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Design, Development of a Fluid Powered Skidding System and Validation, Analysis Based on Computational Contour Approach

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ABSTRACT

A skidding system, sometimes referred to as a jack and slide system, is a horizontal/vertical load handling method that involves hydraulic/pneumatic cylinders pushing (or pulling) shoes that carry a load over a controlled friction surface. Skid is flat structure which supports loads while being moved or lifted using conventional methods. A skid is also called a pallet. It is usually made of wood or steel. Skidding systems are used to move large structures, in a safe and efficient manner. This system can be operated within a designated space to move the load. For that purpose, a skidding track is required. This is a metal track coated with Teflon. On top of it, a skid-shoe or beam is placed inside the track which has a stainless steel bottom and a load carrying structure on top. This paper clearly emphasizes the design, development, fabrication and analysis of a typical fluid powered skidding system.

Keywords: *skidding, pneumatic, Teflon, fluid, friction*

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INTRODUCTION

A fluid power skidding system, sometimes referred to as a *jack and slide system*, is a horizontal/vertical load handling method that involves fluid cylinders pushing (or pulling) *shoes* that carry a load over a *controlled friction surface*. Two I-beams comprising the top chord of the deck truss of the platform typically serve as the skidding surface for a skid base which spans across the beams. This beam is sometimes referred to as the skid beam or capping beam. The skid base is pushed or pulled longitudinally across the platform by two skidding assemblies. For lateral movement of the rig, a substructure carrying the drilling equipment sits on and skids on the top flanges of the skid base. Generally, two skidding assemblies push or pull this substructure across the top of the skid base. In the prior art, there are two basic types of rig skidding assemblies. The first is the rack and pinion type. The second is the rod and piston type. The present invention falls in the second class of rig skidding systems. This type of system employs, for example, a hydraulic cylinder having one end connected to the skid base and the opposite end connected to a device for engaging the capping beams of the platform. By extending or retracting the cylinder rod, the skid base is moved [1].

It is known in the prior art to provide a hydraulic gripper to anchor the end of the hydraulic cylinder to the capping beams. In this system, parallel plates are disposed above and below the top flange of the capping beam on both sides of the web. The plates are hydraulically squeezed together to grip the top flange of the beam, so the hydraulic cylinder may be activated to move the skid base with respect to the platform. In another prior system, the hydraulic cylinder is anchored to the capping beam by a claw. The claw includes a plate which slides on the beam. The capping beam has a plurality of rows of equally spaced rectangular openings, called jacking holes, through the top flange of the beam on both sides of the web. The bottom of the claw typically has four L-shaped fingers attached which fit through four rectangular openings in the beam and under the flange to anchor the end of the cylinder. In yet another prior art system, the end of the hydraulic cylinder is pinned to a claw or shoe which rides on the capping beam.

The shoe has guides attached extending downwardly on either side of the top flange of the beam and inwardly to prevent lifting of the shoe from the beam. A sleeve attached to the shoe contains a circular pin which moves down through the shoe to engage the round holes in the capping beam. The pin is mounted on the lateral centreline of the shoe and accordingly a row of spaced apart holes must be cut along the centreline of the capping beam. A major problem with the last two systems is the cutting of openings through the capping beams. These beams are usually major structural members of the platform and cutting holes through them reduce their structural strength. It is obviously preferable that no holes be cut through such structural members, although some platform designers may make allowance for the loss of steel caused thereby. In the case of the system last described, the holes extend down into the web of the I-beam; a very undesirable situation. In older platforms the jacking holes may already be cut through the capping beam. If this is the case, the drilling contractor must either modify his claw to fit the holes or the oil company must modify the holes or the hole pattern to fit the contractor's claw [2, 3, 4].

A skidding system, sometimes referred to as a jack and slide system, is a horizontal/vertical load handling method that involves hydraulic/pneumatic cylinders pushing (or pulling) shoes that carry a load over a controlled friction surface. Skid is flat structure which supports loads while being moved or lifted using conventional methods. Hence the name skidding system. A skid is also called a pallet. It is usually made of wood or steel. Skidding systems are used to move large structures, in a safe and efficient manner. This system can be operated within a designated space to move the load.

For that purpose, a skidding track is required. This is a metal track coated with Teflon. On top of the system, it a skid-shoe or beam is placed inside the track which has a stainless steel bottom and a load carrying structure on top. The cylinder expands and the load moves along the track accordingly. Then the cylinder is unlocked, retracts and is locked into the next pair of slots. This system is simple and strong. The skid tracks can only be fitted in a straight line which limits manoeuvrability. The weight of the load is directly transmitted to the skid-shoe and the track beneath, so the entire track requires load spreading and/or foundation.

METHODOLOGY

The design and development methodology chosen for our project is Bottom-Up Design. Any design method in which the most primitive operations are specified first and the combined later into progressively larger units until the whole problem can be solved is called bottom-up approach. In bottom-up approach, individual parts of the system are specified in details. The parts are then linked together to form larger components, which are in turn linked until a complete system is formed. The individual parts are designed to fulfill the intended function and then put together to form assemblies of a product. After the assembly is in place, problems are identified and modifications to individual components are made.

Besides the standard vertically oriented applications such as lifting and lowering, we are focussing on the horizontal movement of heavy loads. Skidding Systems are suitable for moving industrial objects and installations to locations where using a crane is not an option. Modular systems; easy to adapt to different load sizes and projects. The moving and positioning of industrial objects and installations is a complex task where accuracy, stability and safety are essential. Since objects and installations differ in weight and size to respond to this, we are developing extremely user-friendly, modular Skidding Systems that are easy to adjust to load size.

The principle of the Skidding Systems is simple; each system consists of a set of tracks, beams and push–pull units with a double-acting pneumatic cylinder. The load rests on the beams, which move horizontally in the tracks. To optimally guide the beams, the tracks are fitted with extremely low friction sliding pads. The beams are connected to the push–pull units, which are fitted with a cylinder with equal pushing and pulling capacity. This allows the system to perform both actions safely and in a controlled manner. The double-acting cylinders in the push–pull units are connected to a compressor by hoses. They can be controlled according to our need.

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PRINCIPAL COMPONENTS

The principal parts that have been used in this system are: pneumatic holder with ratchet mechanism, cylinder pivot, pneumatic cylinder, track, stack up unit, and stack.

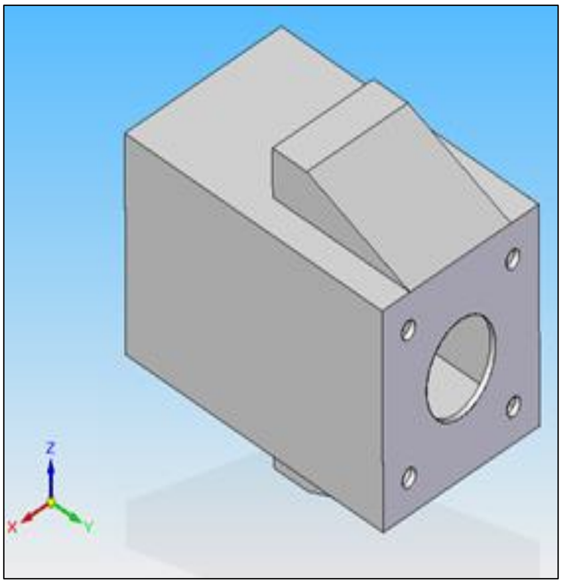

Fig. 1. *Pneumatic holder.*

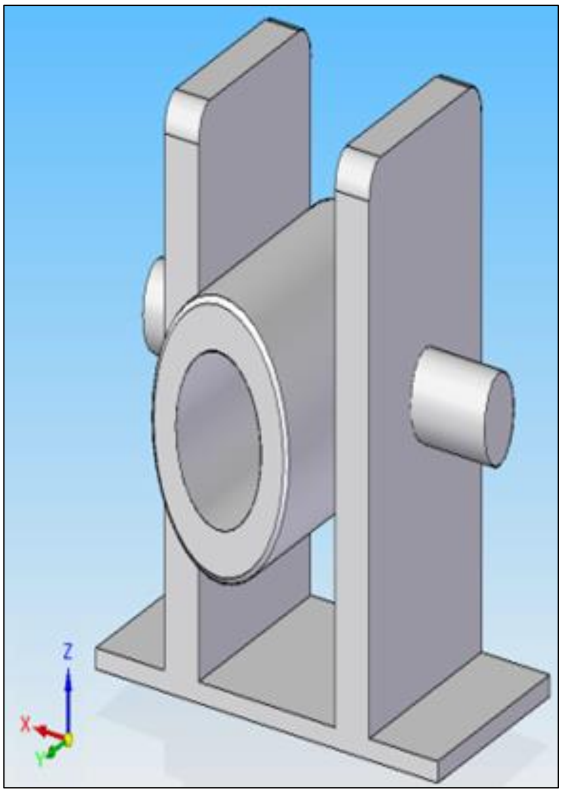

Fig. 2. *Cylinder Pivot.*

Pneumatic holder (Figure 1) is the pneumatic cylinder holder on which the pneumatic cylinder is arrested. It consists of a raised platform on the top and bottom part of the block giving it a triangular structure called ratchets, which are used for locking the push–pull system firmly to the track. The block (Figure 2) is to be fabricated out of mild steel of plate thickness 3 mm holes are drilled on either side for weight reduction.

Cylinder pivot (Figure 3) assembly acts as hinge to the pushing cylinder rod so that it can pitch up and down whenever necessary on the track profile. The pneumatic cylinder (Figure 4) acts as a push–pull system. It is used for bi-directional movement along x-axis. Basically, pneumatic cylinder of two different strokes are used, for the horizontal movement a cylinder with 400 mm is used and for vertical movement a stroke of 300 mm is used of a bore size of 40 mm as standard. The unique "ratchet

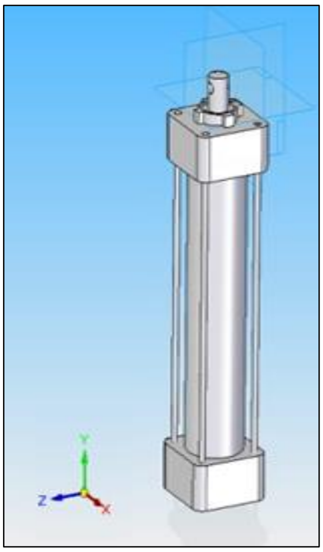

Fig. 3. *Pneumatic cylinder.*

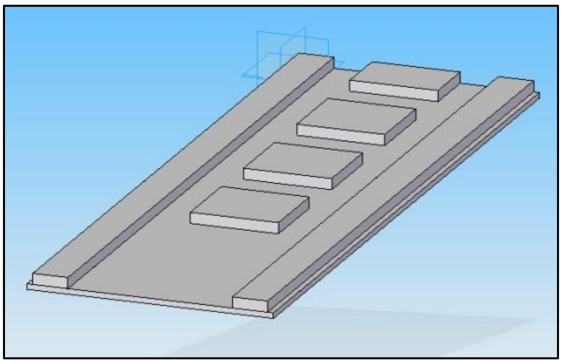

Fig. 4. *Track.*

track" design facilitates continuous movement and automatic resetting of cylinders. Loads can be moved in either direction by simply repositioning the cylinders. These are simple and light weight design modules which spans a length of 90 cm and the length for which the load has to be traversed can be achieved by joining such similar tracks and can be locked using pin blocks.

The jack-up system (Figure 5) is a multipoint lifting system. A typical system setup includes four jack-up units positioned under each corner of a load. In this setup the pneumatic cylinder used has a bore of 40 mm and a stroke of 400 mm. The lifting frame of a jack-up contains four hydraulic cylinders in each corner which lift and stack boxes. A load

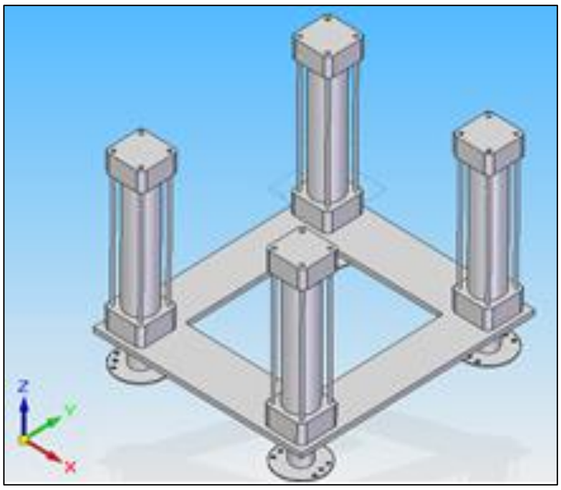

Fig. 5. *Stack up unit.*

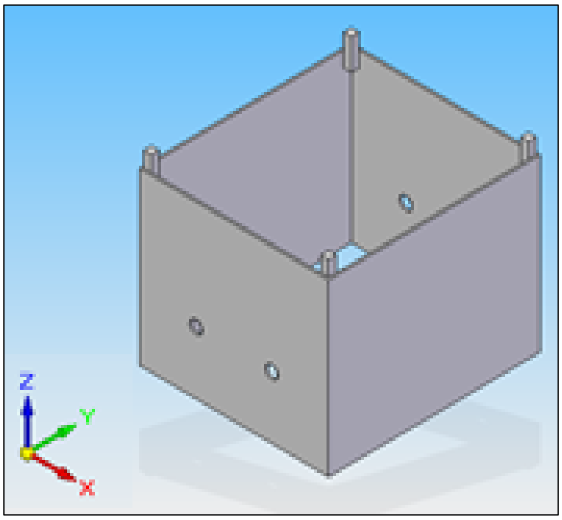

Fig. 6. *Stack.*

(Figure 6) is lifted in increments as boxes are slid into the system, lifted, and stacked; forming 'lifting towers'. Each unit's lifting and lowering operations occur simultaneously. Safe lifting heights are dependent on the expected side load.

Final Assembly of Fluid Powered Skidding System

The pressurized air stored in the storage tank is supplied to the pneumatic cylinder on the x-axis through hose pipes. This results in the building up of pressure within the cylinder and thus results in the extension of the cylinder rod, pushing it in forward direction. Also the retraction of the cylinder rod can be controlled with the help of directional control valves (DCV). The direction of the stroke can be reversed by rotating the pneumatic gripper holder by 180 degree counter/anticlockwise direction, which reverses the direction of ratchet mechanism and in fact the direction is changed. Once the load has been moved to the required distance, then the jack-up system is activated. It consists of 4 pneumatic cylinder placed at the corners, when it is connected to the supply line the cylinder reciprocates which in turn pushes the entire platform upwards. This creates space within it and this empty space is occupied with blocks the platform is lowered once again [5-7]. Rectangular blocks are inserted in so that the block is locked with platform. Again, the platform is raised up as the pneumatic system actuates creating empty space and filling the gap with the block and is locked again. This process is continued where the load is raised by stacking process and is raised up to required height (Figure 7).

DESIGN AND FABRICATION PROCESS

Phase I

Defining and Analysis of Problem

- This step specified the need aim or purpose of the design.

Preliminary Design

- Involved deciding basic working principle, mechanisms.
- Material selection.
- Machining processes involved.
- Tools required.

Initial Market Survey

- Involves drafting bill of materials (initial) and cost estimation.
- Availability of materials and parts were determined.

Revision of Design

- Design was modified based on the survey.

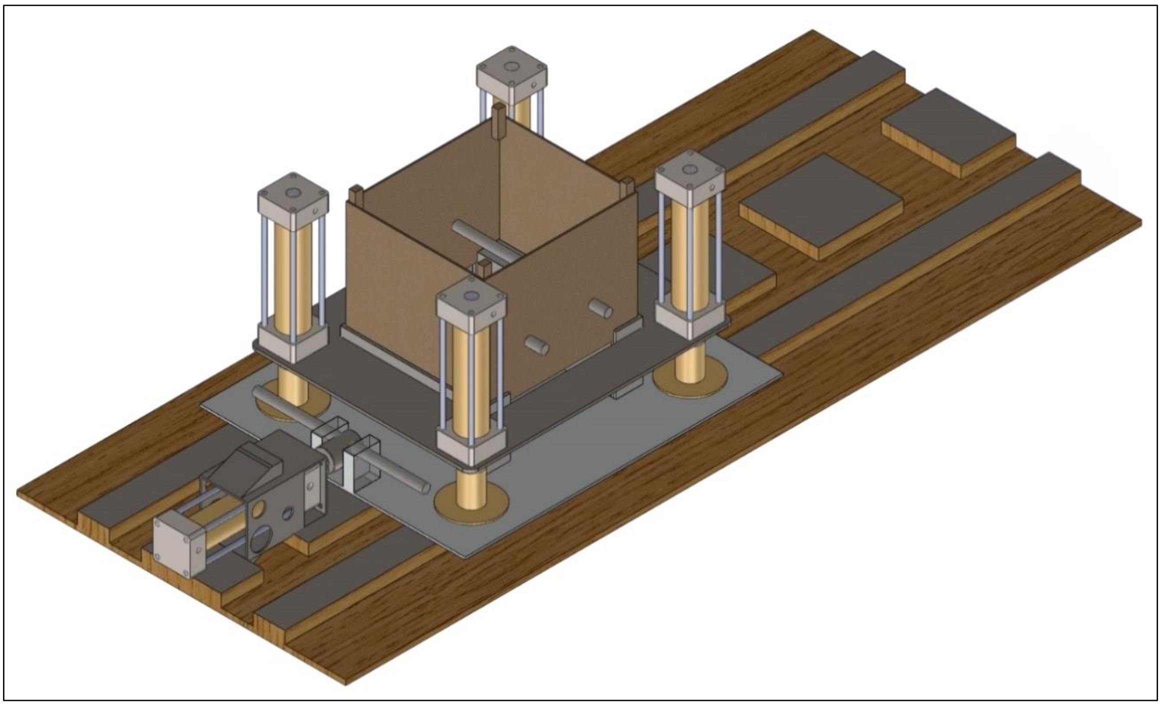

Fig. 7. *Final assembly of fluid skidding system.*

Phase II

Procurement of Materials

- OEM products were initially purchased based on priority and cost.

Modification of Design

- Based on availability of materials and their cost constraints, the design and materials were modified.

Procurement of Materials

- Raw materials, tools, hardware and accessories.

Final Design Drawings

- Involved drafting of drawings.

Machining and Assembly

- Involved processes like cutting, straightening, welding, etc.

Testing and Improvisation

- The model was operated.
- The design was slightly modified to improve the efficiency of the system.

Parameters	Modified values	Old values
Bore diameter of horizontal cylinder, d_x	63 mm	60 mm
Bore diameter of vertical cylinder, d_y	50 mm	40 mm
Stroke length of horizontal cylinder, L	250 mm	300 mm
Stroke length of vertical cylinder, L	250 mm	300 mm
Air pressure (average) P	6 bar	8 bar
Co-efficient of static friction, μ_s	0.2–0.7 (0.5)	0.1
Max. mass, w (including constructional elements)	200 Kg	200 Kg
Max load, W	1962 N	1962 N
Diameter of cylinder rod, d_r	20 mm	10 mm

(Modifications were completely based on the availability and the cost the parts.)

Technical Specifications

The total cost of this project work is Rs.27,000. The fluid powered skidding system can replace the conventional systems use to carry heavy loads like assembled products, monuments, ships, offshore platforms, buildings etc. The flowline in industries can also be replaced by this system since these can be compact under both operating and ideal condition. Automation of this system would improve its operating speed. Incorporation of advances in different fields like fluid power systems, tribology, nanotechnology, composites, mechatronics and automation would improve its performance and ease of operation. This system can be integrated with similar systems in order to increase its scale of operation. Skidding system is easily adaptable to any situation, environmental condition, field and location. The system can be modified according to the necessity since it can be easily disassembled. Co-efficient of friction was calculated using angle of repose. Angle of repose was calculated using trigonometric function on the dimensions of the inclination (Table 1).

Inference: System with MS-MS contact has the lowest co-efficient of friction. Hence it is adopted. Since use of grease on its surface reduces the coefficient of friction value grease is applied on the track.

LOAD CARRIED

- The System was tested under a load of 75 kg.
- Load was successfully moved horizontally along the track at 5 bar pressure.
- Load was successfully lifted vertically by height of 4.3 feet/1.32 m using stacks.
- Height of each stack = 220 mm
- No. of stacks = 6
- Weight of each stack = 6 kg
- Weight of jack-up unit = 30 kg (excluding stacks)

***Table 1**. Coefficient of friction.*

Material–Material	Trial no.	μs	μs (Average)
Wood–wood (Plywood)	1	0.708	0.7583
	2	0.7949	
	3	0.7721	
Mild Steel–wood	1	0.8944	0.844
	2	0.7949	
	3	0.8427	
MS–MS	1	0.4777	0.3905
	2	0.3673	
	3	0.3265	
MS–MS (with grease)	1	0.3265	0.3142
	2	0.3673	
	3	0.2488	

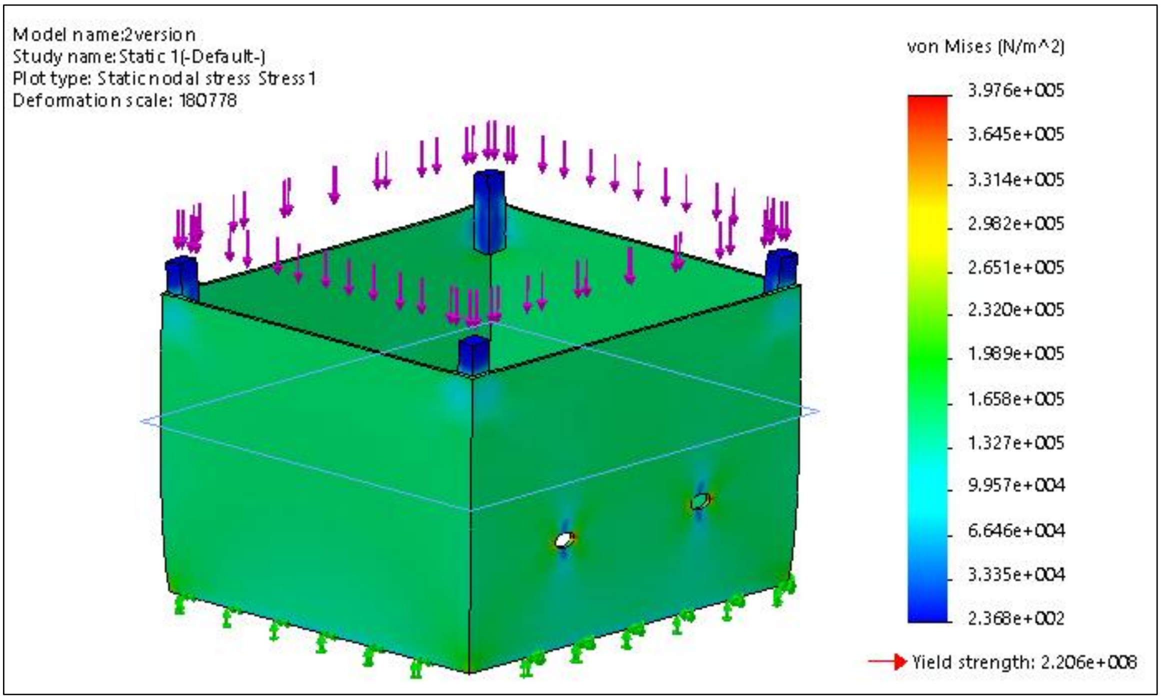

***Fig. 8.** Stress and strain analysis.*

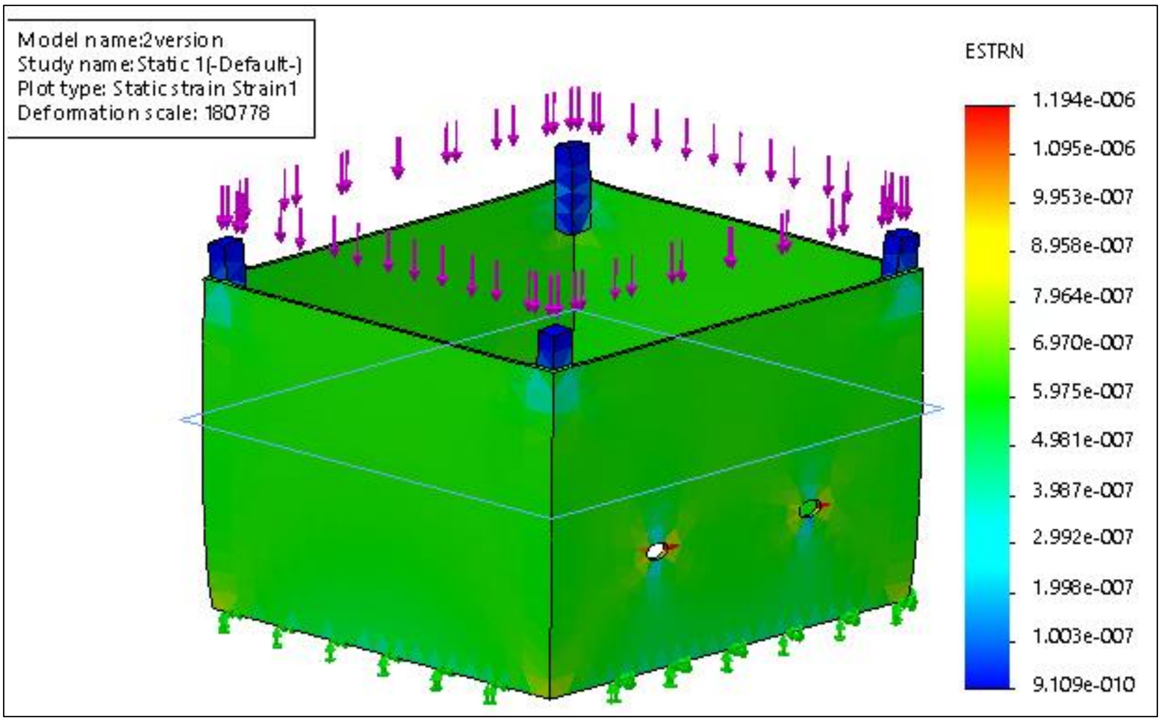

Fig. 9. *Stress and strain analysis.*

NUMERICAL ANALYSIS OF FLUID POWERED SKIDDING SYSTEM

Design Validation

The software used for carrying out analysis is 'SOLID WORKS' version 2017. Computational analysis has been carried out to comprehend the magnitude of compressive load that stack has to withstand. So the stack design has been finalized based on manufacturing and simplicity of design. Once the design was finalized according to dimensions, the test load has been applied and simulation has been accomplished. The material used for first trial run was Plain Carbon Steel (Mild steel). Once material was chosen, defined support structures and defined the fixtures. An external load of 200 kg was applied on the edges of the stack. After the force was applied, it is meshed to reduce its degree of freedom from infinite to finite. Meshing element size was course, which means the size of elements for large not fine. This is done to carry out analysis at a faster rate and overall stress distribution was to be considered, but not elemental stress.

The following contour plots have been analyzed:

1. Stress contour (Figure 8)
2. Strain contour (Figure 9)
3. Displacement contour (Figure 10)

The value obtained in stress contour analysis shows maximum stress to be in the range to 3.967×10^5, which is well within mild steels yield strength limit, which is 2.06×10^8. Hence the design is safe. The value obtained in strain contour analysis shows that the stack undergoes strain within the mild steel limit and no plastic deformation occurs, hence the design is safe. The displacement contour shows that the stacks various displacement vectors and the resultant displacement of the stack, which helps define the overall displacement that might occur while load is applied. This helps identify unified torque and areas that need to be constrained.

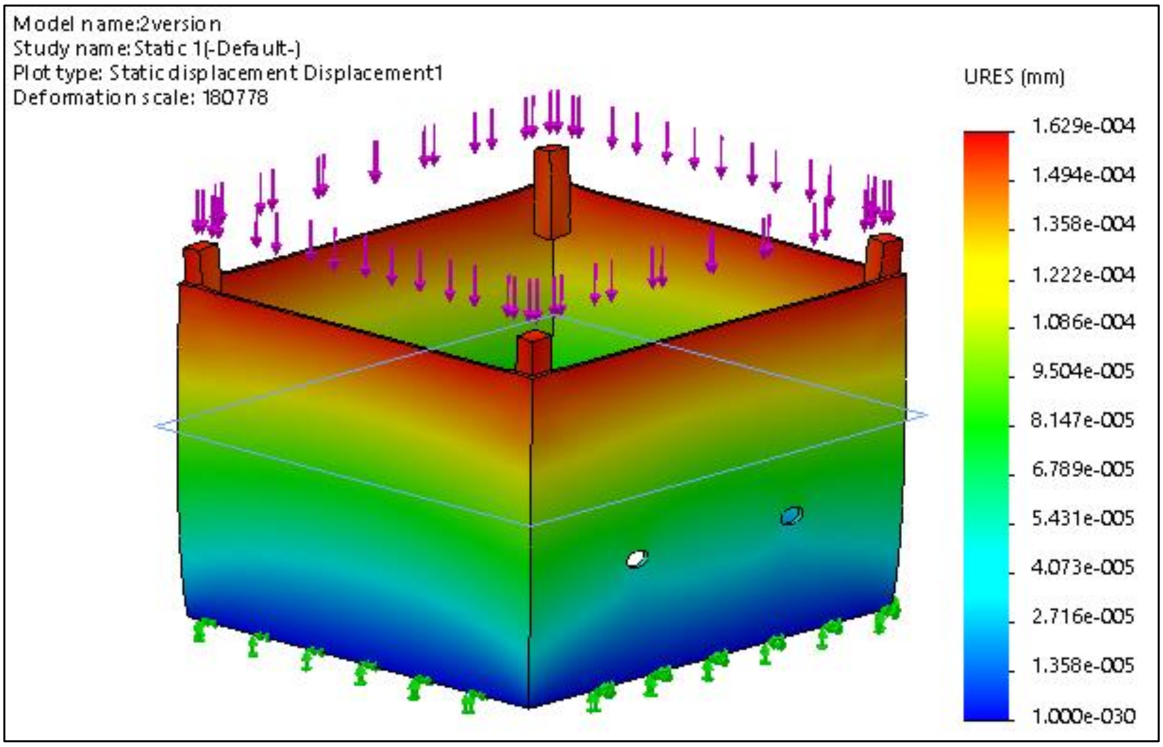

Fig. 10. *Contour plot about displacement.*

SCOPE FOR FUTURE WORK

- Skidding system can replace conventional system due to its high accuracy, less noise, easy setup and low power consumption.
- It can be automated, resulting in simpler operation.
- A number of similar systems can be integrated to increase the scale of operation.
- Sensors can be incorporated to optimize the accuracy and increase level of safety.
- It can be used almost everywhere, in every field due to its simplicity, compactness and adaptability.
- Field of construction is getting more rapid and readymade walls are used to construct buildings. In such cases skidding system would be helpful.
- Offshore platforms and ships can be easily moved and launched using this system.
- Use of hydraulic system can increase the load carrying capacity of the system of same scale.
- Coatings like PTFE can be provided to reduce the coefficient of friction.
- Composite materials can be used to produce stacks, in order to reduce its cost and weight and also increase its strength.

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