Manual power	Hydraulic power	Electric power
change energy	Leaver and linkage	Piston cylinder	Electric motor
Power transmission	Hand leaver	Working fluids	Gear mechanism

3.5. Combining working principle

To fulfill overall function it is necessary to generate overall solutions by combining the different working principles in to working structure that is system synthesis. Here we have use systematic combinations other than mathematical combination because mathematical combinations only to understand quantitative elaborations other than optimum compatibility. We use sticky or the morphological matrix for combining the working principle. The basics we used for combining working principles are:

1. First we eliminated those working principles which have no direct relationships.
2. Combine only compatible sub functions
3. We insure the physical and geometrical compatibility of working principles to combine.
Insure smooth flow of energy, material, and signal

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Once the sand cement clay or soil proportional mixture is prepared based on the required proportion, it will be imputed to the hopper so that the hopper bottom opens and passes the mixture to the feeder then add the mixture to the molding chamber. The top closing is open by linkage mechanism and the feeder is manually slide along the longitudinal direction the feeders protruding part locks the bottom of the hopper to avoid continuous flow of the mixture. Simultaneously the feeder feeds the mixture to the mold chamber where it is compressed to form the brick after the mixture is inserted to the chamber. The top closing is closed and the arm is pulled down in some angular rotation pressing the mixture by the upward movement of the base platform. While the arm is move down ward the then by the reverse motion of the arm the top closing is opened and same downward motion the compressed brick will be detached from the pattern plate.

There are five paths for the concept generated alternatives

- Path one manual, lever, linkage mechanism.
- Path two Hydraulic power, hand lever, linkage.
- Path three Hydraulic, piston, hand lever.
- Path four hydraulic, piston, working fluid.
- Path five electric power, motor, gear mechanisms.

Financial requirement and Economical criteria's

- Easy to maintain or not complex (simple)
- Less Cost and decrease wastage
- Low assembly cost, manufacturing cost & operating cost

Customer requirement

- Stable and Reduce force requirement
- It is less Noise.
- More portable, Speedy & Easy to clean.

Technical criteria's

- ✓ easy to operate
- ✓ Performance
- ✓ Reliability.
- ✓ Maintainability

Manually operated simple interlock brick making machine

The choice of materials for components used for this project is based on the following factors:

- Material strength, low cost, relatively low weight and resistance to corrosion etc.
- Efficiency of equipment.
- Simplicity of design, and cost of the material.
- The major material used for the fabrication are steel and aluminum.
- The stainless steel, mild steel and aluminum were selected because they are easy to welding, machining, resists oxidation and corrosive attack and reduces weight.
- All fasteners are made from stainless steel.

Chapter Four

4. Embodiment design

4.1. Design of a Lever Arm

A lever is a rigid rod or bar (tubular) capable of turning up and down about a fixed point called fulcrum. It is used as a machine to lift a load by the application of a small effort. The ratio of load lifted to the effort applied is called mechanical advantage. Sometimes, a lever is merely used to facilitate the application of force in a desired direction. A lever may be straight / curved and the forces or pressure applied on the lever may be parallel or inclined to one another. The principle on which the lever works is same as that of moments.

The design of a lever consists in determining the physical dimensions of a lever when forces acting on the lever are given. The forces acting on the lever are:

1. Load (W),
 2. Effort (P), and
 3. Reaction at the fulcrum F (RF).
- ✓ Generally the load W is given. Find the value of the effort (P) required to resist this load by taking moments about the fulcrum.
- ✓ Find the reaction at the fulcrum (RF), as discussed below:
- I. When W and P are parallel and their direction is same as shown in Fig. (a), then
- $RF = W + P$ The direction of RF will be opposite to that of W and P.
- II. When W and P are parallel and acts in opposite directions as shown in Fig. (b) And (c), then RF will be the difference of W and P.

$$RF = W - P \text{ OR.....} RF = P - W$$

The direction of RF will be opposite to that of W or P whichever is greater.

Manually operated simple interlock brick making machine

Application of Levers in Engineering Practice

The load W and the effort P may be applied to the lever in three different ways as shown in Fig. The levers shown at (a), (b) and (c) in Fig are called first type, second type and third type of levers respectively.

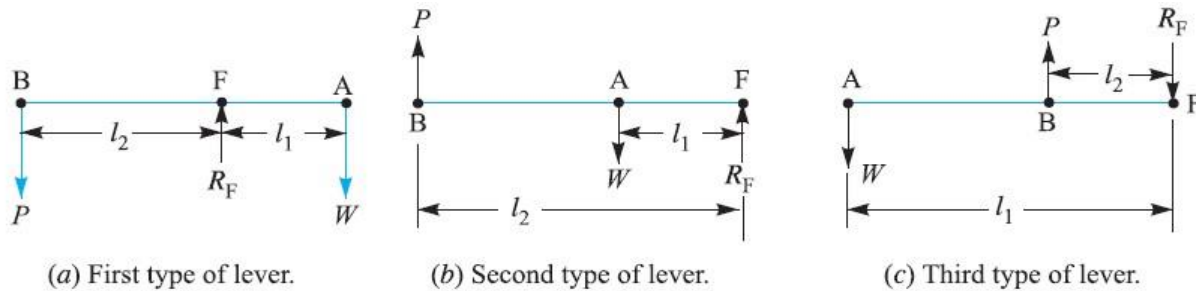


Figure 7 Types of lever arrangement

Design consideration

We select mild steel for lever and pin with the following property.

Tensile stress = 70 MPa; Shear stress = 50 MPa; Bearing pressure intensity = 25 N/mm².

Compressive Strength

The compressive strength of interlocking block/brick is the maximum compressive load it can carry per unit area. The cubes can be cured for like 7 days (possibly for more, for example 14, 21 and 28 days) after -wards are removed from the complete immersion in water and dried. Then after drying by air, it should be loaded at constant rate onto the compression testing machine in order to determine the force and compressive strength of the interlocking brick.

Standard

Size of the brick all sizes shown as Width x Height x Length.

Actual size: 90 x 64 x 190mm.

Nominal size: 100 x 75 x 200mm. as shown below.

$$\text{Area} = \text{length} \times \text{width} = 100 \times 200 = 20,000 \text{ mm}^2$$

The effort load = applied load 21kg = 210 N which is the load applied manually.

Taking moments about the fulcrum (RF) we have the following relations.

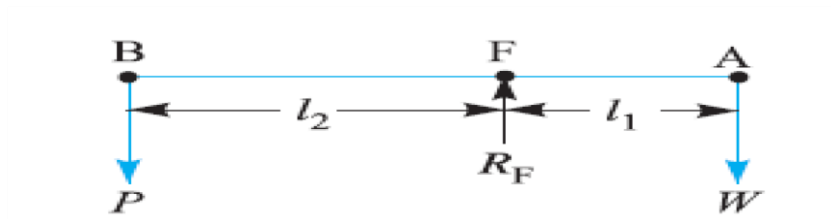


Figure 8. First type of lever.

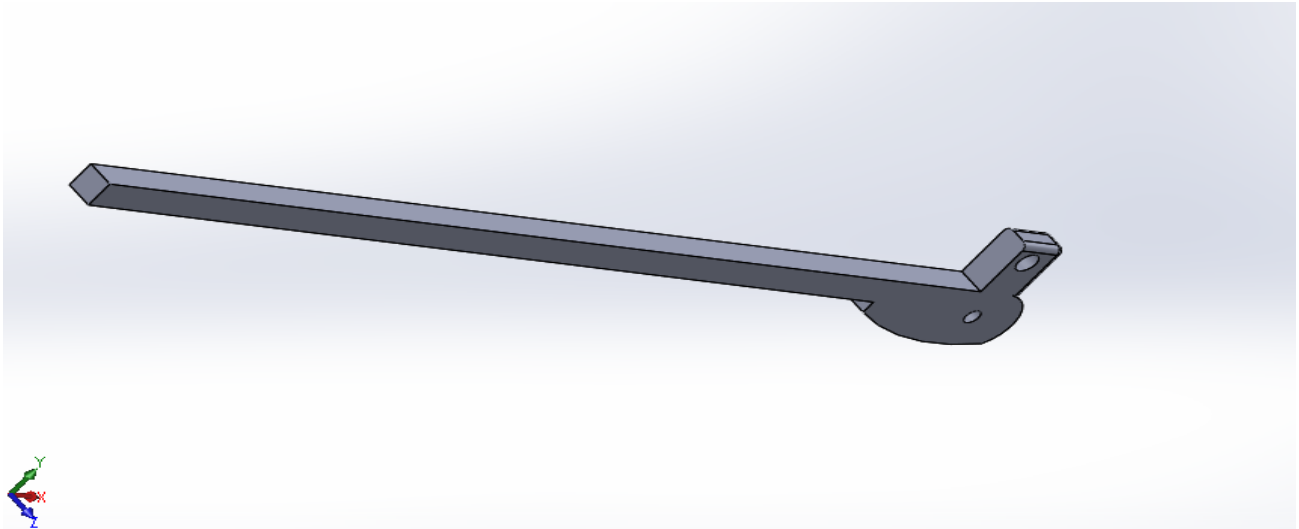


Figure 9. Lever arm

$$W \times l_1 = P \times l_2 \leftrightarrow W = \frac{P \times l_2}{l_1}$$

Where l_1 and l_2 are length of the arm and = 0.08m and 1.42m respectively. Then

$$W = \frac{210N \times 1420mm}{80mm} = 3727.5N.$$

This is the compressive load produced by applying an effort = 21N on the brick that is placed on the molding chamber.

Compressive Strength (N/mm^2) = Compressive Load / Area of brick (size).

$$S = \frac{3727.5N}{20,000mm^2} = 0.1864N/mm^2$$

When W and P are parallel and their direction is same as shown in Fig then R_F

= W + P The direction of R_F will be opposite to that of W and P.

Manually operated simple interlock brick making machine

$$RF = 3727.5 \text{ N} + 210\text{N} = 3937.5\text{N}$$

The dimension of the pin is obtained from bearing pressure considerations and then checked for shear stress. The allowable bearing pressure depends upon the amount of relative motion between the pin and the lever. The length of pin is usually taken from 1 to 1.25 times the diameter of pin (DP).

If the forces on the lever do not differ much, the diameter of pin at load and effort point shall be taken equal to the diameter of the fulcrum pin so that the spares are reduced. Instead of choosing a thick lever, the pins are provided with a boss in order to provide sufficient bearing length.

The diameter of the boss is taken twice the diameter of pin and length of the boss equal to the Length of pin. The boss is usually provided with a 3 mm thick phosphorus bronze bush with a dust proof lubricating arrangement in order to reduce wear and to increase the life of lever. To find the bearing area at point A.

$$A = Lp \times dp = 1.25dp^2 \dots\dots\dots\text{since. } Lp = 1.25dp.$$

$$\text{Bearing pressure} = \frac{W}{\text{bearing area}} = \frac{W}{1.25dp^2} = \frac{3737.5}{1.25 \times dp^2}$$

$$dp = \sqrt{\frac{3737.5\text{N}}{1.25 \times 25\text{Mpa}}} = 11.225\text{mm.} \quad \text{Since Bearing pressure intensity} = 25 \text{ N/mm}^2.$$

$$dp \approx 12\text{mm.}$$

$$Lp = 1.25 \times dp = 1.25 \times 12 = 15 \text{ mm}$$

Since the pin is in double shear and resists the same torque as that on the spindle, therefore resisting torque.

$$T = 2 \times \frac{\pi}{4} d^2 \times \tau \times \frac{d}{2} = \frac{\pi}{4} \times \tau \times d^3.$$

Hand Levers

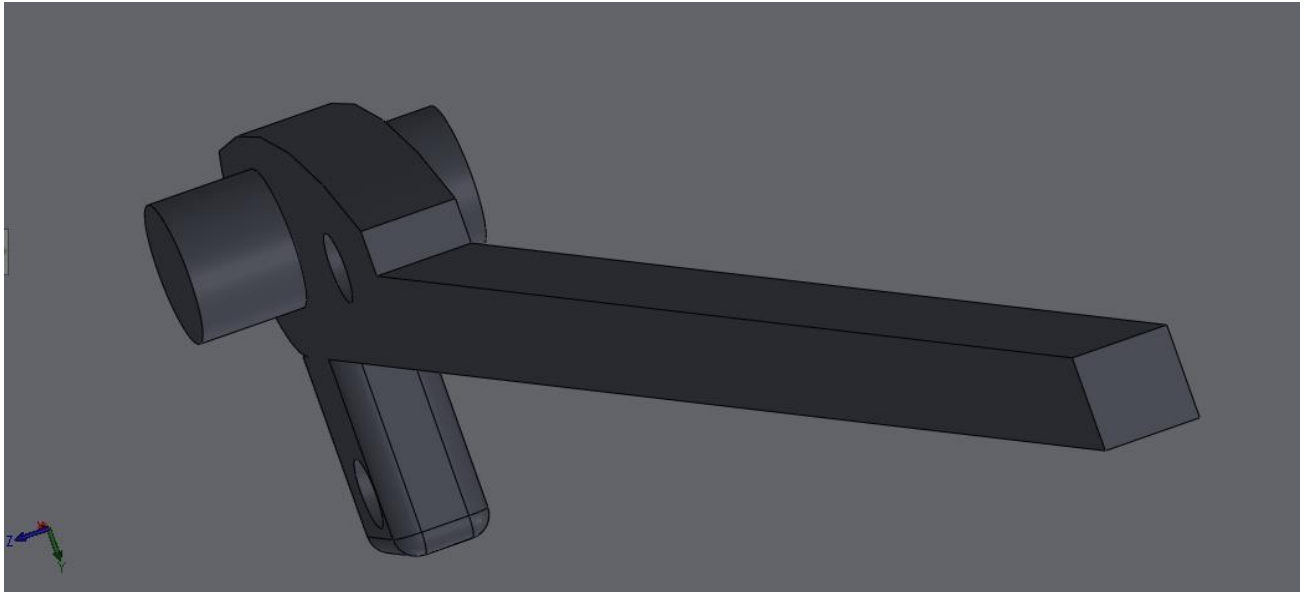


Figure 10. Lever arm with pin.

A hand lever with suitable dimensions and proportions is shown in Figure

Let P = Force applied at the handle, σ_t = Permissible tensile stress, and

L = Effective length of the lever, τ = Permissible shear stress.

For wrought iron, σ_t may be taken as 70 MPa and τ as 60 MPa. In designing hand levers, the following procedure may be followed:

1. The diameter of the pin (d) is obtained by considering the pin under pure torsion.

We know that twisting moment on the shaft, $T = P \times L$

$$T = 210N \times 200mm = 42,000Nmm = 42Nm. \text{ And}$$

$$\text{resisting torque } T = \frac{\pi}{16} \times \tau \times d^3$$

From this relation, the diameter of the pin is:

Manually operated simple interlock brick making machine

$$d = \sqrt[3]{\frac{16T}{\pi \times \tau}} = \sqrt[3]{\frac{16 \times 42,000 \text{ Nmm}}{\pi \times 60 \text{ Mpa}}} = 15.276 \text{ mm} = 16 \text{ mm}$$

2. The diameter of the boss (d_2) is taken as $=1.6 d = 1.6 \times 16 = 24.446 \text{ mm} \approx 25 \text{ mm}$

- ✓ Thickness of the boss (t_2) as $= 0.3d = 0.3 \times 16 \text{ mm} = 4.5 \approx 5 \text{ mm}$.
- ✓ The length of the boss (l_2) may be taken from d to $1.25 d$.

Taking the largest $l_2 = 1.25 \times d = 1.25 \times 16 = 20 \text{ mm}$

- It may be checked for a trial thickness t_2 by taking moments about the axis. Equating the twisting moment ($P \times L$) to the moment of resistance to tearing parallel to the axis, we get

$$P \times L = l_2 \times t_2 \times \sigma_t \left(\frac{d + t_2}{2} \right) \text{ or } l_2 = \frac{2 \times P \times L}{t_2 \times \sigma_t \times (d + t_2)}$$

$$l_2 = \frac{2 \times 210 \text{ N} \times 200 \text{ mm}}{5 \times 70 \text{ N/mm}^2 \times (16 + 5)} = 11.43 \text{ mm} < 20 \text{ mm} \dots \text{which is safe}$$

3. The diameter of the shaft at the Centre of the bearing (d_1) is obtained by considering the shaft in combined bending and twisting. We know that bending moment on the shaft,

$M = P \times l$ and twisting moment, $T = P \times L \dots \dots$ taking equivalent twisting moment,

$$Te = \sqrt{M^2 + T^2} = \sqrt{(P \times l)^2 + (P \times L)^2} = P \sqrt{l^2 + L^2}$$

We also know that equivalent twisting moment,

$$Te = \frac{\pi}{16} \times \tau \times d_1^3 \text{ but } Te = P \sqrt{l^2 + L^2}$$

The length l may be taken as $2l_2 = 2 \times 20 \text{ mm} = 40 \text{ mm}$. From the above expression, the value of d_1 can be determined as:

Manually operated simple interlock brick making machine

$$P\sqrt{l^2 + L^2} = \frac{\pi}{16} \times \tau \times d_1^3 \quad \leftrightarrow \quad 210N\sqrt{40^2 + 200^2} = \frac{3.14 \times 60Mpa}{16} d_1^3$$

$$42831.764Nmm = 11.7809 \times d_1^3$$

$$d_1 = \sqrt[3]{\frac{42831.764Nmm}{11.7809N/mm^2}} = 15.37 = 16mm$$

Knowing the forces acting on the lever, the cross-section of the arm may be determined by considering the section of the lever at which the maximum bending moment occurs. The cross section of the arm may be rectangular, elliptical or I-section as shown in Figure below. But we select the rectangular section, due to easy to manufacture and analysis.

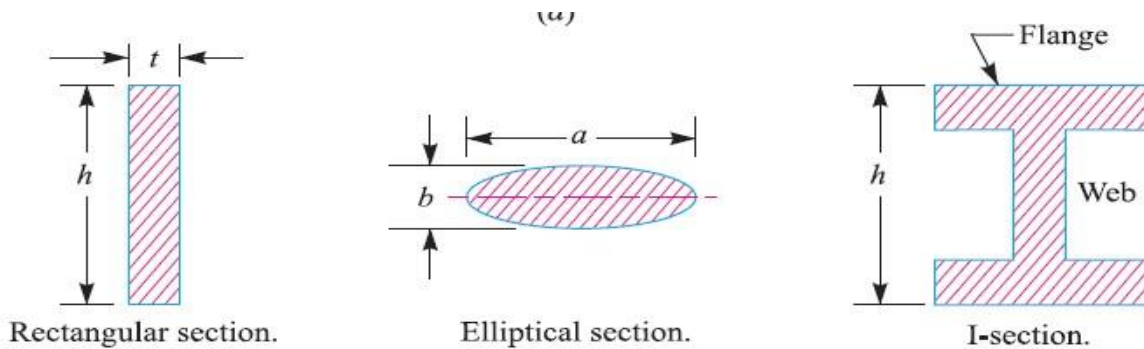


Figure 11. Different types of lever cross section.

We know that section modulus for rectangular section,

$$Z = \frac{1}{6} \times t \times h^2$$

Where t = thickness of the lever arm.

h = height of the rectangular cross-section.

Note: - The height of the lever is usually taken as 2 to 5 times the thickness of the lever.

Taking the maximum $h = 5 \times t \quad \leftrightarrow \quad t = \frac{h}{5} =$

$$Z = \frac{1}{6} \times t \times (5t)^2 = \frac{25}{6} \times t^3$$

The cross-section of the lever near the boss may be determined considering the lever in bending. It is assumed that the lever extends to the Centre of the shaft which results in a stronger section of the lever. We know that the bending moment on the lever, $M = P \times L$

Manually operated simple interlock brick making machine

We know that the bending stress, $\sigma_b = \frac{M}{Z}$ but $Z = \frac{25}{6} \times t^3$ and $M = P \times L$.

The permissible bending stress for the lever material may be taken as 50 MPa from material property.

$$\sigma_b = \frac{P \times L}{\frac{25}{6} \times t^3} = \frac{210N \times 200mm}{\frac{25}{6} \times t^3}$$
$$\frac{50N}{mm^2} \times \frac{25}{6} \times t^3 = 210N \times 200mm.$$
$$t = \sqrt[3]{\frac{42,000}{208.33333}} = 5.86mm \approx 6mm$$

$$h = 5 \times t = 5 \times 6mm = 30mm.$$

4.2. Design of Link

As shown below on the figure the pressure on the link can be calculated by considering the pressure that applied on the lever and taking a moment about the pivot (RF).

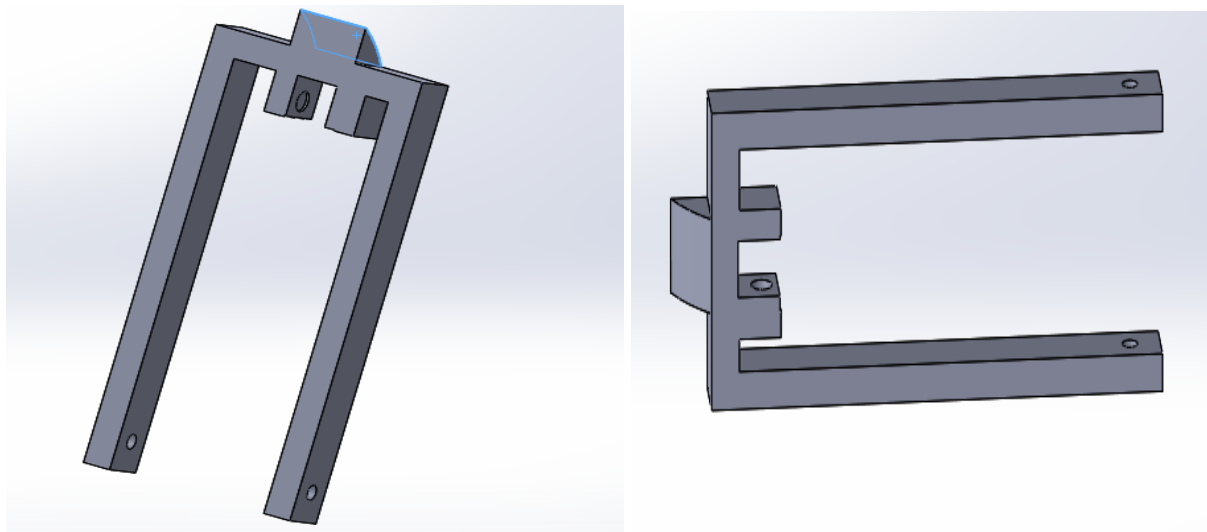


Figure 12. Links.

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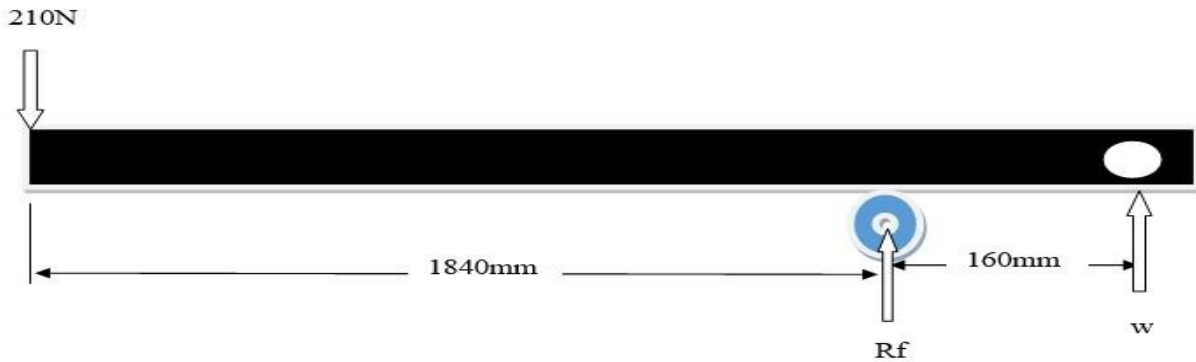


Figure 13. Force arrangement on link.

Moment at pivot or R_f .

$$P \times 1840\text{mm} = W \times 160\text{mm}$$

$$W = \frac{P \times 1840}{160} = \frac{210\text{N} \times 1840\text{mm}}{160\text{mm}} = 2415\text{N}$$

$$R_f + W = P$$

$$R_f = P - W = 210\text{N} - 2415\text{N} = -2205\text{N}$$

The assumed direction of the reaction force is wrong therefore it should be in the reverse direction of the given direction.

$$R_f = 2205\text{N} \dots\dots\dots \text{Down ward}$$

The dimensions of the link are determined as:

Thickness = 6 mm.

Length = $1840 - 1500 + 160 = 500\text{mm}$.

Width = 30mm

Tensile Strength in links

In order to check the Tensile Strength of the link connector due to bending stress, we have to calculate the force analysis at a point on which the link & link connector joined together. 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. The Young's modulus (E) is the same in tension and compression.

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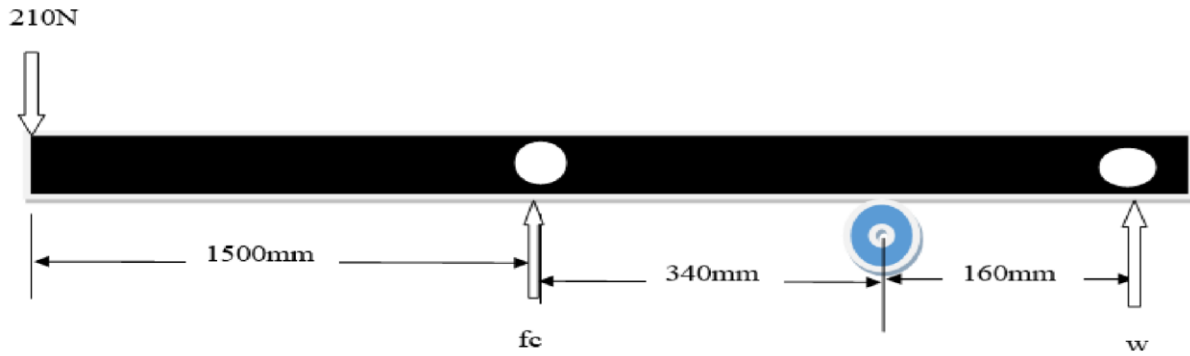


Figure 14. Force arrangement on lever arm.

Taking moment at a point of the lever supported by the pin, we have;

$$\begin{aligned}\sum M, \text{ at pin support} &= 0 \leftrightarrow F_c \times 340\text{mm} + P \times (1840\text{mm}) = 0 \\ F_c \times 340\text{mm} &= P \times (1500 + 340)\text{mm} \\ F_c &= \frac{210\text{N} \times 1840\text{mm}}{340\text{mm}} \\ &= 1137\text{N}\end{aligned}$$

The link connector between arm and link we have to take the following assumptions:

Thickness of the link connector $t = 4\text{mm}$

Width of the link connector $w = 50\text{mm}$

Area of the link connector $A = t \times w = 4\text{mm} \times 50\text{mm} = 200\text{mm}^2$

The distributed force or load $F' = \frac{F_c}{2} = \frac{1137\text{N}}{2} = 568.5\text{N}$

The allowable tensile stress on the link is $\sigma t = \frac{F'}{A} = \frac{568.5\text{N}}{200\text{mm}^2} = 2.8425\text{Mpa}$.

From the list of materials we select mild steel with material property as:

The allowable stresses for the handle and pin are 50 MPa in tension and 45 MPa in shear.

Which is less than the yield strength of mild steel. So the design is safe.

$$= 2.8425\text{Mpa} < 50\text{ MPa}$$

Manually operated simple interlock brick making machine

The pin for this connector is designed based on the following:

To design the pin the bearing area of pin must be calculated first.

$$\text{Bearing area of pin} = Lp \times dp = 1.25dp \times dp = 1.25 \times dp^2$$

From the material property the bearing pressure = $25\text{Mpa} = 25\text{N/mm}^2$

$$\text{Bearing pressure} = \frac{\text{the force at } Fc}{\text{bearing area}} =$$

$$25\text{N/mm}^2 = \frac{F'}{1.25 \times dp^2} \leftrightarrow 25\text{N/mm}^2 = \frac{568.5\text{N}}{1.25 \times dp^2}$$

$$dp = \sqrt{\frac{568.5\text{N}}{1.25 \times 25\text{N/mm}^2}} = 4.265\text{mm} \approx 5\text{mm}$$

Pin -3. The other pin which is located at the bottom of the line

$$\text{Bearing area} = Lp \times dp \dots \text{but } Lp = 1.25 \times dp \text{ and Bearing area} = 1.25 \times dp^2$$

$$\text{Bearing pressure} \left(\frac{25\text{N}}{\text{mm}^2} \right) = \frac{w}{\text{bearing area}} = \frac{2415\text{N}}{1.25 \times dp^2}$$

$$dp = \sqrt{\frac{2415\text{N}}{1.25 \times \frac{25\text{N}}{\text{mm}^2}}} = 8.79\text{mm} \approx 10\text{mm} \dots \dots \dots \text{to standard.}$$

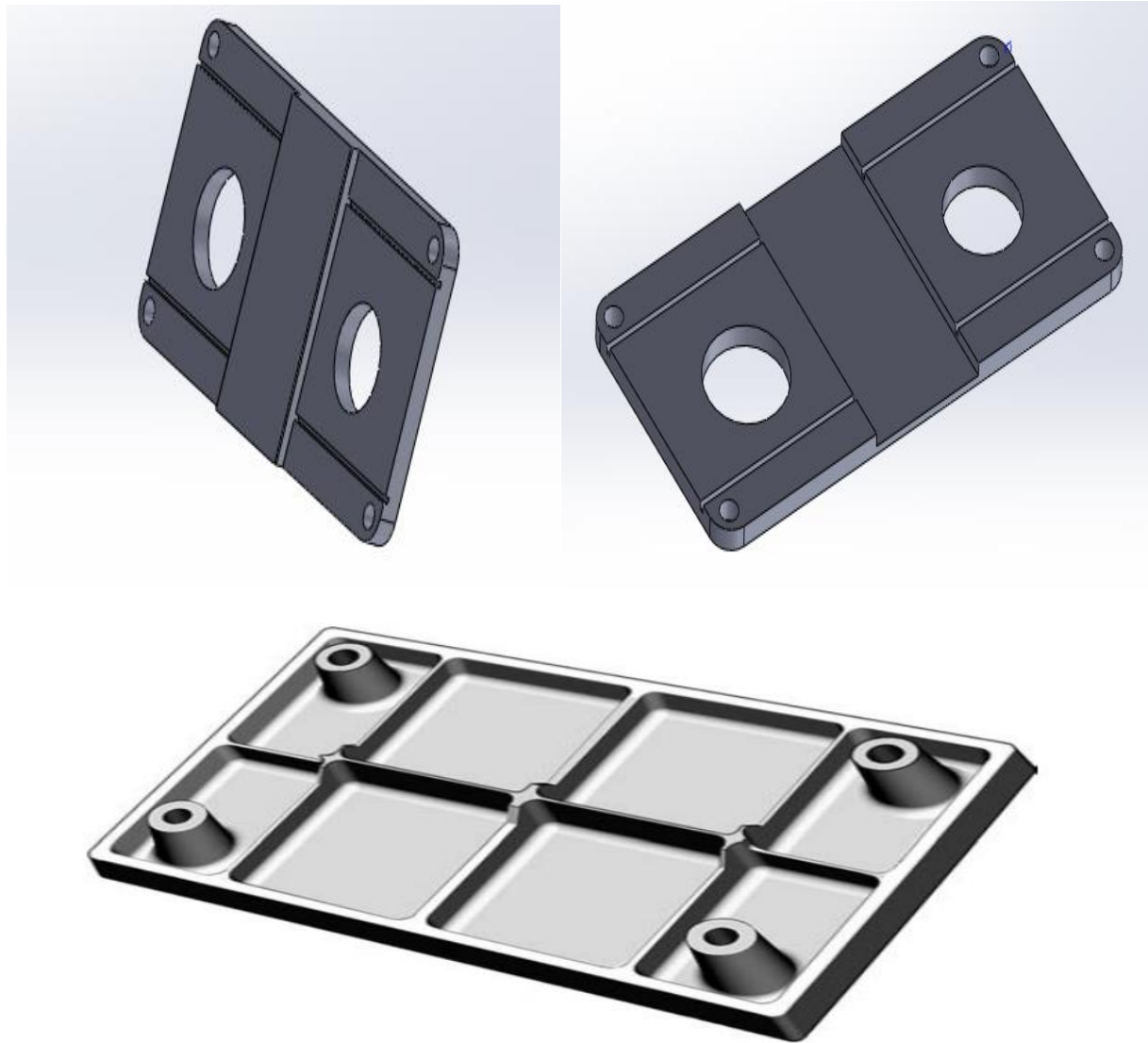
4.3. Design of die plate

In today's practical and cost-conscious world, sheet-metal parts have already replaced many expensive cast, forged, and machined products. The reason is obviously the relative cheapness of stamped, or otherwise mass-produced parts, as well as greater control of their technical and aesthetic parameters. That the world slowly turned away from heavy, ornate, and complicated shapes, and replaced them with functional, simple, and logical forms only enhanced this type tendency. But, sheet-metal patterns can also be used to imitate different brick designs of previous centuries.

Metal plate patterns, probably the most versatile products of modern technology, are used to replace parts previously welded together from several components. A well-designed sheet-metal patterns can sometimes eliminate the need for cement/mortar binder assemblies. The metal

Manually operated simple interlock brick making machine

pattern dies are an ideal forming tools that can produce large quantities of parts that are consistent in appearance, quality, and dimensional accuracy. It is a forming tool capable of shaping the brick, compressed it, drawing its shape into considerable depths, finishing and smoothing the edges, and otherwise altering the shape and the outline of the brick part to suit the wildest imaginable brick designs.



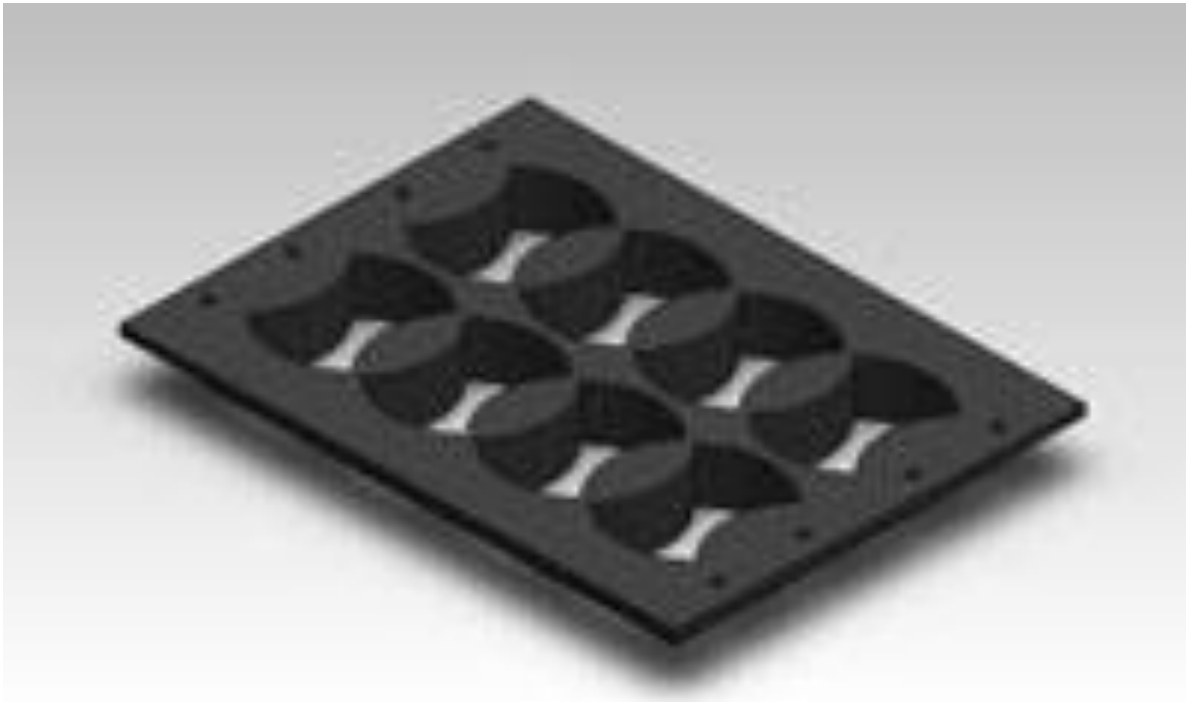
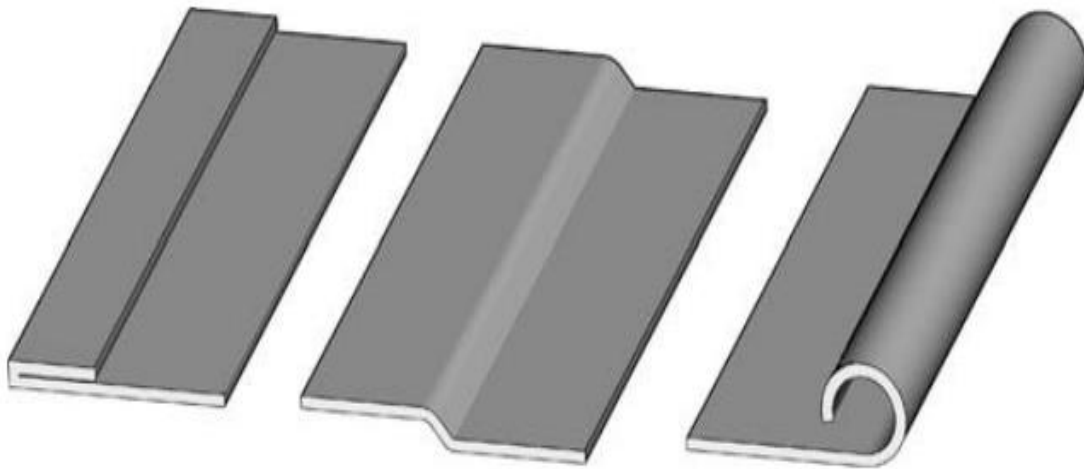


Figure 15. Types of die plate.

4.4. Design of support

There are four square rectangular hollow section RHS stands that support the whole weight of the components of the machine. In order to design the support and check the buckling strength we first calculate the forces distributed for each RHS stand and also the overall mass carried by it.

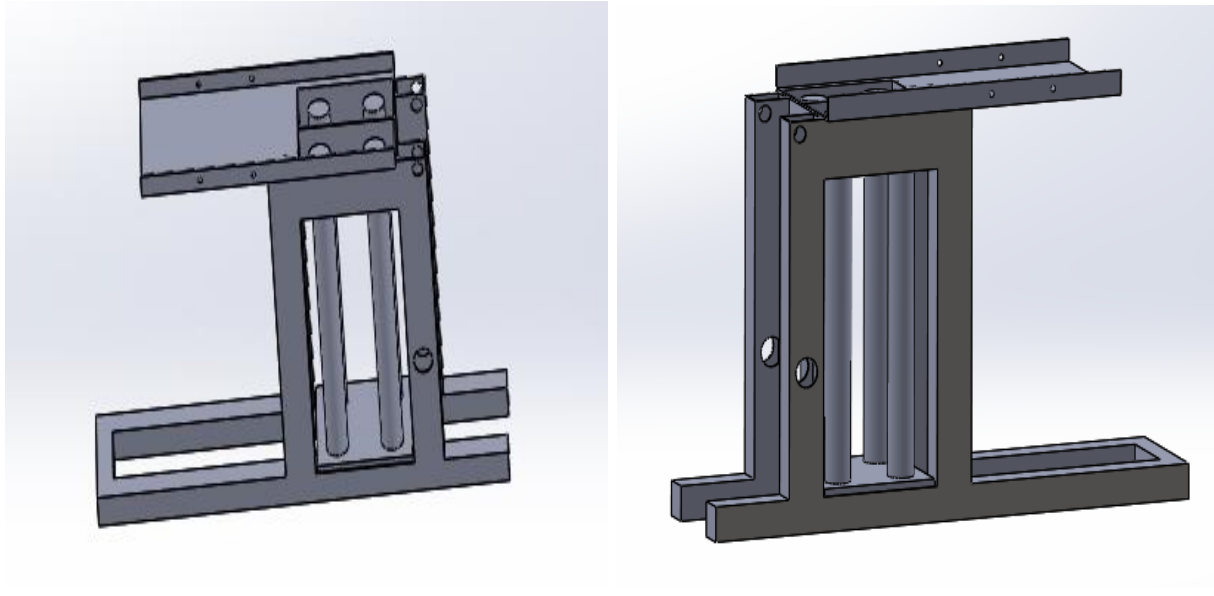


Figure 16. Support

In the design of support we have to consider the following things.

- Dimension of the molding chamber
- Dimension of the feeder
- Mass of the molding chamber
- Mass of the feeder
- Mass of the hopper
- Mass of the mix and
- Mass of the two bricks.
- Mass of die plate, etc.

The dimensions (height, length and width) of the molding chamber taken as 80mm, 210mm and 200mm. respectively. This is based on the dimension the brick that have been molded.

In order to find the critical load resisting or acting on the support, we have to consider first the dimensions of molding chamber. The dimensions of molding chamber is $210 \times 80 \times 200 \text{ mm}$ and the dimension of the feeder is the same as that of the molding chamber. Or the width and length of the feeder is equal to the width and length of the molding chamber. And also the width and length of the feeder is equal to the width and length of the hopper at the base. There may be a slight difference at the top of the hopper, due to the enlargement in the hopper at the top, in order to immerse the clay soil easily.

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Weights of the molding chamber, feeder and hopper.

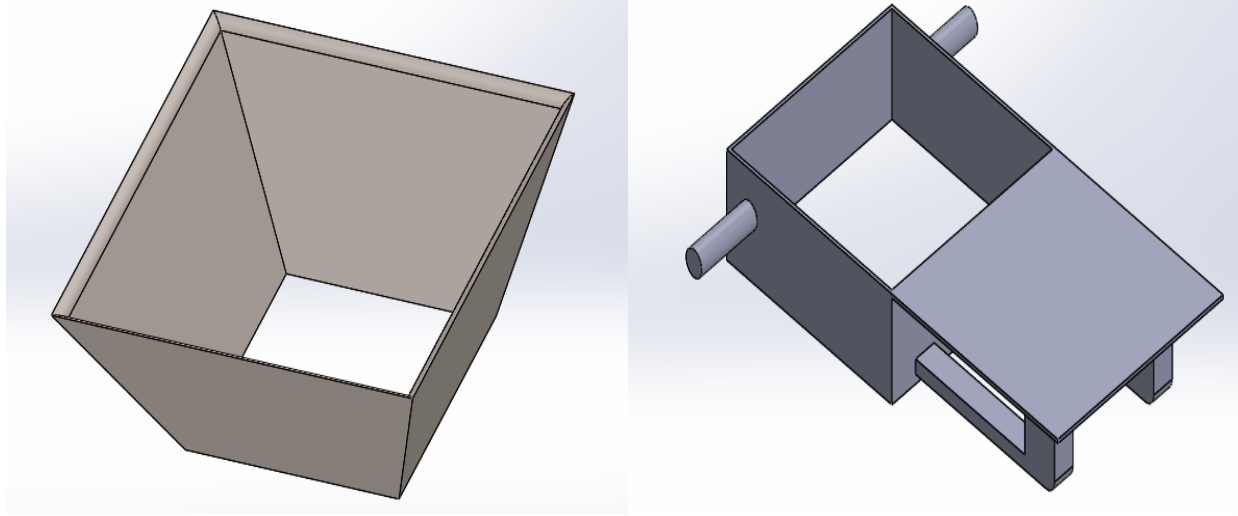


Figure 17. Hopper & feeder

In order to find the mass of each molding chamber first we find the volume of the chamber.

$$V_1 = \text{thickness} \times \text{height} \times \text{length}.$$

$$= 4 \text{ mm} \times 80 \text{ mm} \times 200 \text{ mm} = 64,000 \text{ mm}^3.$$

$$V_2 = \text{thickness} \times \text{height} \times \text{width}.$$

$$= 4 \text{ mm} \times 80 \text{ mm} \times 210 \text{ mm} = 67,200 \text{ mm}^3$$

$$V_T = 2 \times (V_1 + V_2) = 2 \times (64,000 \text{ mm}^3 + 67,200 \text{ mm}^3)$$

$$= 262,400 \text{ mm}^3 = 2.624 \times 10^{-4} \text{ m}^3.$$

$$\text{Density of the material for steel} = 7850 \text{ kg/m}^3.$$

$$\text{Therefore mass the molding chamber } M = \rho_{\text{steel}} \times V_T$$

$$= 7850 \text{ kg/m}^3 \times 2.624 \times 10^{-4} \text{ m}^3.$$

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$$= 2.5984 \text{ Kg.}$$

Volume of the hopper is taken almost equal to the volume of the molding chamber and also the volume of the feeder can be *calculated as*:

$$V_1 = 2 \times (3\text{mm} \times 75\text{mm} \times 200\text{mm}) = 90,000 \text{ mm}^3$$

$$V_2 = 2 \times (3\text{mm} \times 75\text{mm} \times 210\text{mm}) = 94,500 \text{ mm}^3$$

$$V_T = 90,000 \text{ mm}^3 + 94,500 \text{ mm}^3$$

$$= 184,500 \text{ mm}^3 = 1.845 \times 10^{-4} \text{ m}^3$$

Therefore mass of the feeder is *calculated as* $M = \rho_{\text{steel}} \times V_T$

$$= 7850 \frac{\text{kg}}{\text{m}^3} \times 1.845 \times 10^{-4} \text{ m}^3$$

$$M = 1.448325 \text{ Kg}$$

The volume and mass of the lever are determined as: $V_{\text{lever}} = l \times h \times t$

Thickness, Length, Width/height of lever are 6 mm, 1500mm, 30mm respectively

$$V = 6\text{mm} \times 30\text{mm} \times 1500\text{mm}$$

$$= 2.7 \times 10^{-4} \text{ m}^3$$

$$\text{Mass of the lever } M = \rho_{\text{steel}} \times V_T = 7850 \frac{\text{kg}}{\text{m}^3} \times 2.7 \times 10^{-4} \text{ m}^3$$

$$= 2.1195 \text{ Kg}$$

The volume and mass of the link are determined as: $= l \times h \times t$

Thickness, Length, Width/height of link are 6 mm, 500mm, 30mm respectively.

$$V = 6\text{mm} \times 30\text{mm} \times 500\text{mm}$$

$$= 90000 \text{ mm}^3 = 9 \times 10^{-5} \text{ m}^3.$$

$$\text{Mass of the link } M = \rho_{\text{steel}} \times V_T = 7850 \frac{\text{kg}}{\text{m}^3} \times 9 \times 10^{-5} \text{ m}^3$$

$$M = 0.7065 \text{ Kg}$$

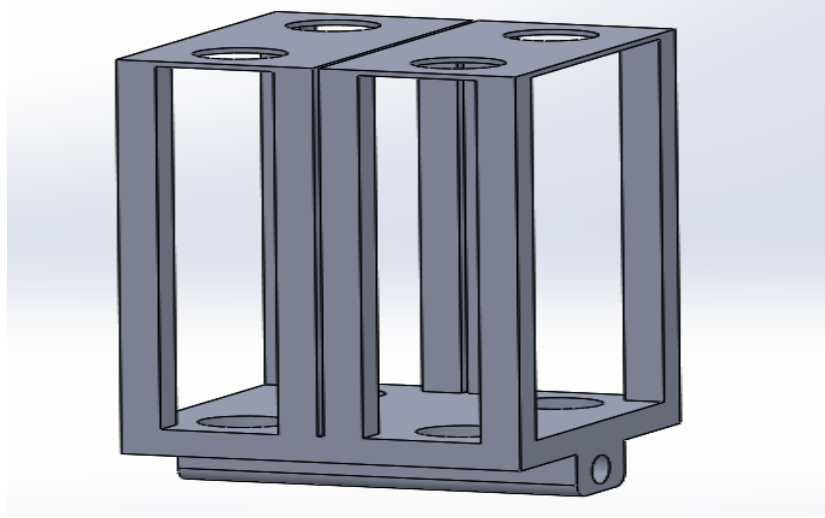


Figure 18. Slider (brick holder).

Total mass = *mass of hopper + mass of feeder + mass of molding chamber + mass of mild steel road and sliding plate + mass of top restraint closing + mass of link + mass of the lever + mass of brick + Others*

$$= 2.5984 \text{ Kg} + 1.448325 \text{ Kg} + 2.5984 \text{ Kg} + 3.0453 \text{ Kg} + 0.7065 \text{ Kg} + 2.12 \text{ Kg} + 14 \text{ Kg} + 15 \text{ Kg}$$

$$= 41.517 \text{ Kg.}$$

Load = mass $\times$ gravity

$$P = 41.517 \text{ Kg} \times 10 \text{ m/s}^2 = 415.17 \text{ N}$$

The value of the stress corresponding to the critical load is called critical stress and is denoted by σ_{cr} . The value of the critical load is:

$$P = \frac{P_{cr}}{\text{factor of safety}}$$

$$P_{cr} = P \times \text{factor of safety} = 1.5 \times 415.17 \text{ N.}$$

$$= 622.754 \text{ N.}$$

The value of the critical stress is:

$$\sigma_{cr} = \frac{P_{cr}}{A} \quad \text{but} \quad P_{cr} = \frac{n^2 \times \pi^2 \times E \times I}{L^2}$$

Where $I = A \times r^2$

$n = 1$ and substituting to σ_{cr} becomes

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2 \times E \times A \times r^2}{A \times L^2} = \frac{\pi^2 \times E \times r^2}{L^2}$$

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$$\sigma_{cr} = \frac{\pi^2 \times E}{\left(\frac{L}{r}\right)^2} \dots \dots \text{where } \frac{L}{r} = \text{is the slenderness ratio.}$$

A = is the cross-sectional area and r = its radius of gyration.

E = The modulus elasticity of the material

$$= 200\text{Gpa} = 200\text{KN/mm}^2$$

σ_y = the yield strength of steel = 250Gpa = 250KN/mm²

The radius of gyration can be found by using the concept of section modulus I_x and I_y

$$I_x = \frac{1}{3} \times b \times h^3 = \frac{1}{3} \times 2\text{mm} \times 30^3 = 18,000\text{mm}^4$$

$$I_y = \frac{1}{3} \times h \times b^3 = \frac{1}{3} \times 2\text{mm} \times 100^3 = 666,666.6667\text{mm}^4$$

$$I_A = I_x + I_y = 18,000\text{mm}^4 + 666,666.6667\text{mm}^4$$

$$I_A = 684,666.6667\text{mm}^4$$

$$A = A_1 + A_2 = (2\text{mm} \times 30\text{mm}) + (2\text{mm} \times 100\text{mm}) = 260\text{mm}^2$$

$$A = 260\text{mm}^2.$$

$$K_A = \sqrt{\frac{I_A}{A}} = \sqrt{\frac{684,666.6667\text{mm}^4}{260\text{mm}^2}} = 51.316\text{mm}$$

$$K_A = r = 51.316\text{mm}$$

$$L = 1000\text{mm}, \text{ and } E = 200\text{Gpa} = 200,000 \text{ N/mm}^2$$

Using Euler's critical load equation and factor of safety for buckling, we have

$$I = \frac{P_{cr} \times L^2}{\pi^2 \times E} = \frac{622.754\text{N} \times (1000\text{mm})^2}{\pi^2 \times 200,000 \text{ N/mm}^2}$$

$$= \frac{622,754,000\text{N mm}^2}{197,3920.88 \text{ N/mm}^2}$$

$$= 315.4908 \text{ mm}^4.$$

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2 \times E \times A \times r^2}{A \times L^2} = \frac{\pi^2 \times E \times r^2}{L^2}$$

$$= \frac{\pi^2 \times 200,000\text{N/mm}^2 \times (51.316^2)}{(1000\text{mm})^2} = \frac{2633.33\text{mm}^2 \times 197,3920.88 \text{ N/mm}^2}{(1000\text{mm})^2}$$

$$= 5197.988 \text{ N/mm}^2$$

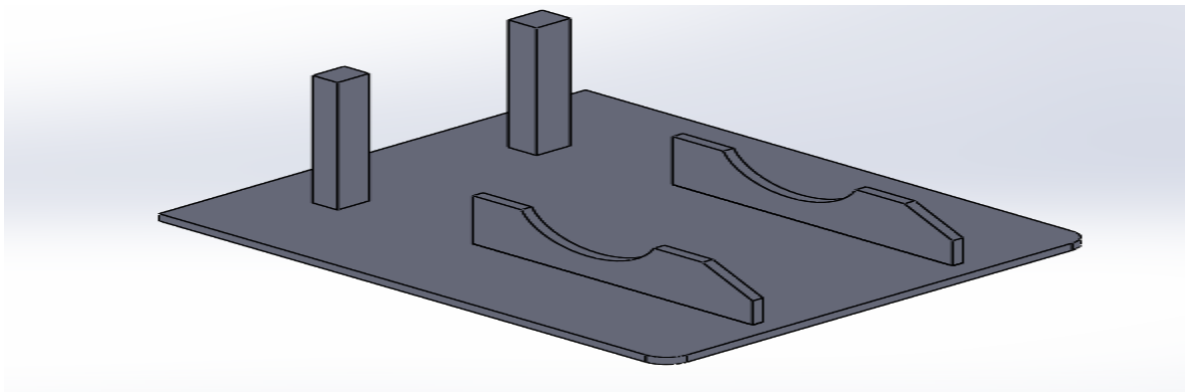


Figure 19. Upper closing.

4.4. Design of welded joint

Welding is an effective method of making permanent joints between two or more metal parts. Welding is a permanent joint which is obtained by the fusion of edge the two parts to be joined together, with or without the application pressure and filler material. The heat required for the fusion the material may be obtained by burning of gasses or by electric arc. Cast iron, steel and its alloys, brass and copper are the metals that may be welded easily. Production of leak proof joints that can withstand high pressures and temperatures are made With Possible advanced welding technology. For this reason, welding is fast replacing casting and forging wherever possible. When compared to riveting, welding is cheaper, stronger and simpler to execute at site with considerable freedom in design. Hence, it is widely used in ship building and structural fabrication in place of riveting.

Advantages of welding over other joint

- ✓ The welding joint provides maximum efficiency which is not possible in case of riveted joint
- ✓ The welding structure is smooth in appearance it looks pleasing
- ✓ Welding joint is stronger and cheapest in cost
- ✓ The processes of welding takes less time than others
- ✓ It is possible to weld any part the body at any point

Types of welding:

Gas tungsten arc welding, shielded metal arc welding, oxy-acetylene, plasma arc welding and etc. from those types of welding we select shielded metal arc welding because of welded part is covered to protect from damage and its low cost.

Types of weld selected: - fillet welding.

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Assumption

- ✓ The load is distributed uniformly along the entire length of the weld
- ✓ Stress is spread uniformly over its effective section.
- ✓ And it is in static condition.

Advantages of welded joints over riveted joints.

- ✓ Welding structures are usually lighter than riveted joints.
- ✓ Welded joints provide maximum efficiency, which is not possible in riveted joints.
- ✓ Alteration and additions can be easily made in the existing structures.
- ✓ Smooth structure in appearance, therefore its look pleasing.
- ✓ Tension member are not weakened as in the case of riveted joints.
- ✓ Greater strength often has the strength of the parent metal itself.
- ✓ Sometimes, the members are of such shape that the welding is easier.
- ✓ Welding provides very rigid joints.
- ✓ It is possible to weld any part of a structure at any point.
- ✓ The process of welding takes less time than riveting.

Disadvantages of welded joints over rivet joints.

- ✓ Members may be distorted or additional stresses may be developed for heating and cooling during fabrication.
- ✓ Requires a highly skilled labor and supervision. There is a possibility of crack developing for no provision for expansion and contraction on the frame. Inspection is more difficult.

Types of welded joints.

- ✓ But joint - two parts in approximately in the same plane.
- ✓ Corner joint: - two parts located approximately at right angle each other.
- ✓ Lap joint: - between over lapping parts in parallel plates.
- ✓ T- joint: - joints at approximately right angle in the form of “T”.
- ✓ Edge joint: - between the edge of two or more parallel parts.

Lap joint: lap joint divided into the following type

1) - Single transverse 2) - Double transverse and 3) - Parallel.

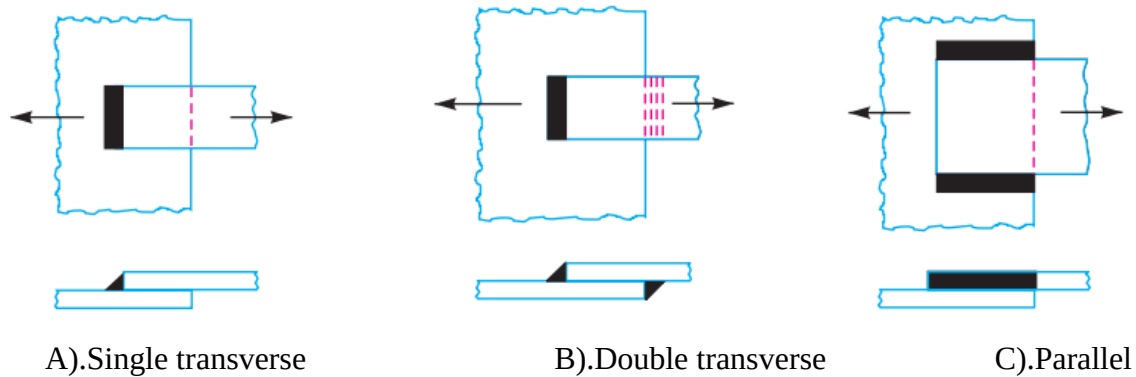


Figure 20. Welded lap joint

The type of weld we have to use is single transverse fillet weld / single transverse fillets /

Assumption

Since the weld is weaker than the plate due to slag and blow holes therefore the weld is given a reinforcement which may be taken as 10% of the plate thickness. To determine the strength of the fillet joint, assumed that the section of the fillet is a righted angle triangle with hypotenuse making equal angles with other two sides.

Where; t = throat thickness

S = leg or size of weld

L = length of weld. We find that throat thickness $t = S \cdot \sin 45^\circ = 0.707S$

The minimum area of the weld or throat area is,

$A = \text{throat thickness} \times \text{length of weld} \quad A = t \times L$

Then, force $(P) = 0.707S \times L \times \sigma_{all}$ ----- (4.2)

Since, $L=90\text{mm}$ and $P = 567\text{KN}$ the total compacting force supported in both sides.

$567,000\text{N} = 0.707S \times 90\text{mm} \times 130$. $S = 6.85\text{mm}$.

For more to be safe let's take $S = 8\text{mm}$. Since $t = 0.707S$ $t = 0.707 \times 8\text{mm}$. $t = 5.656\text{mm} \approx 7\text{mm}$

4.6. Design of bolt

4.6.1. Material selection for bolt

So the material we chose for bolt has to have high wear resistance, good machine ability, tensile strength and toughness.

- ✓ The material is 500/7, minimum tensile strength.
- ✓ This metal is graphite cast iron.

4.6.2. Design analysis of bolt

During design of bolt the following included:

- ✓ Tensile stresses due to stretching of the bolt
- ✓ Torsional shear stress due to frictional resistance at the threads.
- ✓ Shear stress across threads.
- ✓ Compressive or crushing stress on the threads.
- ✓ Bending stress if the surfaces under the bolt head are not perfectly.

The resultant axial load on a bolt depends upon the following factors:

- ✓ The initial tension due to tightening of the bolt,
- ✓ The external load, and
- ✓ The relative elastic yielding (springiness) of the bolt and the connected members.

Assumption:-

- ✓ The shear loads are carried by friction.
- ✓ The attached members are rigid and do not deflect with loads.

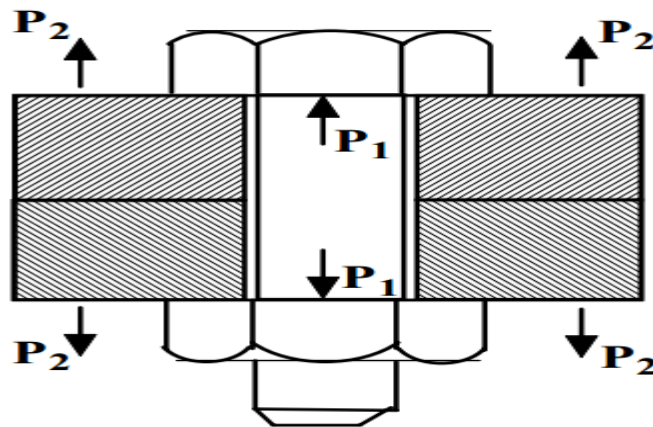


Figure 21. Bolted joint.

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Bolt and nut selection

A screwed joint is mainly composed of two elements *i.e.* a bolt and nut. The screwed joints are widely used where the machine parts are required to be readily connected or disconnected without damage to the machine or the fastening.

For standard hexagon-head bolt. Points of stress concentration are at the fillet, at the start of the threads (run out), and at the thread-root fillet in the plane of the nut when it is present. The diameter of the washer face is the same as the width across the flats of the hexagon. The thread length for metric bolts, where d is the nominal diameter

$$L_T = \begin{cases} 2d + 6 & L \leq 125 & d \leq 48 \\ 2d + 12 & 125 < L \leq 200 \\ 2d + 25 & L > 200 \end{cases}$$

Assuming our bolts to tension load, a bolted connection loaded in tension by the forces P .

- Bolt length = L
- Thread length = L_T
- Unthreaded length = L_d .
- Major diameter = d
- Head height = H
- Head chamfer = 30°

According to Indian Standard Thread designation M20 x 2.5C indicates a metric bolt of nominal diameter 20 mm and a course pitch of 2.5 mm. from khurimi text book.

- Based on the above standard bolt initial tightening load is given by:
 - $P_1 = 284d = 284 \times 20 = 5680N$

The major diameter d is the largest diameter .The root diameter d_r is the smallest diameter. The pitch diameter d_p is a theoretical diameter between the major and minor diameters.

The pitch is the distance between adjacent thread forms measured parallel to the thread axis.

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Table 3. Dimension of bolt and nut

Nominal major diameter(d)	Pitch(p)	Tensile stress	Minor diameter
20	2.5	245	222

The minor diameter (d_r) = $d - 1.226869p$ and pitch diameter (d_p) = $d - 0.649519p$

Where p is pitch = 2.5mm. From table 8-1, we have d= 20mm

$$L_t = 2d + 6 \quad L \leq 125 \quad d \leq 48$$

$$M20 = 20\text{mm}, \text{ then } L_t = 2 \times 20 + 6 = 46\text{mm}.$$

$$d_p = d - 0.649519p = 20 - 0.649519 \times 2.5 = 18.4\text{mm}.$$

$$d_r = d - 1.226869p = 20 - 1.226869 \times 2.5 = 16.93\text{mm}.$$

The total length of bolts and nuts take as 70mm (L). $L_t = 46\text{mm}$ from the previous calculation and the thickness of the metal = 10mm. unthreaded length of nut with washer (L_d) = material thickness that means 10mm.

$$L = L_d + L_t + H \text{ where } H \text{ is bolt head. Then } H = L - L_d - L_t, H = 70 - 10 - 46 = 14\text{mm}$$

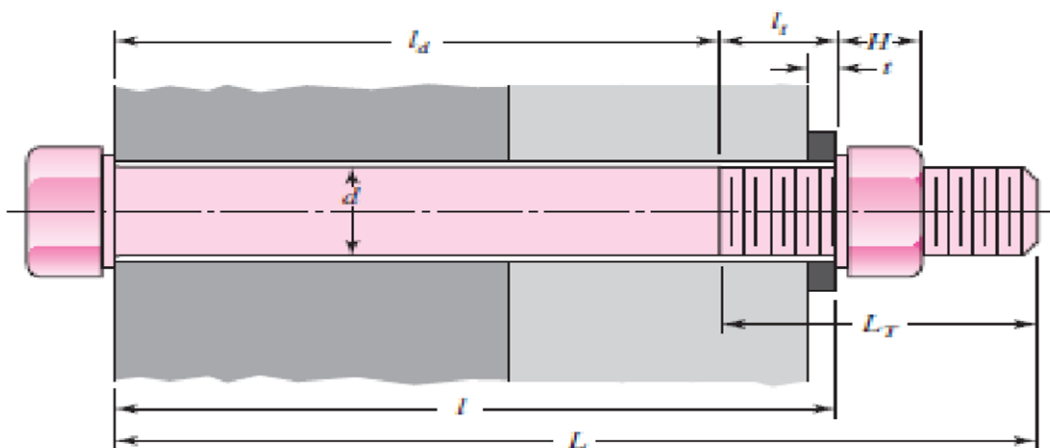


Figure 22. Dimensions of bolt and nut.

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Stress due to external force:

The following stresses are induced in a bolt when it is subjected to an external load.

a) Tensile stress: the bolts, studs and screws usually carry a load in the direction of the bolt axis which induced tensile stress in the bolt.

Let d_r = root or core diameter of the thread and

σ_t = permissible tensile stress for bolt materials.

= 600Mpa from the material selection, and

d_r = 16.93mm from the above calculation.

$$\text{The external load applied (p)} = \frac{d_r \times 2 \times \sigma_t}{4} = \frac{3.14 \times 16.93 \times 2 \times 600}{4} = 135\text{kN}$$

$$\text{If the external load is taken up by a number of bolts, then } p = \frac{d_r \times 2 \times \sigma_t}{4} n$$

Where n = number of bolts. We use eight bolts for this project. $p = 135 \times 8 = 1080\text{kN}$.

b) Shear stresses: sometimes the bolts are used to prevent the relative movement of two or more parts, and then the shear stress is induced in the bolt. The shear stresses should be avoided as far as possible. it should be noted that when the bolts are subjected to direct shearing loads, they should be located in such a way that the shearing load come up on the body(i.e. shank) of bolt and nut up on the thread portion.

When a number of bolts are used to share the shearing load, the finished bolt should be fitted to remanded holes. Let d = major diameter of the bolt and n = number of bolts. Therefore, shearing

$$\text{load carried by the bolt (Ps)} = \frac{d \times 2 \times \tau \times n}{4}$$

Where $\tau = 0.5\sigma_t = 0.5 \times 600\text{Mpa} = 300\text{Mpa}$.

$$P_s = \frac{20 \times 2 \times \tau \times 8}{4} = 753.6\text{kN}$$

Chapter four

4. Manufacturing process

A manufacturing process is usually carried out as a unit operation, which means that it is a single step in the sequence of steps required to transform the starting material into a final product. Manufacturing is the use of machines, tools and labor to produce goods for use or sale. The term may refer to a range of human activity, from handicraft to high tech, but is most commonly applied to industrial production, in which raw materials are transformed into finished goods on a large scale. Such finished goods may be used for manufacturing other, more complex products. Manufacturing is a collection of interrelated activities that includes product design and documentation, material selection, planning, production, quality assurance, management and marketing of goods. The fundamental goal of manufacturing is to use these activities to convert raw materials in to finished goods on a profitable base. The five inputs required are raw materials, equipment, tooling and fixtures, energy and labor. Manufacturing operation can be divided into two basic types:-processing & assembly operations.

4.1.Processing operations

A processing operation uses the application of energy to alter a work part's shape, physical properties, and appearance to add value to the material. The forms of the applied energy include mechanical, thermal, electrical, and chemical. These energy forms are applied in a controlled way by means of machinery and tooling. Human energy may also be required, but the human workers are generally employed to control the machines, in order to oversee the operations, load and unload parts from the machine, before and after each cycle of operation. Three categories of processing operations are distinguished:

- ✓ Shaping operations alter the geometry of the starting work material by various methods. Common shaping processes include casting, forging, welding and machining.
- ✓ Property-enhancing operations add value to the material by improving its physical properties without changing its shape.
- ✓ Surface finishing operation.

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4.2. Assembly operations

This operation is the second basic and main type of manufacturing operation. In this assembly operation two or more separate parts are joined to form a new component of the machine. Components of the new entity are connected either permanently or semi permanently or conveniently disassembled. Certain mechanical assembly methods are available to fasten two (or more) parts together in a joint that can be conveniently disassembled. The use of screws, bolts, and other threaded fasteners are important traditional methods in this category. Permanent joining processes include welding, brazing, soldering, and adhesive bonding. They form a joint between components that cannot be easily disconnected. Other mechanical assembly techniques form a more permanent connection; these include rivets, press fitting, and expansion fits.

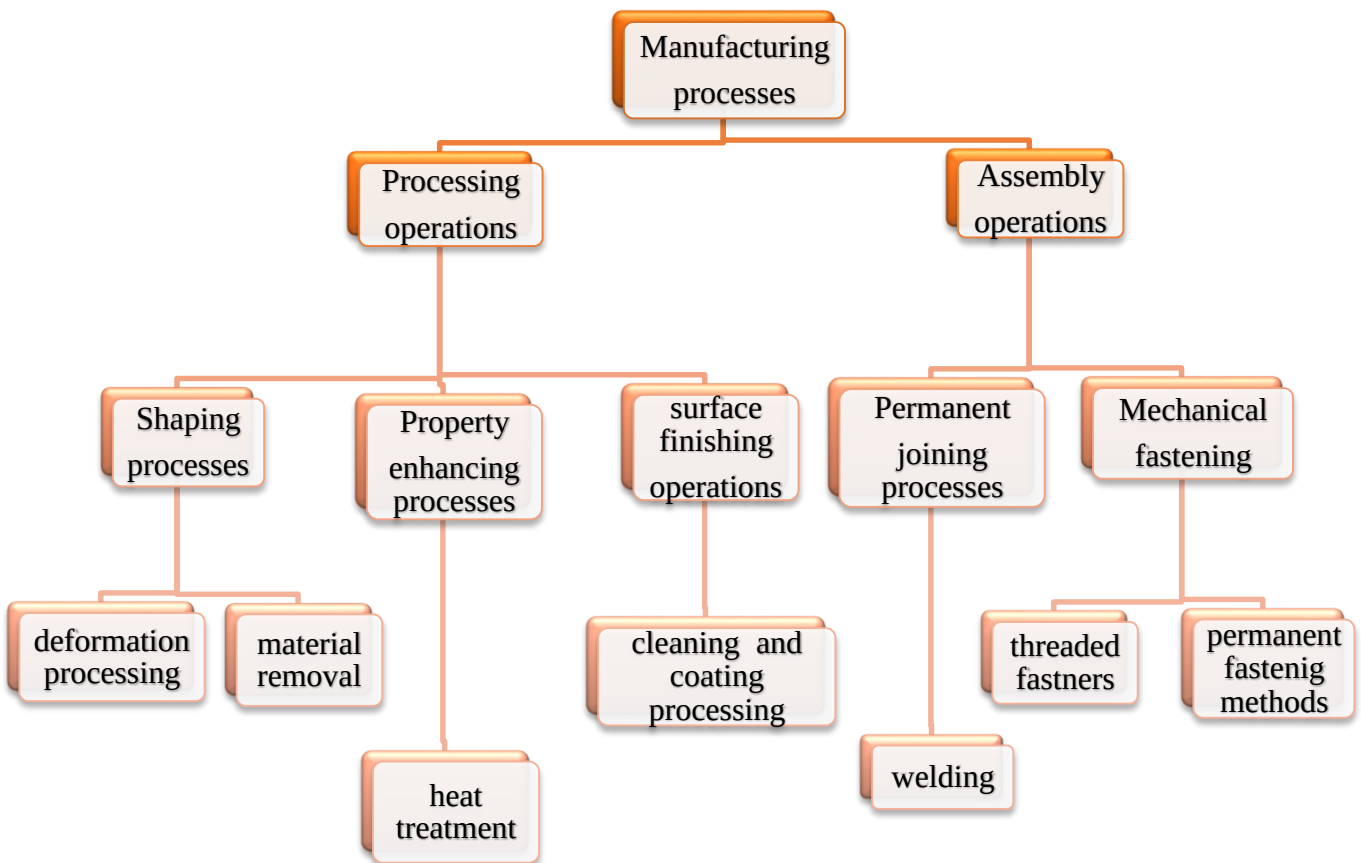


Figure 23. Process flow

Chapter five

5. Cost analysis

The total amount of cost that can be spent or the total amount of prices of the design of manually operated brick making machine in overall calculation is called cost analysis. In our design, main and considerable cost is cost for the raw materials, cost for fabrication, cost for finishing material, cost of daily labor, and cost for assembly and other safety purpose. Costing is the process of recording the expenses incurred in producing a product and computing the cost of the produced article by keeping a record of the cost of each item involved in the manufacture of a product.

Cost estimation

For estimating the cost of a product on various items of expenditure that have wasted on the machine and for the purpose of calculations, the total cost of the product is divided into the following Elements of Cost.

1. Direct material costs: It is the cost of those materials which are directly used for the manufacture of the product and become a part of the finished product. This expenditure can be directly allocated and charged to the manufacture of a specific product or job and includes the scrap and waste that has been cut away from original bar or by casting.

3. Direct other expenses: These are the expenses, except direct materials cost and direct labor cost, which can be identified and allocated to a particular product, *e.g.* cost of machine hours and cost of tools, jigs and fixtures etc.

The basic materials used in this project are: - Mild steel, Aluminum and Carbon steel

Mass method of calculation of cost. $\text{Mass} = \rho \times V$

Table 4. The material cost of value birr per kg.

Material	Density (kg/m ³)	Value birr/ kg
Mild steel	7850-7865	88
Carbon steel	7750	85
Alloy steel	7700	80.5
Aluminum	2700	72.34

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Table 5. The components of the machine are listed below.

N.o	Components	Description	Mass (kg)	Material	Cost (birr)
1	Lever arm	RHS(40 x 40x4mm), L=1500mm.	2.37407	Milled steel	210
2	Support	RHS(40× 40× 6mm) L=6000mm.	30.8829	Alloy steel	2486.08
3	Link	Sheet metal (500 x30 x5mm)	2.5208	Milled steel	221.8304
4	Hopper	Sheet metal (200 x 210 x 3mm).	2.5984	Aluminum	187.97
5	Feeder	Sheet metal (200 x 75 x 3mm).	1.448325	Aluminum	105
6	Chamber	Sheet metal (200 x 210 x 3mm).	2.5984	Carbon steel	220.864
7	Slider	Rolled milled steel D = 60mm with plate (200 x 210 x 10mm)	6.0453	Milled steel	531.986
8	Pattern plate	Carbon plate (200 x 210 x 6mm)	3.4624	Alloy steel	278.72
9	Head closing	Sheet metal (200 x 210 x 4mm).	1.7065	Alloy steel	143.48
10	Total				4385.195

Chapter 6

6.1. Result and discussion

Standard brick size from masonry unit catalogue

Size of the brick all sizes shown as Width x Height x Length.

Actual size: 90 x 64 x 190mm.

Nominal size: 100 x 75 x 200mm.

This size is moderate brick size with better compressive strength and the machine is friendly

$$\text{Area} = \text{length} \times \text{width} = 100 \times 200 = 20,000 \text{ mm}^2$$

The effort load = applied load 21kg = 210 N which is the load applied manually.

Compressive load

$$W = \frac{210N \times 1420mm}{80mm} = 3727.5N.$$

Compressing pressure applied on a unit brick

$$S = \frac{3727.5N}{20,000mm^2} = 0.1864N/mm^2$$

Pin and with boss of the arm

$$dp \approx 12mm.$$

$Lp = 1.25 \times dp = 1.25 \times 12 = 15 \text{ mm}$ calculated the length and diameter of pin and cheek for shear stress and it is below the max shear strength. .

$$d = \sqrt[3]{\frac{16T}{\pi \times \tau}} = \sqrt[3]{\frac{16 \times 42,000Nmm}{\pi \times 60Mpa}} = 15.276 \text{ mm} = 16mm$$

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Pin 2 and 3.

Bearing area = $L_p \times dp$... but $L_p = 1.25 \times dp$ and Bearing area = $1.25 \times dp^2$

$$\text{Bearing pressure} \left(\frac{25N}{mm^2} \right) = \frac{w}{\text{bearing area}} = \frac{2415N}{1.25 \times dp^2}$$

$$dp = \sqrt{\frac{2415N}{1.25 \times \frac{25N}{mm^2}}} = 8.79mm \approx 10mm \dots \dots \dots \text{to standard.}$$

1. The diameter of the boss (d_2) is taken as $=1.6 d = 1.6 \times 16 = 24.446mm \approx 25mm$
2. Thickness of the boss (t_2) as $= 0.3d = 0.3 \times 16mm = 4.5 \approx 5mm$
3. The length of the boss (l_2) may be taken = from d to $1.25 d$.

Taking the largest $l_2 = 1.25 \times d = 1.25 \times 16 = 20mm$

Hand Levers

$$\sigma_b = \frac{P \times L}{\frac{25}{6} \times t^3} = \frac{210N \times 200mm}{\frac{25}{6} \times t^3}$$

$$\frac{50N}{mm^2} \times \frac{25}{6} \times t^3 = 210N \times 200mm.$$

$$t = \sqrt[3]{\frac{42,000}{208.33333}} = 5.86mm \approx 6mm$$

$$h = 5 \times t = 5 \times 6mm = 30mm.$$

Design of support

Total mass carried = 41.517Kg.

The critical load applied on the support

$$\begin{aligned} P_{cr} &= P \times \text{factor of safety} = 1.5 \times 415.17N. \\ &= 622.754N. \end{aligned}$$

Manually operated simple interlock brick making machine

$$I_x = \frac{1}{3} \times b \times h^3 = \frac{1}{3} \times 2mm \times 30^3 = 18,000mm^4$$

$$I_y = \frac{1}{3} \times h \times b^3 = \frac{1}{3} \times 2mm \times 100^3 = 666,666.6667mm^4$$

$$I_A = I_x + I_y = 18,000mm^4 + 666,666.6667mm^4$$

$$I_A = 684,666.6667mm^4$$

$$A = A_1 + A_2 = (2mm \times 30mm) + (2mm \times 100mm) = 260mm^2$$

$$A = 260mm^2.$$

$$K_A = \sqrt{\frac{I_A}{A}} = \sqrt{\frac{684,666.6667mm^4}{260mm^2}} = 51.316mm$$

$$K_A = r = 51.316mm$$

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2 \times E \times A \times r^2}{A \times L^2} = \frac{\pi^2 \times E \times r^2}{L^2} = 5197.988 N/mm^2$$

6.2. Simulation

Lever arm

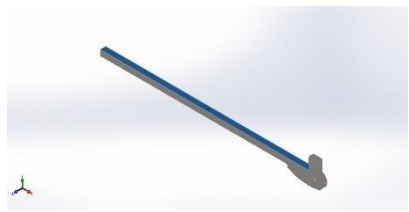
Study name	Static 3
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus

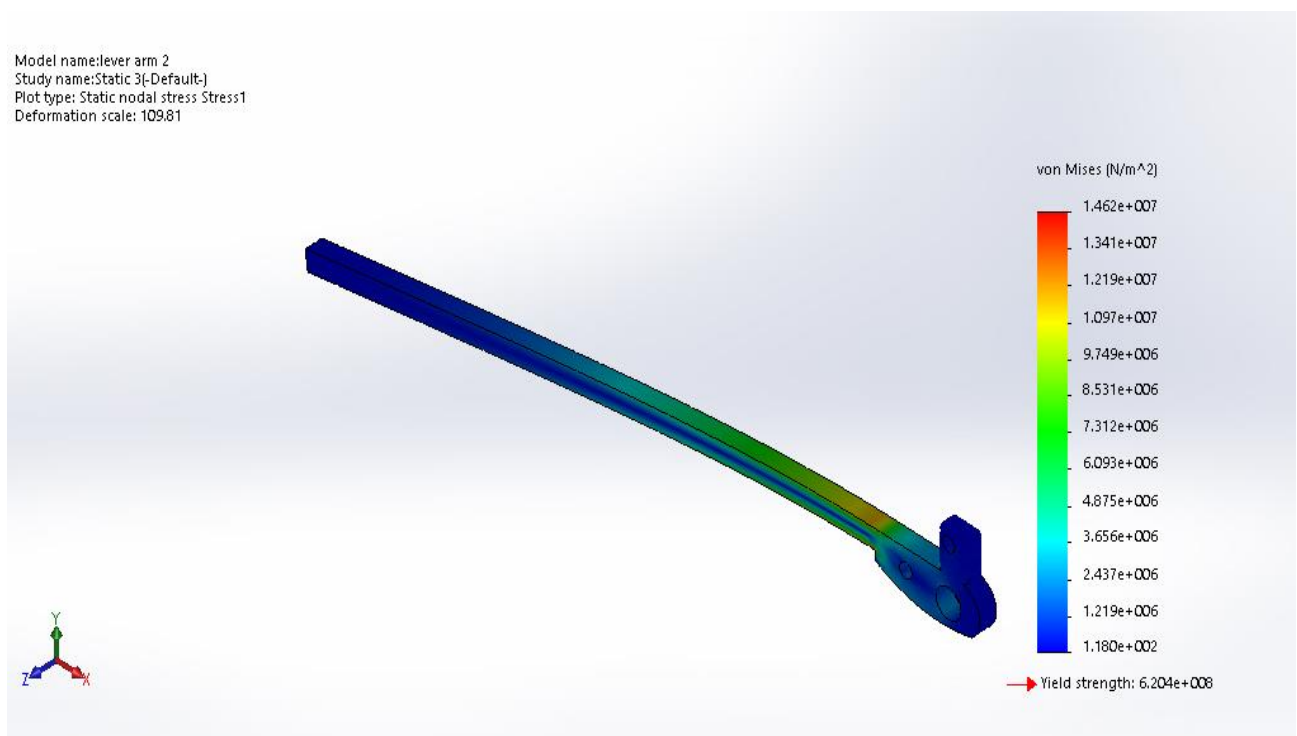
Manually operated simple interlock brick making machine

In plane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off

Model Reference	Properties	Components
	Name: Alloy Steel Model type: Linear Elastic Isotropic Default failure criterion: Max von Misses Stress Yield strength: 6.20422e+008 N/m² Tensile strength: 7.23826e+008 N/m² Elastic modulus: 2.1e+011 N/m² Poisson's ratio: 0.28 Mass density: 7700 kg/m³ Shear modulus: 7.9e+010 N/m² Thermal expansion coefficient: 1.3e-005 /Kelvin	Solid Body 1(Cut-Extrude3)(lever arm 2)

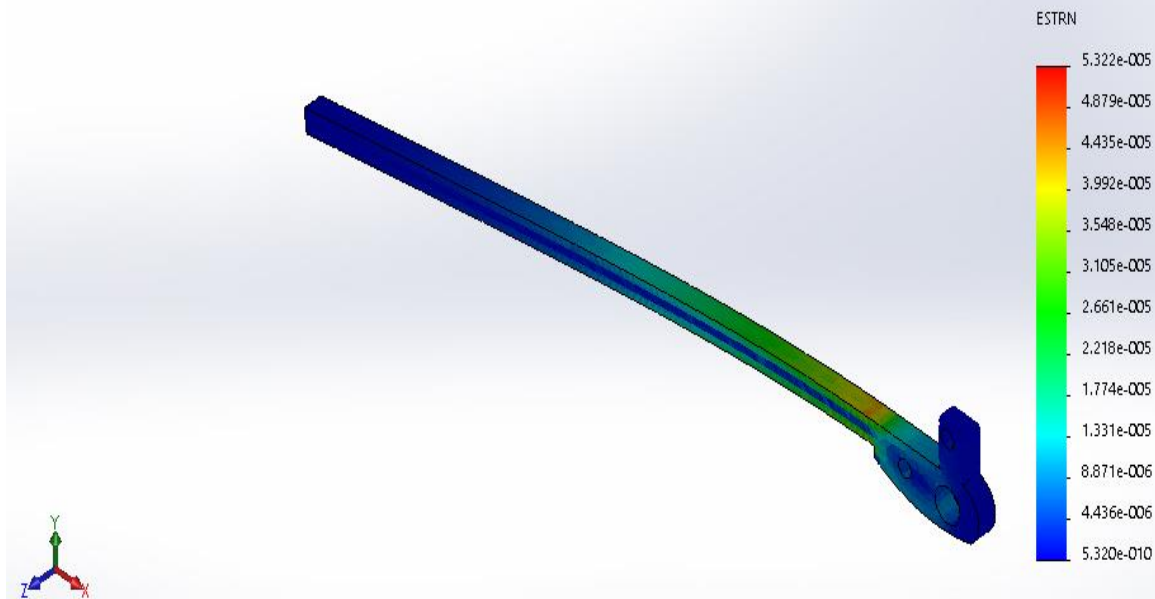
Manually operated simple interlock brick making machine

Load name	Load Image	Load Details
Force-2		Entities: 1 face(s) Type: Apply normal force Value: 210 N

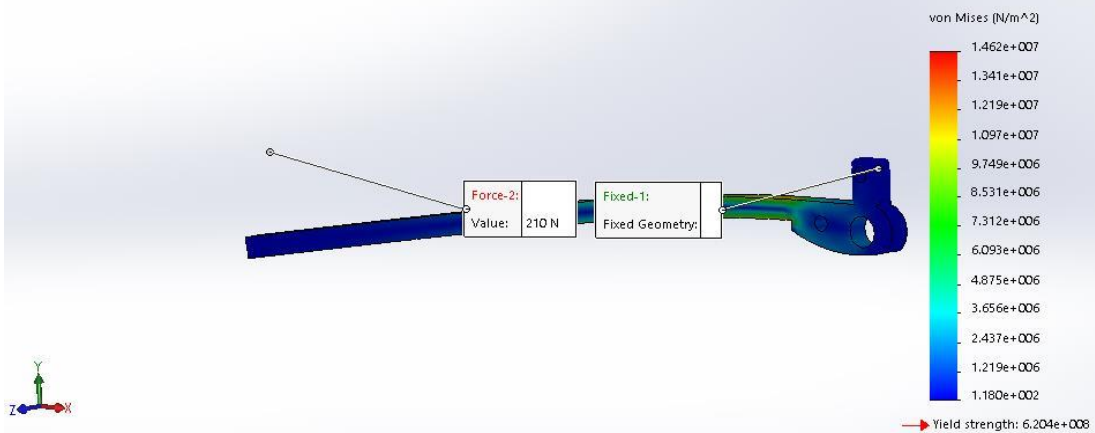


Manually operated simple interlock brick making machine

Model name: lever arm 2
Study name: Static 3(-Default-)
Plot type: Static strain Strain1
Deformation scale: 109.81



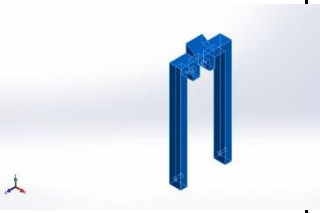
Model name: lever arm 2
Study name: Static 3(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 109.81



Link

Model Reference	Properties	Components
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Manually operated simple interlock brick making machine

	Name: Alloy Steel	Solid Body 1(Cut-Extrude9)(link)
	Model type: Linear Elastic Isotropic	
	Default failure criterion: Max von Misses	
	Yield strength: 6.20422e+008 N/m ²	
	Tensile strength: 7.23826e+008 N/m ²	
	Elastic modulus: 2.1e+011 N/m ²	
	Poisson's ratio: 0.28	
	Mass density: 7700 kg/m ³	
	Shear modulus: 7.9e+010 N/m ²	
	Thermal expansion coefficient: 1.3e-005 /Kelvin	

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	209.981	0.0165176	-210.017	296.983

Reaction Moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	0

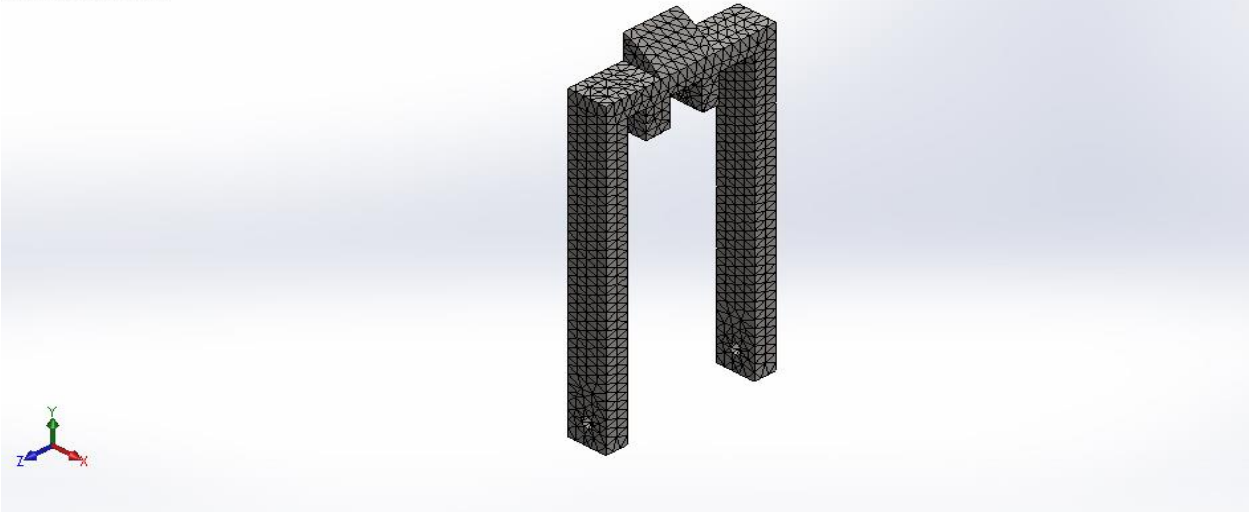
Mesh information - Details

Total Nodes	13835
Total Elements	8106
Maximum Aspect Ratio	12.308
% of elements with Aspect Ratio < 3	98.2
% of elements with Aspect Ratio > 10	0.0987

Manually operated simple interlock brick making machine

% of distorted elements(Jacobian)	0
Time to complete mesh(hh:mm:ss):	00:00:01
Computer name:	

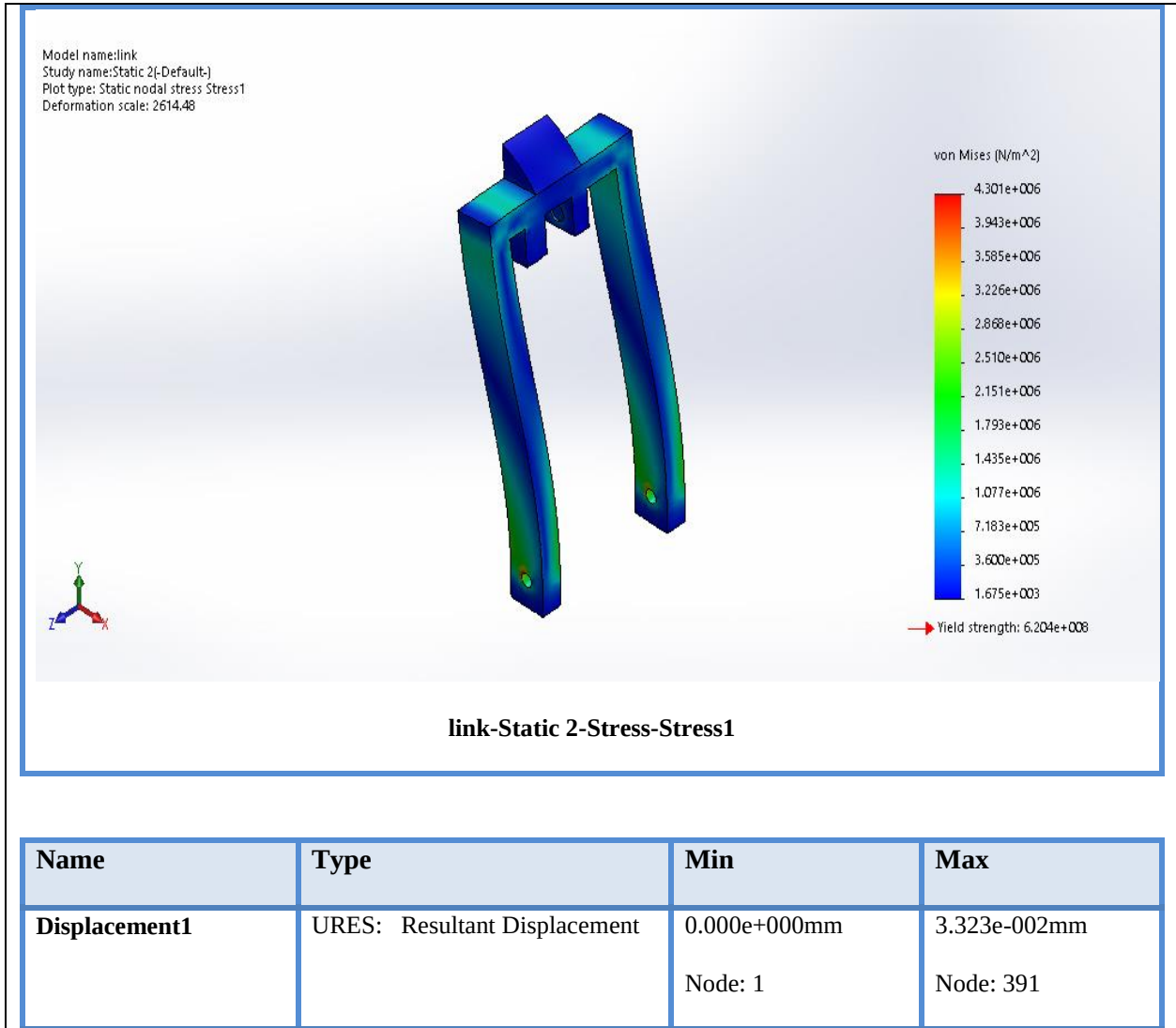
Model name:link
Study name:Static 2(Default-)
Mesh type: Solid Mesh



Study Results

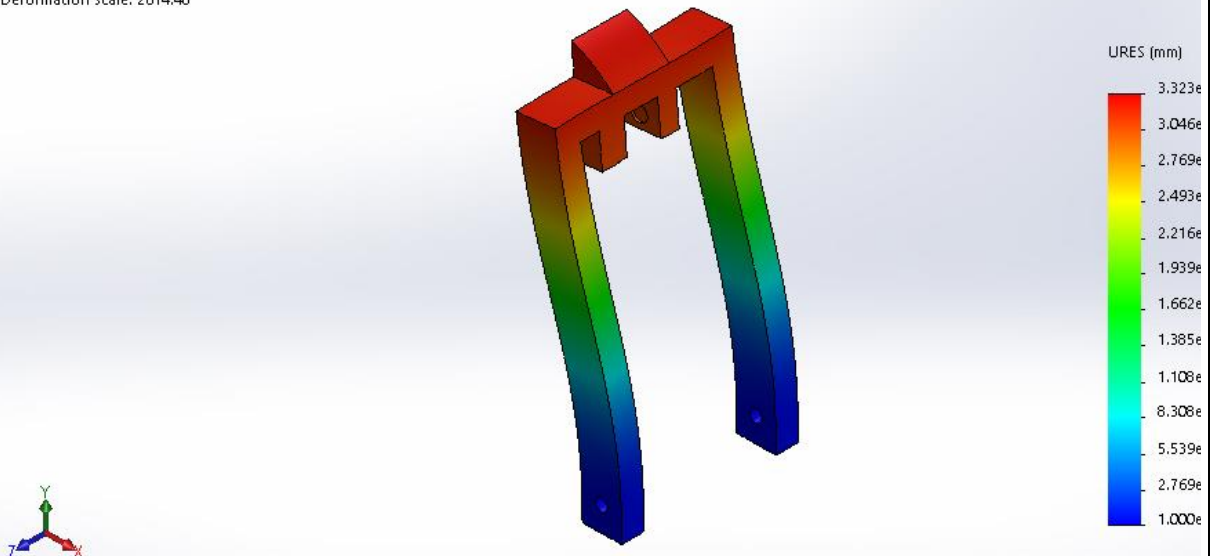
Name	Type	Min	Max
Stress1	VON: von Mises Stress	1.675e+003N/m ²	4.301e+006N/m ²
		Node: 11337	Node: 1206

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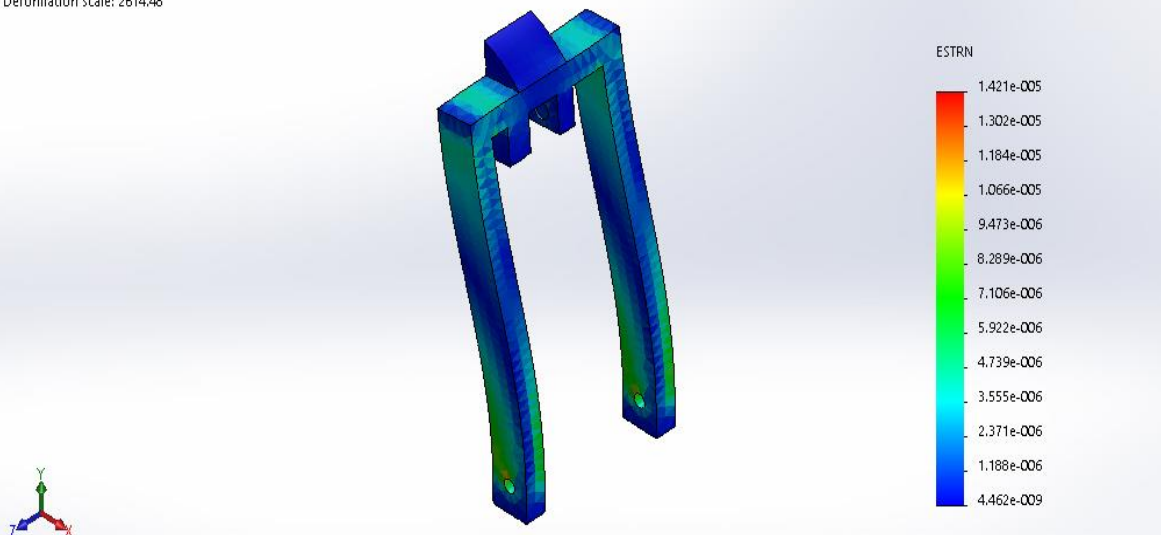
Manually operated simple interlock brick making machine

Model name:link
Study name:Static 2(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 2614.48



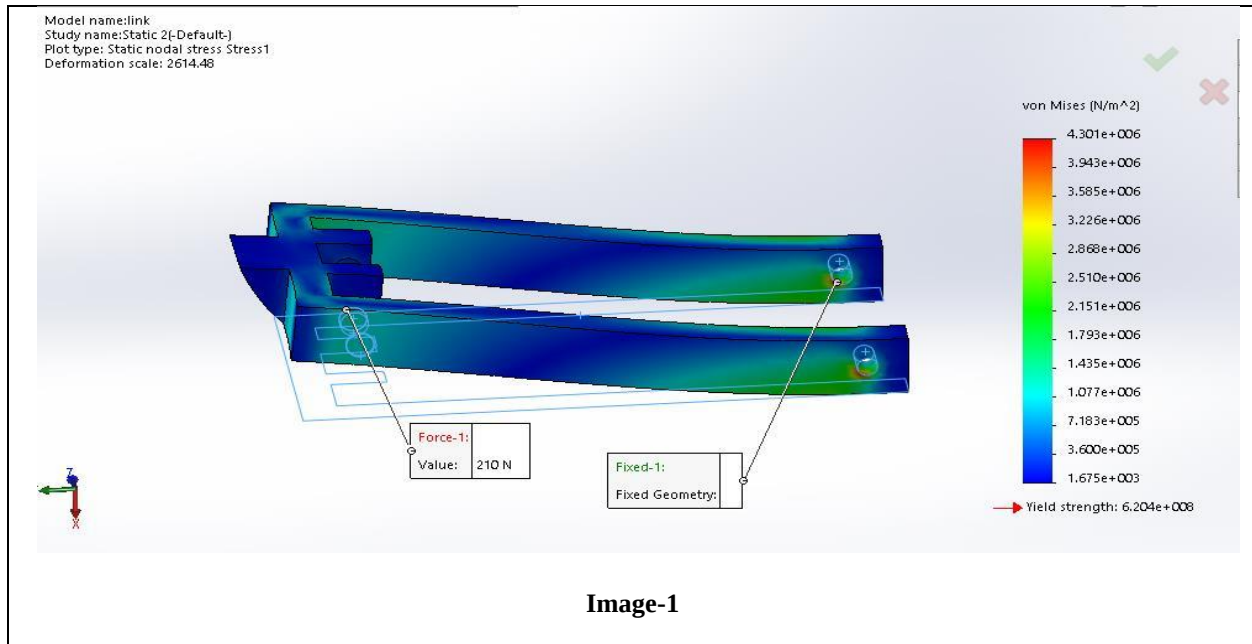
link-Static 2-Displacement-Displacement1

Model name:link
Study name:Static 2(-Default-)
Plot type: Static strain Strain1
Deformation scale: 2614.48



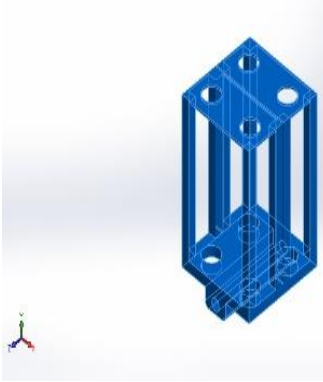
link-Static 2-Strain-Strain1

Manually operated simple interlock brick making machine



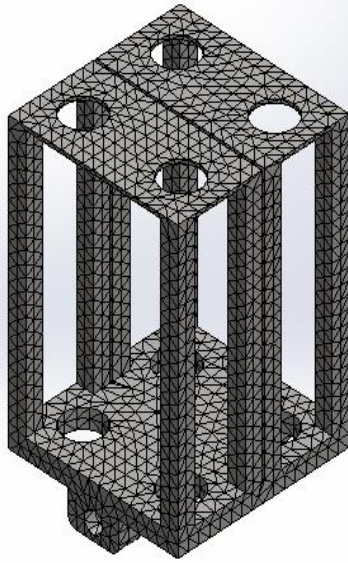
Slider

Model information.

Model Reference	Properties		Components
	Name:	Alloy Steel	Solid Body 1(Boss- Extrude4)(sliding)
	Model type:	Linear Elastic Isotropic	
	Default failure criterion:	Max von Misses Stress	
	Yield strength:	6.20422e+008 N/m ²	
	Tensile strength:	7.23826e+008 N/m ²	
	Elastic modulus:	2.1e+011 N/m ²	
	Poisson's ratio:	0.28	
	Mass density:	7700 kg/m ³	
	Shear modulus:	7.9e+010 N/m ²	
	Thermal expansion coefficient:	1.3e-005 /Kelvin	

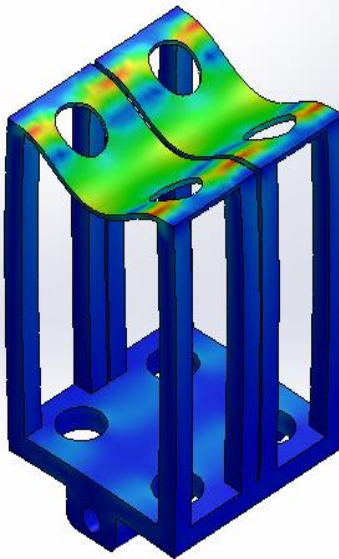
Manually operated simple interlock brick making machine

Model name:sliding
Study name:Static 4(-Default-)
Mesh type: Solid Mesh

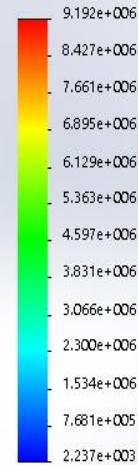


Name	Type	Min	Max
Stress1	VON: von Mises Stress	2.237e+003N/m^2 Node: 4961	9.192e+006N/m^2 Node: 1941

Model name:sliding
Study name:Static 4(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 1174.59



von Mises (N/m^2)



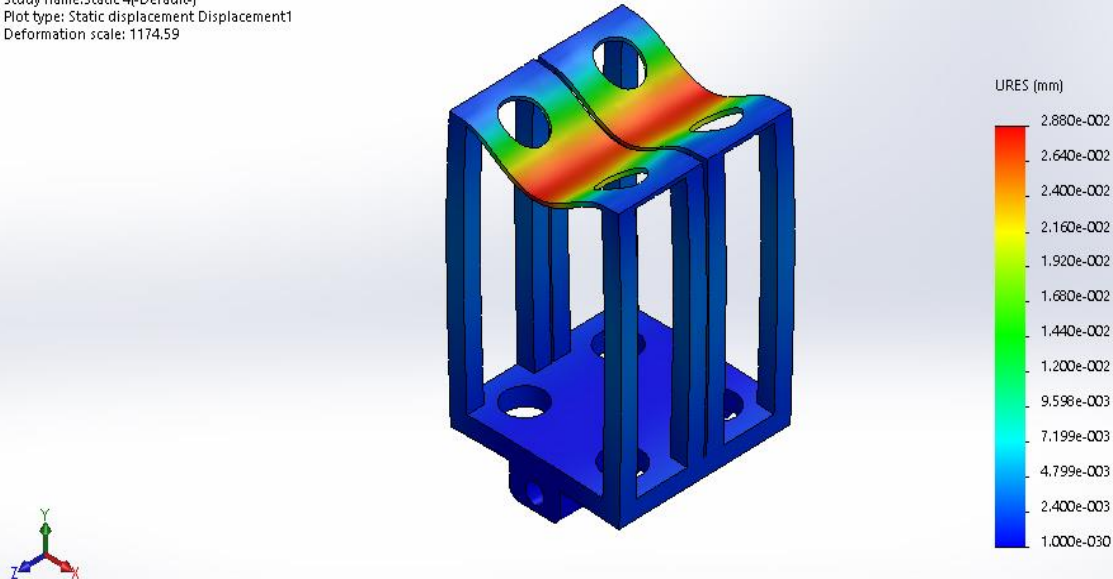
→ Yield strength: 6.204e+008



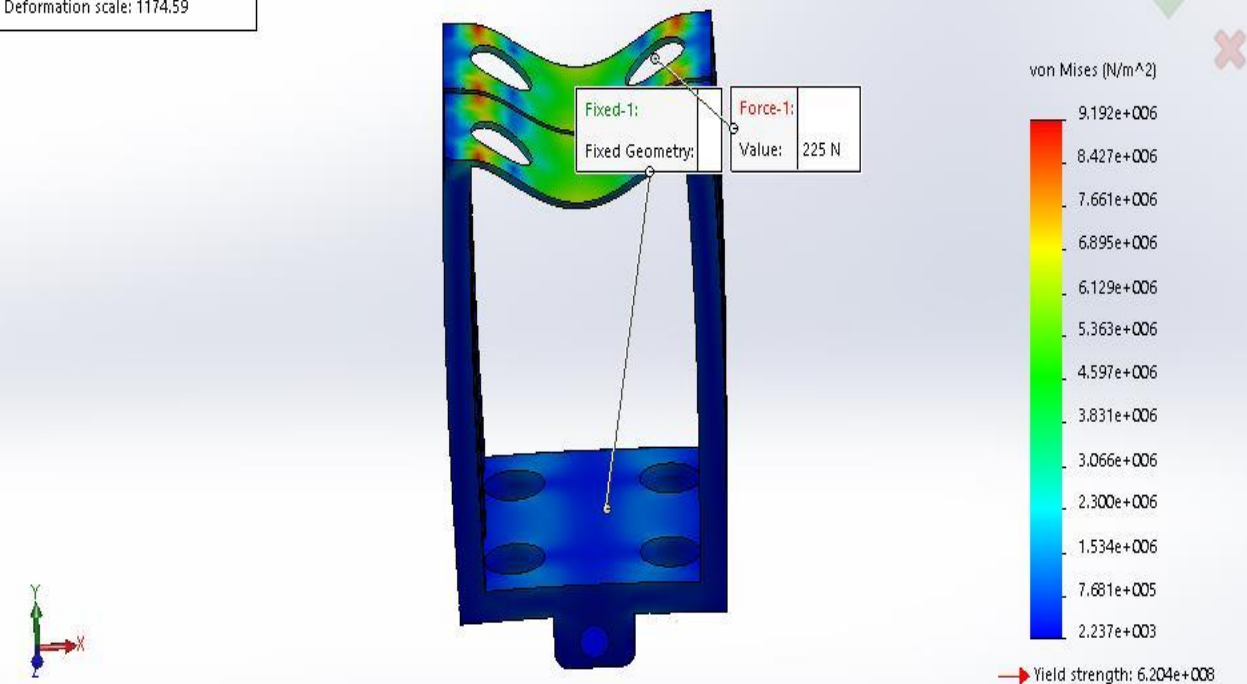
sliding-Static 4-Stress-Stress1

Manually operated simple interlock brick making machine

Model name:sliding
Study name:Static 4(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 1174.59



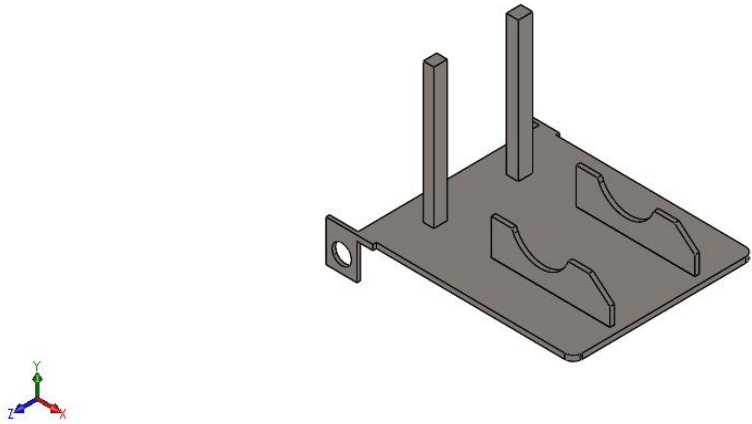
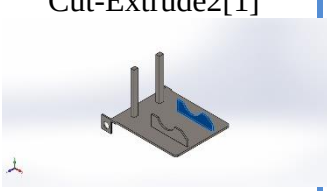
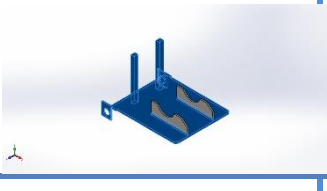
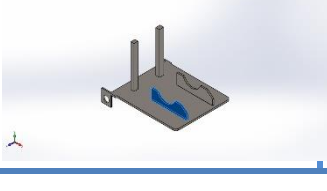
Model name:sliding
Study name:Static 4(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 1174.59



Manually operated simple interlock brick making machine

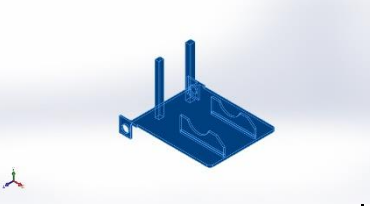
Head closing

Model Information

 Model name: head closing Current Configuration: Default			
Solid Bodies			
Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Cut-Extrude2[1] 	Solid Body	Mass:0.158985 kg Volume:2.06475e-005 m ³ Density:7700 kg/m ³ Weight:1.55806 N	C:\Users\MULUALEM\Documents\Desktop\solid work\head closing.SLDPRT Jun 01 16:50:04 2018
Boss-Extrude12 	Solid Body	Mass:2.83796 kg Volume:0.000368566 m ³ Density:7700 kg/m ³ Weight:27.812 N	C:\Users\MULUALEM\Documents\Desktop\solid work\head closing.SLDPRT Jun 01 16:50:04 2018
Cut-Extrude2[2] 	Solid Body	Mass:0.158129 kg Volume:2.05362e-005 m ³ Density:7700 kg/m ³ Weight:1.54966 N	C:\Users\MULUALEM\Documents\Desktop\solid work\head closing.SLDPRT Jun 01 16:50:04 2018

Manually operated simple interlock brick making machine

Material Properties

Model Reference	Properties	Components
	Name: Alloy Steel Model type: Linear Elastic Isotropic Default failure criterion: Max von Misses Stress Yield strength: 6.20422e+008 N/m ² Tensile strength: 7.23826e+008 N/m ² Elastic modulus: 2.1e+011 N/m ² Poisson's ratio: 0.28 Mass density: 7700 kg/m ³ Shear modulus: 7.9e+010 N/m ² Thermal expansion coefficient: 1.3e-005 /Kelvin	Solid Body 1(Cut-Extrude2[1])(head closing), Solid Body 2(Boss-Extrude12)(head closing), Solid Body 3(Cut-Extrude2[2])(head closing)

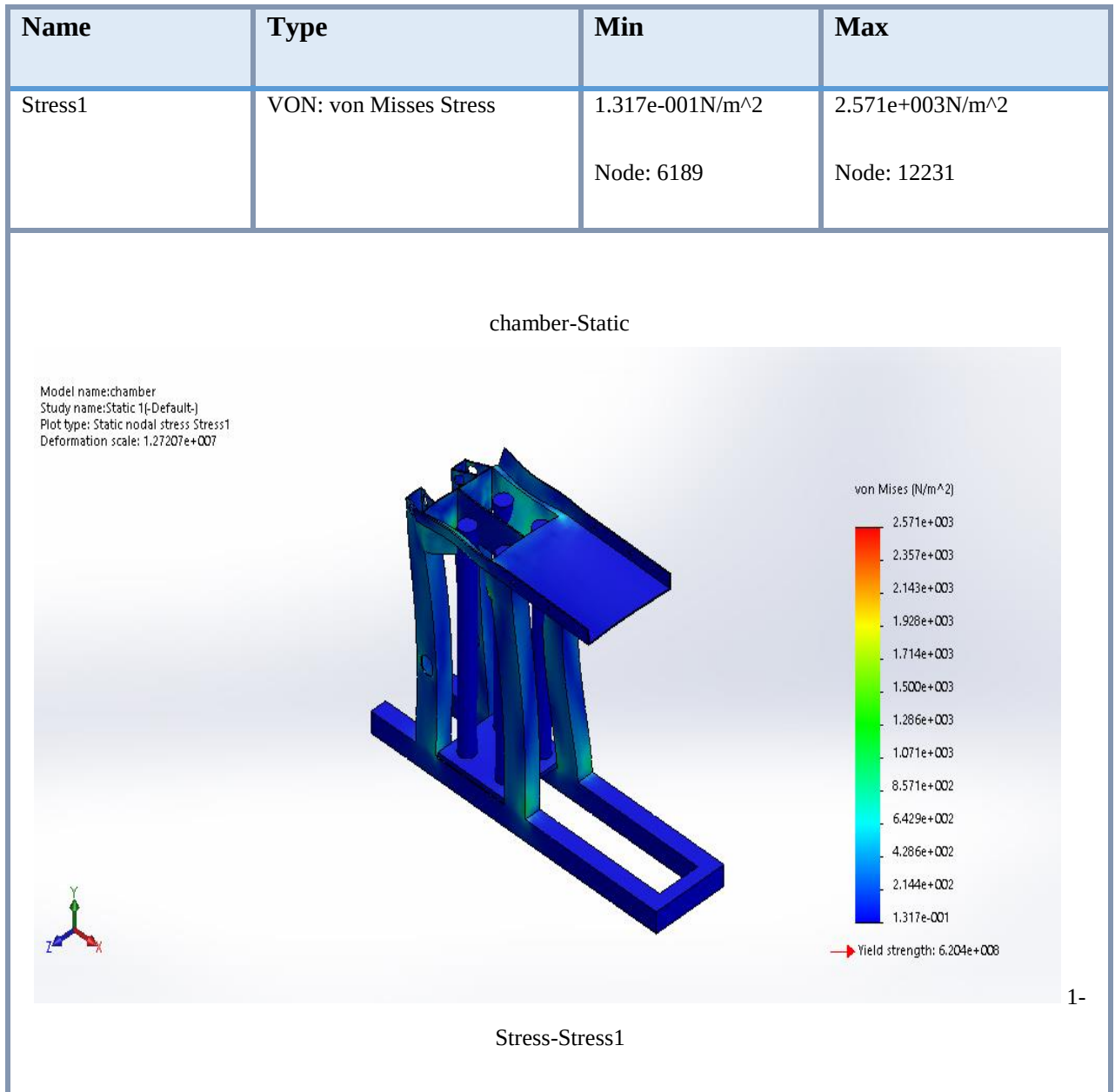
Model name:head closing
Study name:Static 2(-Default-)
Mesh type: Solid Mesh



Manually operated simple interlock brick making machine

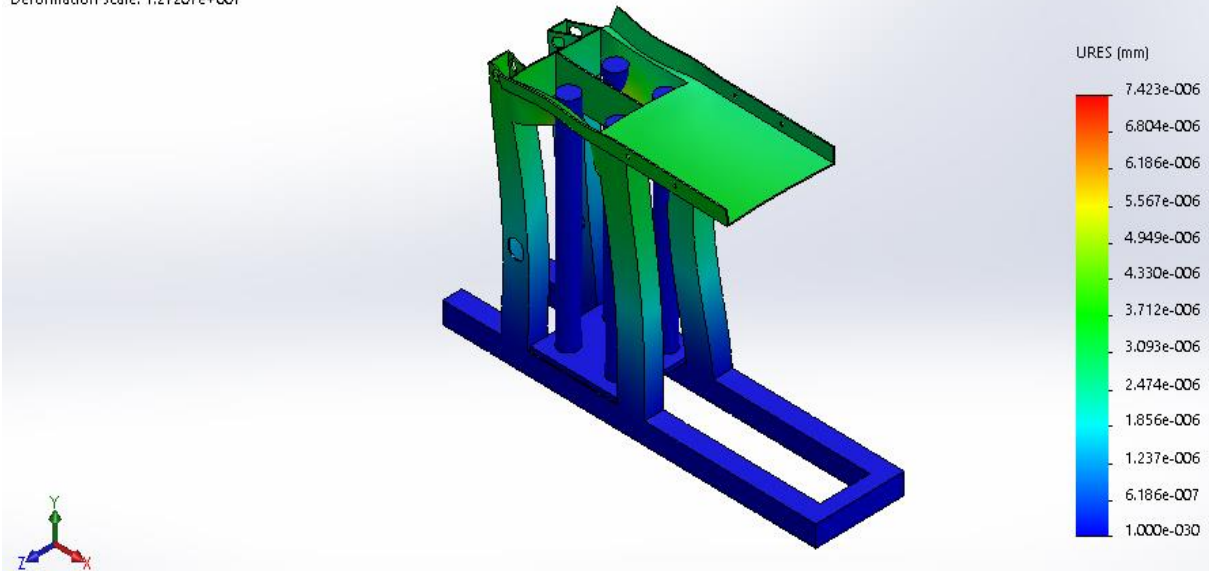
Support

Study Results



Manually operated simple interlock brick making machine

Model name:chamber
Study name:Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 1.27207e+007



Model name:chamber
Study name:Static 1(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 1.27207e+007

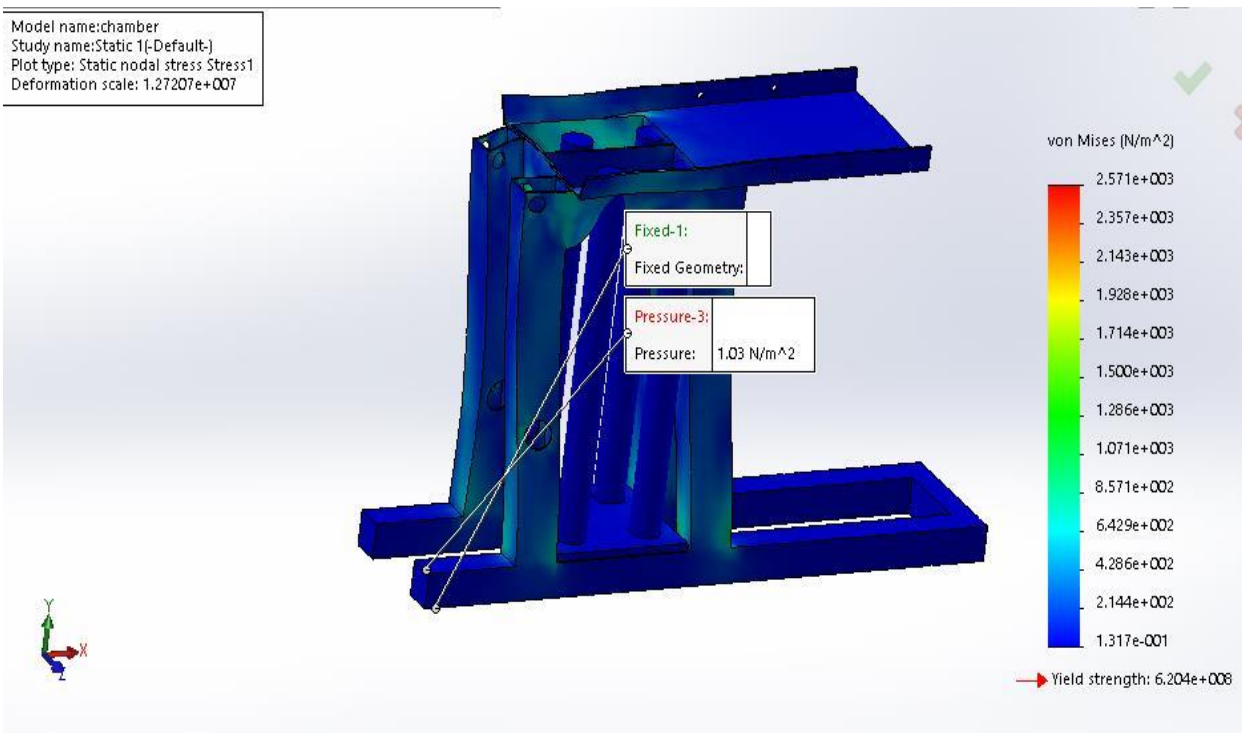


Image-1

Manually operated simple interlock brick making machine

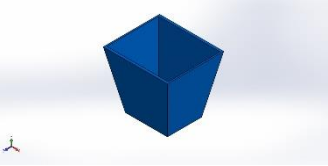
Model Information of hopper



Model name: hopper

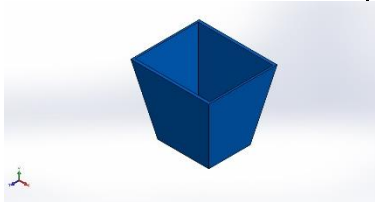
Current Configuration: Default

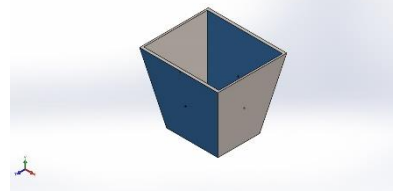
Solid Bodies

Document Name and Reference	Treated As	Volumetric Properties	Document Path/Date Modified
Cut-Extrude2 	Solid Body	Mass:2.70443 kg Volume:0.000351225 m³ Density:7700 kg/m³ Weight:26.5034 N	C:\Users\MULUALEM\Documents\Desktop\solid work\project part\hopper.SLDPRT May 12 04:29:01 2018

Manually operated simple interlock brick making machine

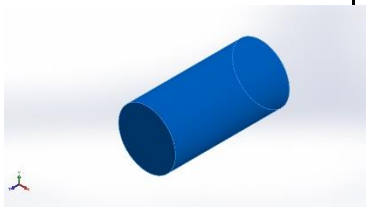
Material Properties

Model Reference	Properties	Components
	Name: Alloy Steel Model type: Linear Elastic Isotropic Default failure criterion: Max von Misses Stress Yield strength: 6.20422e+008 N/m² Tensile strength: 7.23826e+008 N/m² Elastic modulus: 2.1e+011 N/m² Poisson's ratio: 0.28 Mass density: 7700 kg/m³ Shear modulus: 7.9e+010 N/m² Thermal expansion coefficient: 1.3e-005 /Kelvin	Solid Body 1(Cut-Extrude2)(hopper)

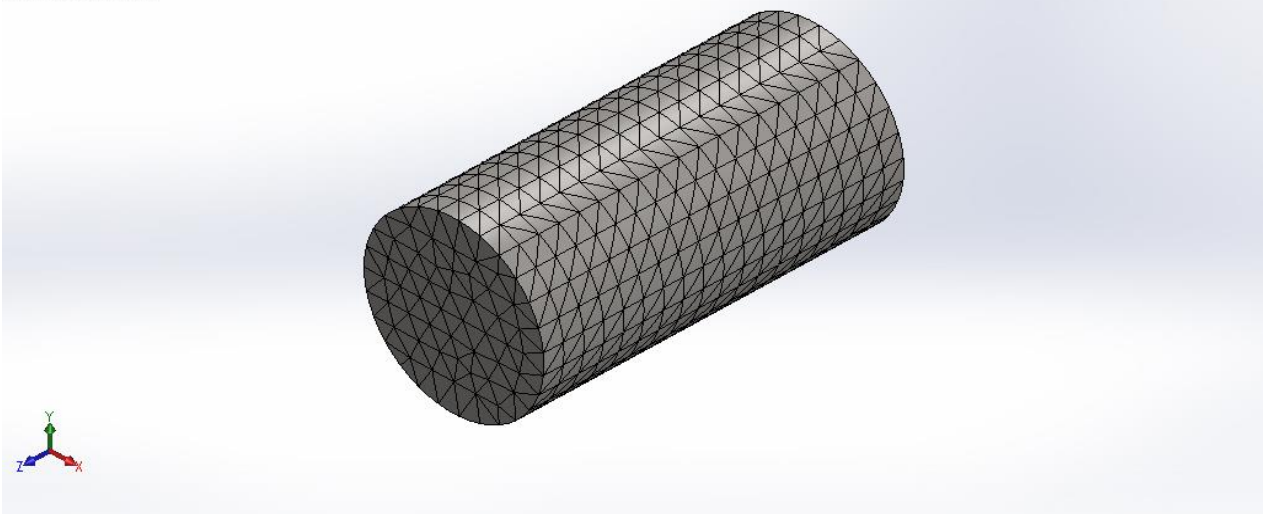
Load name	Load Image	Load Details
Force-1		Entities: 4 face(s) Type: Apply normal force Value: 225 N

Manually operated simple interlock brick making machine

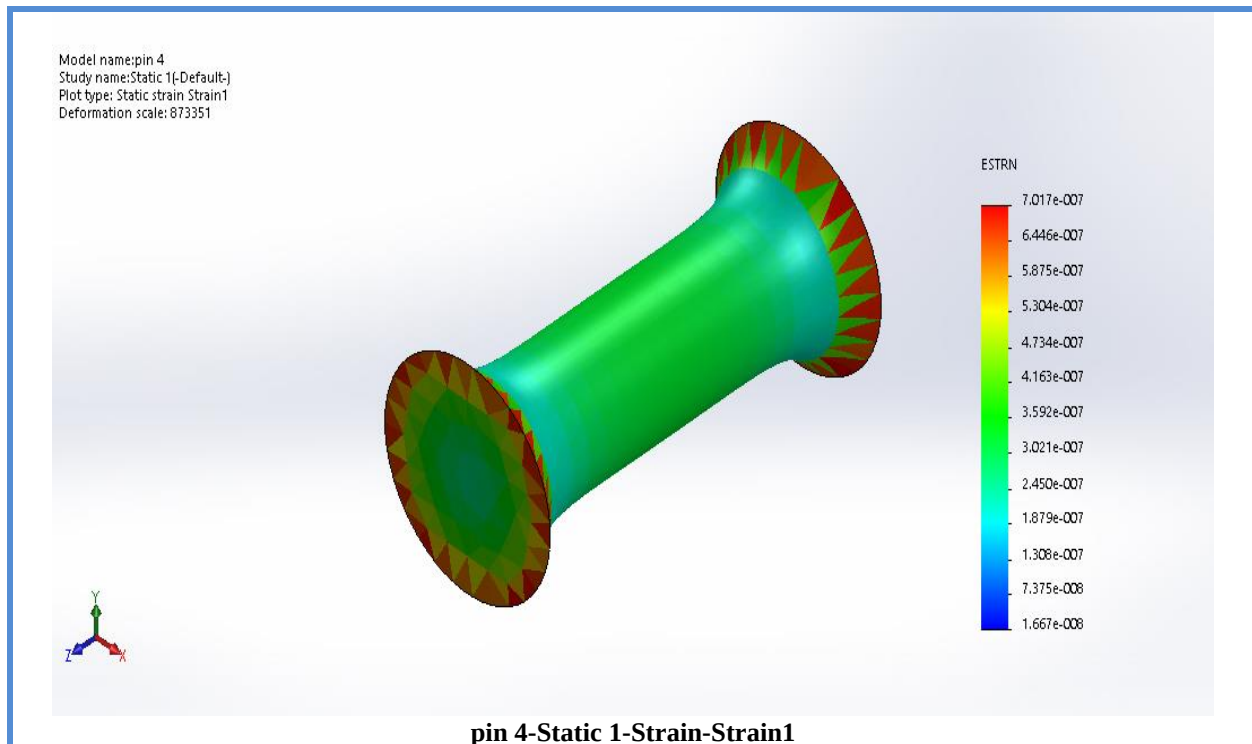
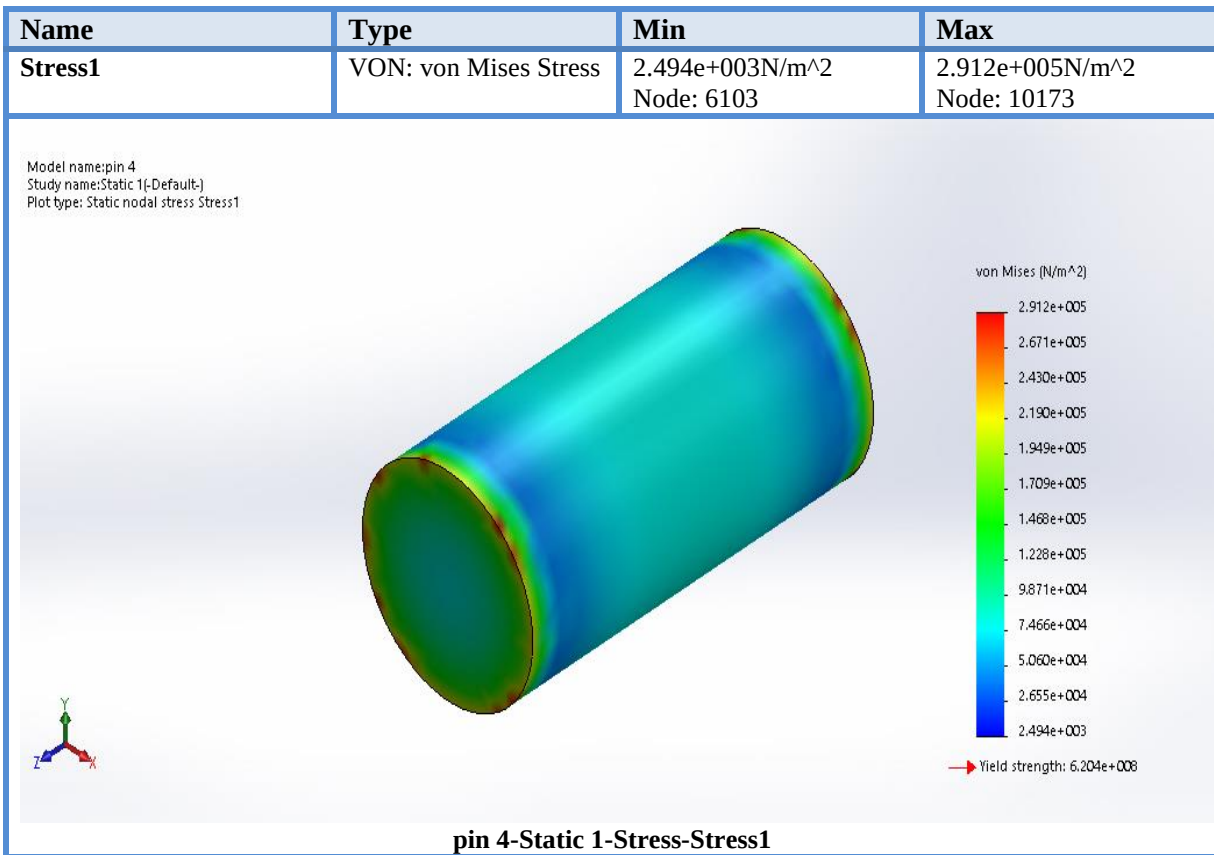
Material Properties of pin

Model Reference	Properties	Components
	Name: Alloy Steel	Solid Body 1(Boss-Extrude1)(pin 4)
	Model type: Linear Elastic Isotropic	
	Default failure criterion: Max von Misses Stress	
	Yield strength: 6.20422e+008 N/m ²	
	Tensile strength: 7.23826e+008 N/m ²	
	Elastic modulus: 2.1e+011 N/m ²	
	Poisson's ratio: 0.28	
	Mass density: 7700 kg/m ³	
	Shear modulus: 7.9e+010 N/m ²	
	Thermal expansion coefficient: 1.3e-005 /Kelvin	

Model name: pin 4
Study name: Static 1(-Default-)
Mesh type: Solid Mesh



Manually operated simple interlock brick making machine



Manually operated simple interlock brick making machine

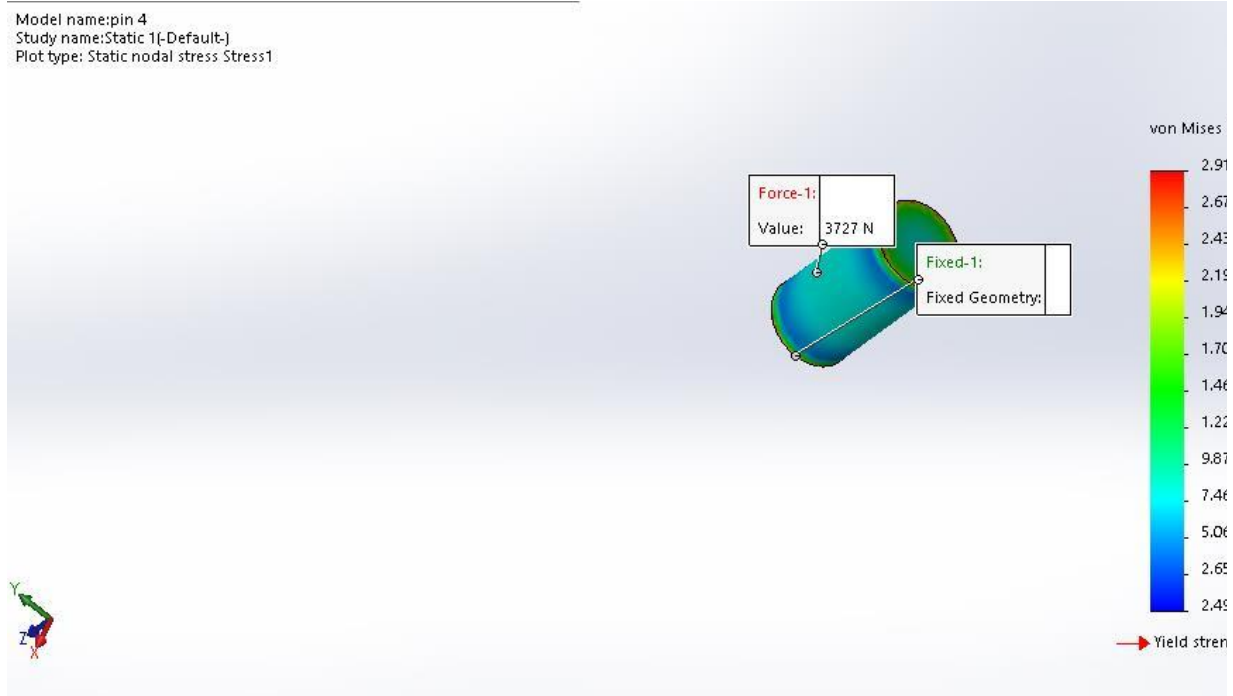


Image-1

All the parameters analysed mathematically and checked for the various stress affecting the corresponding component the parameter is evaluated against another max yield stress value then the calculated stress using the previously determined parameter shall be small or less than the max stress therefore all the pins have allowable shear stress below the max shear stress of mild steel the base or bushes are checked for bearing stress or pressure and found safe link 2 resists the tensile load acting on it the tensile stress is below the yield tensile strength of mild steel the support is also examined for buckling due to critical load and using moment of inertia for the section and radius of gyration the obtained critical stress is below the critical stress that cause the support to buckle.

The other thing we have done is simulating using solid work software after we draw the three dimension solid structure of each part apply material apply load and fixture and then mesh the load acting area and detect where will be the maximum stress concentrated area and detecting the area where increasing this load affects the component and results in failure of that machine element this regions are shown by red color and very low stress region by green color and it also gives the stress at the region in comparison with the yield

Manually operated simple interlock brick making machine

stress if the max stress is below the yield strength of the material that we select it is safe and no need to proceed but if the stress in the stress concentrated region is above the yield strength of the material selected return back and to under go the same procedure by selecting again the material.

Chapter 7

7. Conclusion and recommendation

Generally, The project major objective was to design and simulate manual interlocking brick making machine and the other specific objectives of the project were develop integrated mechanism that provides better solution for problems observed on manual brick making machine through conceptual design, perform strength analysis for each component, draw the 2D and 3D part and assembly drawings using solid work software and afterwards simulating each component therefore as previously detected problems on manual brick making machine were unable to make multiple bricks at single time with different shape then our design provides better solution by mixing this two design features together in this single machine the machine can produce two brick at a time and the various shapes can be achieved by using adaptable pattern plate that will be tighten to the head closing and the reciprocating sliding member using bolt then after this conceptual design components are designed and each components are safe this machine has great contribution for constructions by producing interlocking bricks that require less mortar to join with each other however there were lack of material in the workshop due to this we were obligated to change the design and fabrication approach to design and simulation if material were provided it was a lot easier to show in reality but now it is a bit difficult for us to show the real operation we also recommend to any mechanical engineer shall update or redesign this brick making machine by improving many existing features decreasing the manual power used to compress the soil mixture this construction area is highly advantageous and new work area that uphold improvement after all the objective is satisfied well enough .

8. Reference

1. Design and building Interlocking mortar less building blocks Patent Nos. 3,888,060 and 4,640,071.
2. An Interlocking Brick construction for toys (Automatic Binding Brick) was first developed in Denmark in 1949.
3. The interlocking block configurations were first developed by Etherington (1985).
4. Pascal Odul, CRATerre- EAG, “compressed earth blocks: manual of design and construction”, Volume II, 1985
5. Soraj kumar panigrahi, kommula venkata parasuram and clever kelogetswe “design and development of low cost brick making machine”, university of Botswana, 2004.
6. Simion Hosea Kintingu, “design of interlocking bricks for enhanced wall construction flexibility, alignment accuracy and load bearing”, The University of Warwick, School of Engineering ,May 2009.
7. Hubert Guillaud, Thierry Joffroy,
8. S.K. Kolawole and J.K. Odusote, “Design, Fabrication and Performance Evaluation of a Manual Clay Brick Moulding Machine”, February 2013.

9. Appendix