MAJOR PROJECT

REPORT ON

FABRICATION OF MULTI TERRAIN FIREFIGHTER VEHICLE WITH SLEWING AND TILTING NOZZLE

A Main-project report submitted in partial fulfilment of the requirements for the award of the degree of

Bachelor of Technology in Mechanical Engineering

By

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CERTIFICATE

This is to certify that the thesis / dissertation entitled **FABRICATION OF MULTI TERRAIN FIREFIGHTER VEHICLE WITH SLEWING AND TILTING NOZZLE** that is being submitted by Sri / Smt. / Ms **DYAPA AASHRITH REDDY(20671A0314), GANDRA VISHWA TEJA (20671A0315), ELURI KARTHEEK (20671A0317), G. SREEMAN NITISH KUMAR (21675A0315)** in partial fulfilment for the award of **Bachelor of Technology in Mechanical Engineering** to the **J.B. INSTITUTE OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)** is a record of bonafide work carried out by him / her under our guidance and supervision. The results embodied in this thesis are original work and have not been submitted to any other University or Institute for the award of any degree or diploma.

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EXTERNAL EXAMINER

DECLARATION

I Dyapa Aashrith Reddy, Gandra Vishwa Teja, Eluri Kartheek, G. Sreeman Nitish Kumar hereby solemnly affirm that the main-project report entitled **FABRICATION OF MULTI TERRAIN FIREFIGHTER VEHICLE WITH SLEWING AND TILTING NOZZLE,** being submitted by me in partial fulfilment of the requirement for the award of the degree of Bachelor of Technology in Mechanical Engineering, to the J.B. Institute of Engineering & Technology, is a record of bonafide work carried out by me under the guidance of Mr. G. Narasimhulu The work reported in this report in full or in part has not been submitted to any University or Institute for the award of any degree or diploma.

Place: Hyderabad
Date:

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ABSTRACT

Title: Fabrication of Multi Terrain Firefighter Vehicle with Slewing and Tilting Nozzle

Fire accidents and wildfire spread occurs in many places across the globe. Several lives, properties and resources get converted into ashes due to fire accidents / wild fires every day. Apart from the loss of lives and property, fire accidents will also damage environment by releasing huge amounts of pollutants into environment. In recent days we have witnessed one of such wildfire spread in Canada which has burnt millions of hectors of forest causing great damage to nature and pollution that came out of this wild fire impacted Canada as well as America and made 1000's of families to relocate.

During fire accidents and wildfire, any sort of delay in stopping fire, increases the risk to lives and loss of property. With the present-day firefighting trucks, it is getting difficult to handle fire accidents that are happening within city (where the roads are flat). Whereas in forests and villages, the paths are not flat, they are rough terrains hence present-day firefighting trucks cannot reach the fire site in time to stop the fire. Due to which millions of hectors of forest & crops and properties gets converted into ashes, lives will be lost with no help reaching in time and huge amounts of pollution is enters in to our environment.

As a one-step solution to above problem, we are planning to fabricate a prototype multi-terrain fire fighting vehicle that can travel on flat as well as in rough terrains and quinch the fire with least human efforts.

LIST OF FIGURES

CHAPTER 1

1.1 INTRODUCTION

Firefighters often face challenges when handling high-pressurized nozzles during firefighting operations. The force exerted by these nozzles can be substantial, making it physically demanding for firefighters to maintain control. The water stream's powerful recoil can lead to fatigue, affecting their ability to effectively manage the nozzle and direct the water flow accurately. In addition, the high-pressure environment adds an element of danger, requiring skilled and experienced personnel to handle the equipment safely.

To address these issues, there is a growing need for innovative solutions in firefighting technology. One promising approach involves the development of a specialized firefighting machine equipped with a tilting and rotating nozzle mechanism. This machine aims to enhance efficiency and control during firefighting operations, reducing the physical strain on firefighters and improving overall effectiveness in combating fires in various terrains.

The proposed firefighting machine incorporates motors for tilting and gears for rotating the nozzle head platform. This design allows for precise control over the direction and angle of the water stream, providing firefighters with a tool that is not only powerful but also highly maneuverable. By providing these crucial adjustments, the machine minimizes the manual effort required from firefighters, allowing them to focus on strategic decision-making and coordination during firefighting efforts.

One key feature of the machine is the integration of a rocker bogie mechanism, enhancing its mobility across diverse terrains. The rocker bogie, commonly used in planetary rovers, provides stability and adaptability, allowing the machine to traverse uneven surfaces with ease. This capability is essential in emergency situations where firefighting efforts may be required in challenging environments, such as rough terrain, debris-laden areas, or even confined spaces. The machine's ability to navigate multi-terrain surfaces ensures that it can reach and address fire incidents effectively, regardless of the surrounding conditions.

The incorporation of a user-friendly control system is another significant aspect of the proposed firefighting machine. With a single vehicle driver able to operate the entire system, the need for additional firefighters to manage the equipment is eliminated. This not only streamlines the firefighting process but also reduces the personnel required on-site.

The motorized nature of the machine's operations contributes to increased efficiency in firefighting efforts. The motorized tilting and rotating functions enable precise water stream targeting, allowing firefighters to adapt quickly to changing fire dynamics. This responsiveness is crucial in controlling and suppressing fires rapidly, preventing further escalation and minimizing damage to property and lives.

CHAPTER 2

LITERATURE REVIEW

2.1 FIREFIGHTING TRUCK

The present-day firefighting truck is commonly equipped with flashy illuminations, deafening alarm bell, and a water tank. one among the most important, most outstanding indications of a fireplace scene is the top-notch massive size and red colored firefighting truck as shown in figure (2.1). An ancient age water pump carrying trolley is transformed as an appropriate automobile carrying all the critical gadget including ladders, electricity tools and rescue tools as the car moves from the fireplace station to the fireplace scene.

Fig (2.1) firefighting truck

A firefighting truck is an automobile delivering a group of firefighters from their station to the scene, along with all the essential auxiliary gadget. these generally include ladders like a ground ladder and an aerial ladder, first useful resource, and protective tools,

These firefighting vehicles additionally bring respirational equipment inclusive of a snorkel to help the sufferers of the fireplace. whilst the primary purpose of the fireplace engine is to successfully comprise and extinguish the hearth, the fire truck is greater centered towards rescuing people from the fire scene, saving lives, ventilating the constructing or place, and imparting any emergency first useful resource or scientific remedy to the affected sufferers.

Due to the fact that fires are recognized to be extremely unpredictable and will be inclined to spiral out of control, fireplace engines are right away followed through hearth trucks wearing ample emergency equipment along with respiration mask, chainsaws, fanatics and robust lighting fixtures. This more precaution is extraordinarily necessary for the reason that an unforeseen situation occurs like a fireplace explosion or that there are humans trapped in the constructing.

The main distinguishing element that separates the truck from the engine is that the former is the actual rig with a massive ladder. that is what gives fireplace vehicles their proper difference. it's far specialized gadget that is referred to as out for shape fires and comparable conditions that require extra manpower and emergency firefighting equipment.

2.2 HISTORY

There is no doubt approximately the fact that fires are as vintage because the complete human civilization which is why groups and societies have continually felt the want to give you organized ways to guard themselves from unpredictable fires as shown in figure (2.2).

Fig (2.2) unpredictable fires

Also, considering how the world itself and populations have improved so swiftly with rural regions and concrete regions becoming so densely-packed the want to give you fire protection strategies at a civic stage had multiplied an excellent deal. This turned into specially glaring during the formation of numerous American colonies when

people found out that something needed to be executed to shield the brand-new settlements from getting destroyed via these fires.

2.3 WATER PUMPS ON WAGON WHEELS

The primary ever fireplace apparatus that came into lifestyles changed into the pumps-on-wheels gadget which basically included a water supply pump that became established on to a wood chassis as shown in figure (2.3). there has been additionally a huge lever connected to this framework whose fundamental purpose became to offer an area to the firefighters to rest their toes.

Fig (2.3) wooden pump

Despite the fact that pumps on their personal had existed when you consider that Roman times, they proved to be slightly tough when used to for the purpose of fireplace extinguishing. that is on the whole due to the fact most of the early types of pumps without A doubt spurted water than spraying it which made it pretty challenging to generate an ok movement of water. This device was called “bucket brigades” returned then and turned into even used to position out fires in Europe.

2.3.1 HORSE-DRAWN PUMPERS

Quickly sufficient, because of the technological improvements publish-business Revolution, the pumps-on-wheels equipment turned into replaced by horse-drawn steam pumper. groups of horses had been used to pull steam vans which will pump water on the hearth scene.

This went on from the 1840s all of the way until the primary international warfare, in particular in the United States of America. There had been big horses that pulled heavy steam-powered hearth vans along with a team of three to four men who had to be gift at the scene in order to operate the pump.

2.3.2 GASOLINE ENGINES

Even as horse-led steam trucks did clear up quite some issues, there have been nevertheless big issues confronted by firefighters in terms of logistics. The large groups of horses needed to be watered, fed and solid which proved to be pretty time-ingesting and costly.

With the appearance of the 19th century, these horse-driven vehicles have been taken over by means of gas engines. From the first world struggle till the 1920s, fuel engines have been used to strength the hearth vehicles. A slow increase in efficiency changed into observed through people as fuel completely outdated using steam. those engines proved to be quicker and more efficient than horse-drawn steam powered vehicles because the water pumps have been an awful lot higher able to create a powerful flow of water.

"Type 3 engine" (pdf). santa barbara county fire.on 31 December 2013

2.3.3 MODERN FIRE TRUCKS

The fireplace vans that you see now within the modern-day present-day age are specifically the end result of ladder vehicles that have been evolved in the first half of the 20 th century. these vans were especially created because American towns were expanding both upwards and outwards hastily and certainly one of their most defining

capabilities at some point of that century changed into the boom of the skyscraper. The civic opponents of America sensed a drawing close need for a firefighting equipment that was durable, effective and ensured remaining safety. The fires were additionally greater commonplace at more heights which strongly called out for a ladder truck.

A pivotal invention that incorporated the ladder technology become the “Hayes Ladder” which turned into very exceptional from the previously used traditional form of ladders. the principle difference became that this one had the ladder installed to the truck with a spring mechanism that allowed firefighters to raise or increase the ladder at tall homes.

This in addition allowed them to rescue humans from higher-degree windows or even enter the building from a selected height.

This precise fire system gained enormous reputation in the course of the USA and the concept of a ladder established to the hearth vans was carried ahead to the 21st century, ensuing inside the much-comparable current-day fire truck.

2.3.4 EXTRAORDINARY STYLES OF HEARTH VANS

Ever for the reason that idea of the use of a hearth truck turned into formulated for hearth protection, it has passed through several adjustments that have resulted in a ramification of different types of fireplace trucks.

some of those are nonetheless used quite typically whilst others have confronted terrific decline in their reputation.

2.3.5 TRADITIONAL HEARTH TRUCK

this is a well-known type of fireplace truck with an engine which has been specially advanced for firefighting operations. It serves the cause of taking the firefighters to the hearth scene as well as wearing essential equipment, hoses and gadget to the scene together with a constrained water supply.

The form of gear carried via the conventional fireplace apparatus significantly on elements just like the size of the automobile and the type of terrain it has to deal with. The latter can range from rugged or difficult terrain to a smoother one.

some of the most fireplace device consists of fireplace extinguishers, ladders, respiration equipment, hydraulic rescue tools, thermal imaging cameras and floodlights. they may even bring greater materials and matters regarding the cleanup or elimination of risky materials from the fireplace scene.

There are also variations inside the traditional styles of fireplace vans in which some even incorporate a hard and fast deluge gun, additionally referred to as a ‘grasp move’. The number one motive of this gun is to release a heavy stream of water while it's far directed to a selected spot. whilst this onboard water movement runs out, the engine is attached to outside and more everlasting sources of water consisting of hearth hydrants or water tenders.

2.4 PUMPER TRUCK

These are one of the most commonly used fire apparatus by most fire departments and are also often called ‘triple combination pumpers’ as shown in figure (2.4). They are similar to wagons and are typically fitted with a hose body, fire pump and a water tank. A pumper is seen at any fire scene where it is basically used to provide firefighters with important tools to help contain the fire and also to save the victims.

Fig (2.4) pumper truck

2.4.1 TURNTABLE LADDER TRUCK

This is a special aerial apparatus that makes use of a massive telescopic ladder so one can advantage get admission to to the ones areas which can be at quite a peak. The specific call of this fireplace truck comes from the truth that there is a turntable gift built-in the back of integrated the truck which mounts a big ladder. The turntable allows the ladder to pivot which makes it easier to spray water built-in-integrated favored path.

Many modern-day turntable ladders built-integrated a water function where-built-integrated some consist of a pre-piped waterway that extends all the way across the ladder while the others have an on-board deliver reservoir. they also regularly perform other features built-in integrated maintaining some of extra tools like an aerial ladder, onboard pump, fireplace hose and a quad.

2.4.2 HEAVY RESCUE VEHICLE

As the name suggests, this type of fire apparatus is specialty equipment that is used for technical rescue operations.

It is sometimes referred to as ‘rescue squad’ which is one of the reasons why you will often see heavy rescue vehicles not only at a fire scene, but also in massive traffic collisions, swift-water rescues and in building collapses.

2.4.3 TILLER TRUCK

A specialised ladder truck, the tiller truck is a firefighting apparatus that has a turntable ladder connected to a semi-trailer truck. it's far like a hybrid version that makes use of both trailer and tractor. interestingly even though, it has two drivers, in conjunction with separate steering wheels for each the the front and rear wheels.

This department between the two offers the tiller truck the exquisite potential to move pretty successfully, that is considered one of its foremost capabilities. This effects in sharper turns, especially in maze-like roads and slim streets. any other super function of th4e tiller truck is its duration that regularly crosses over 50 feet. This creates additional space in the truck for wearing fire-related important tools and system.

A variant of the tiller truck is tiller-quint that's a form of truck that has an added on-board water tank outfitted in the fundamental vehicle.

2.4.4 WILDLAND FIRE ENGINES

The principle purpose or aim at the back of Wildland fire engines is for you to maneuver on tough, difficult terrains, coupled with an excessive clearance for suspension and wheels. these are kinds of hearth vehicles that are used in place of the regular traditional vans to fight fires in difficult hills and mountains.

most of these cars function a 4-wheel force that performs absolutely well in tough terrain areas. in comparison to conventional forms of fire equipment, Wildland hearth engines have the capability to pump water even as using that significantly permits them to run assaults on plant life fires on the way to prevent them from spreading rapidly. flora fires could have a devastating tendency to spread certainly quick that ends up destroying a long way too many flora, crops and timber. that is why Wildland fireplace engines are ideal for firefighting in such areas.

2.4.5 QUINTS

This hearth equipment is one of those misunderstood fireplace truck with a piece of controversy connected to it. Quint consists of out 5 key functions, two of which might be that it incorporates a pump in addition to an aerial device on a single vehicle. It in addition performs different tactical firefighting functions which include presenting grasp movement to hearth fighters including pump and hose, giving them an get admission to to multiplied areas with the help of aerial devices and ground ladder and finally, ensuring a continuous deliver of water through its water tanks and pumps.

2.4.6 A-WAGON

Usually known as a dangerous substance’s equipment, A-Wagon is a special automobile this is used to fight brush fires and grass fires. The specialize call of this fireplace apparatus is because of the reality one upon a time, these motors consisted of separate auxiliary cars that launched water from the pump. This indicates that the motor should allow the car to roll and pump each at quite the equal time.

2.4.7 WATER TENDERS

These are often described as mobile water supply apparatus which can be broadly speaking designed to pick, delivery, and supply water to emergency fireplace scenes. most of these automobiles have pretty a basic and simple layout and that they usually don’t come with a pump due to the fact their foremost feature or purpose is to have a right water supply. Water tenders are not supposed for off-avenue use for the reason that they may be a two-wheel pressure and are generally operated through one or firefighters.

Walter A: First responder handbook: fire service edition

2.4.8 FOREMOST ADDITIVES OF A FIREPLACE TRUCK

when you have a look at a fire truck from afar, all you can simply see is the bright purple colour, improved ladders set up on the principle branch of the car and possibly, water pumps producing in no way-ending sprays of water. but, in case you look intently, or perhaps, ever get an possibility to sit inside a fire truck, you'll comprehend this is seemingly simple and large automobile has a lot more to it.

A hearth truck consists of a few key elements and components, each of that is extraordinarily critical and serves a totally important and a unique feature.

those are a number of the most basic and most important components of a fire struck.

2.4.9 GRIPPED STEPS

each fire truck has a chain of gripped steps that permit firefighters to move around the automobile conveniently and convenience.

2.4.10 FLOOD LIGHTS

these are high-depth synthetic lights that provide an extremely good source of illumination in particular all through the night when there is a fireplace scene in the dark.

REFERENCE BOOKS

As they are saying, authentic studying in no way stops and further in this example, maximum fire vans are equipped with references books on firefighting that firefighters

can take help from or confer with in times of bewilderment or when they need to ensure of something.

VENTILATOR ENTHUSIASTS

as the call suggests, those are used on the fireplace scenes to flow into air and provide adequate air flow. They basically create a motion of the air to disperse fumes from the fireplace.

AERIAL LADDER

that is essential for commercial fires wherein it may reach up to one hundred and five feet. It frequently comes with a grasp circulation hose and the ladder is raised towards the constructing with the assist of a hydraulic piston rod.

HOSES

those are huge bendy hollow tubes that are established on the pinnacle of the hearth vehicles and are able to launch a thousand gallons of water according to minute.

PUMP PANEL

every other important factor, the pump panel helps manipulate or restrain the go with the flow and strain of the water-spraying hoses. The fireplace opponents need years of practice which will be capable of operate the pump penal efficaciously and efficiently.

AIR TANKS

these are usually portable, smooth-to-use devices that can help you save in compressed air that is tons-wished particularly at a hearth scene. Firefighters can also fill these tanks with breathing gases that can offer instantaneous aid to the fireplace sufferers.

RADIO STRUCTURES

unnecessary to say, radio systems are one of the maximum important portions of public safety gadget. these are in-constructed inside the fire truck vehicle and are used to talk with the backend group at the principle fire branch.

CHAPTER 3

METHODOLOGY

3.1 PART DESIGN:

3.1.1 BOGIE

We have drawn 2 squares of width 25mm which are 250mm distance apart from each other as shown in figure (3.1.1).

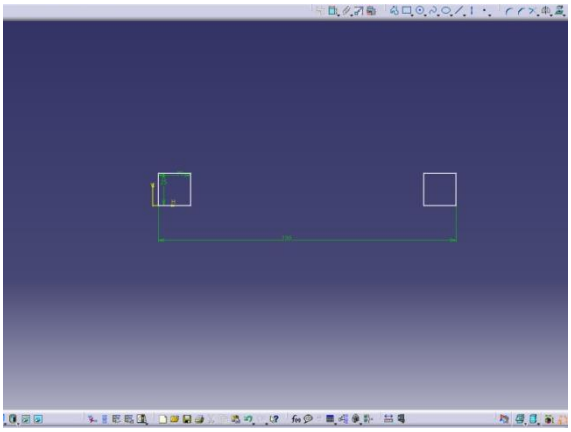

Fig (3.1.1) square sketch

We have used pad command to generate 3D of the sketch for length 350mm with thickness 2mm as shown in figure (3.1.2).

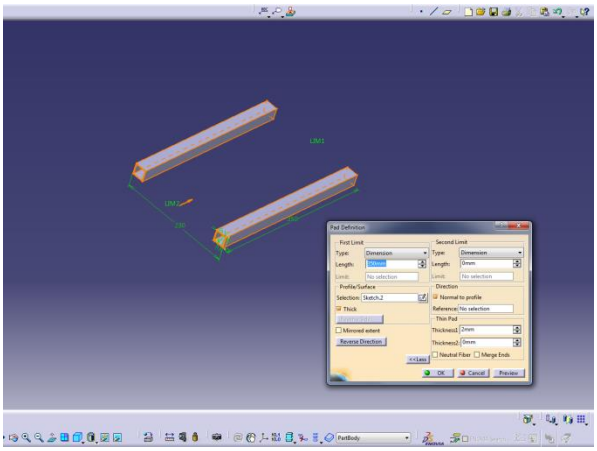

Fig (3.1.2) pad of square sketch

We have drawn 3 squares at both the ends of one pipe which are of with 25mm as shown in figure (3.1.3).

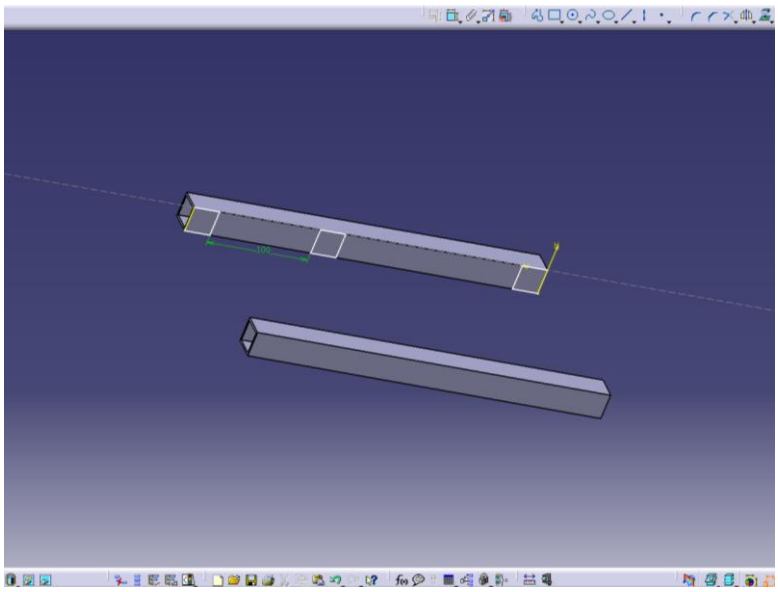

Fig (3.1.3) square sketch

We have used pad command to generate 3D of the given sketch for length 180mm as shown in figure (3.1.4).

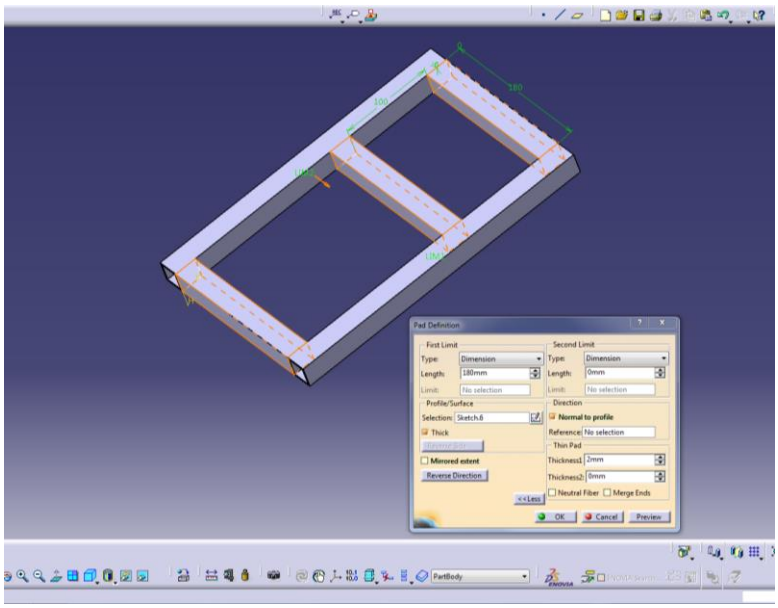

Fig (3.1.4) pad command

We have drawn a profile of width 25mm, length 273mm and another length 248mm as shown in figure (3.1.5).

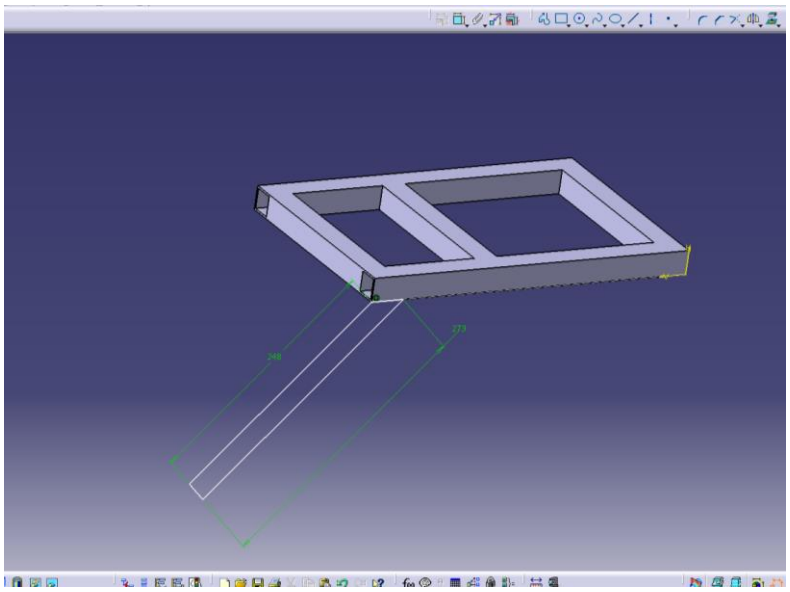

Fig (3.1.5) profile sketch

We have used pad command for generation of square pipe for length 25mm as shown in figure (3.1.6).

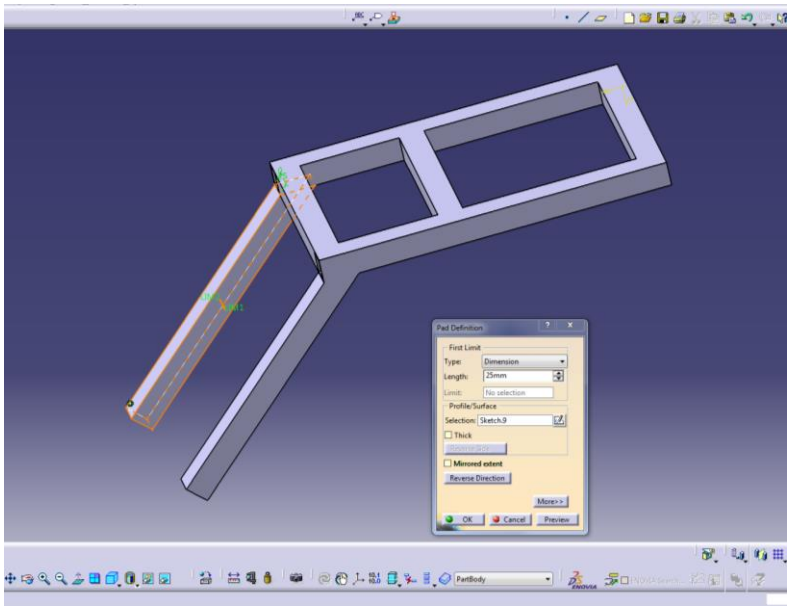

Fig (3.1.6) pad command on profile

We have drawn a rectangle of width 140mm and breadth 120mm using rectangle as shown in figure (3.1.7).

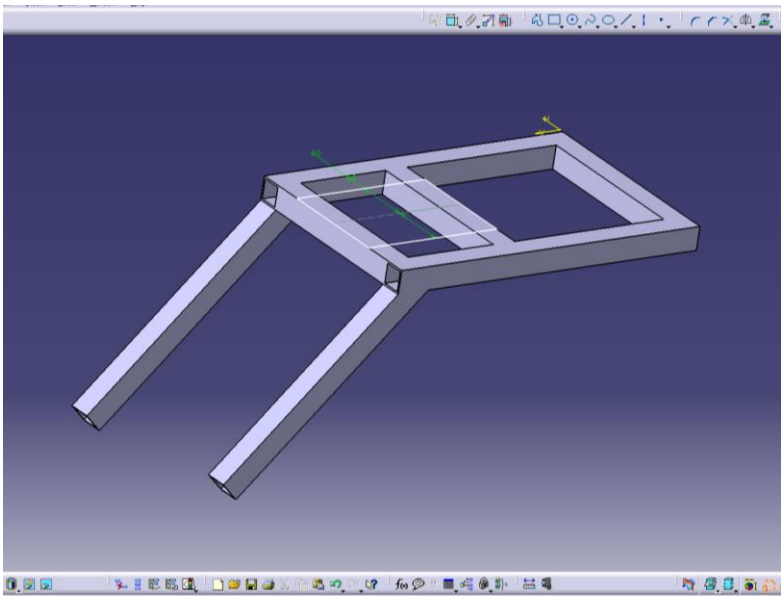

Fig (3.1.7) rectangle sketch

We have generated rotation mechanism base support plate for length 2mm as shown in figure (3.1.8).

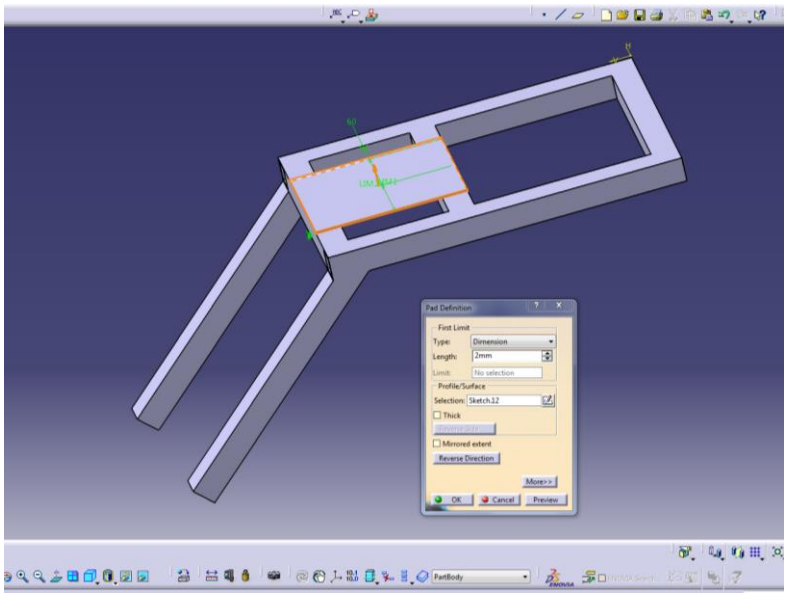

Fig (3.1.8) base plate

We have generated gear and rotation onto the base plate for length 20mm as shown in figure (3.1.9).

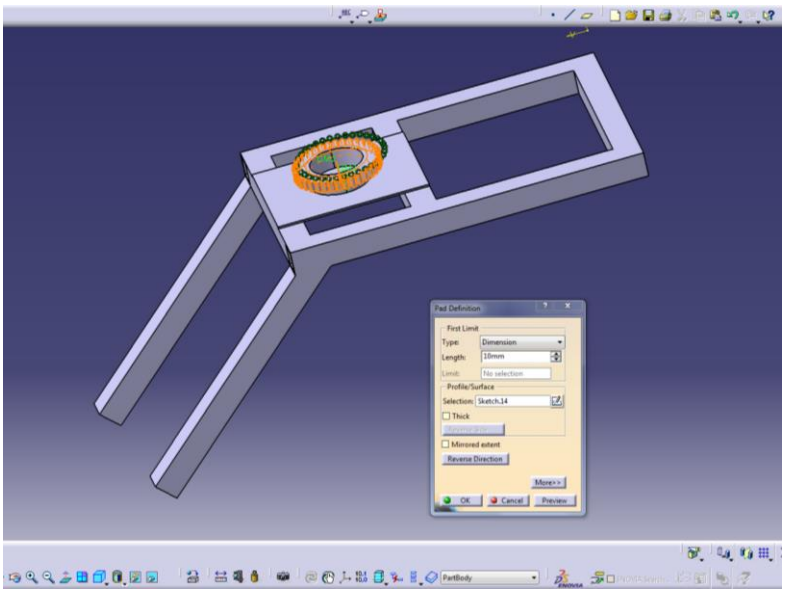

Fig (3.1.9) gear and rotation mechanism

We have generated motor support plates using pad command for length 2mm as shown in figure (3.1.10).

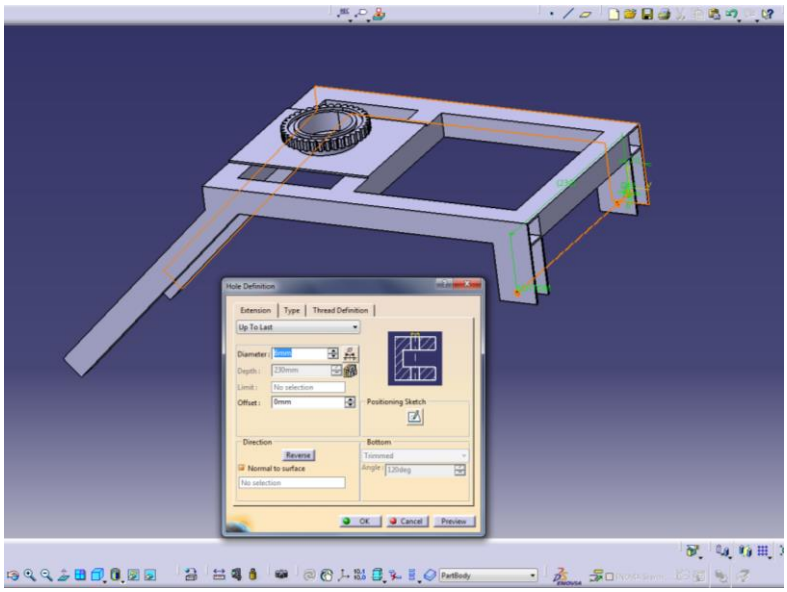

Fig (3.1.10) pad on motor support plate

We have generated motor support plates using pad command for length 2mm as shown in figure (3.1.11).

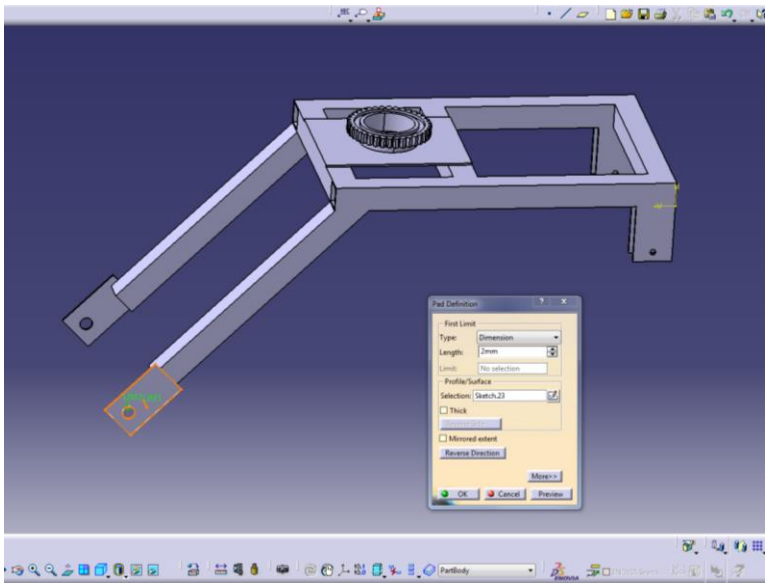

Fig (3.1.11) pad on motor support plate

3.1.2 ROCKER

We have drawn a square sketch of width 20mm using rectangle command as shown in figure (3.1.12).

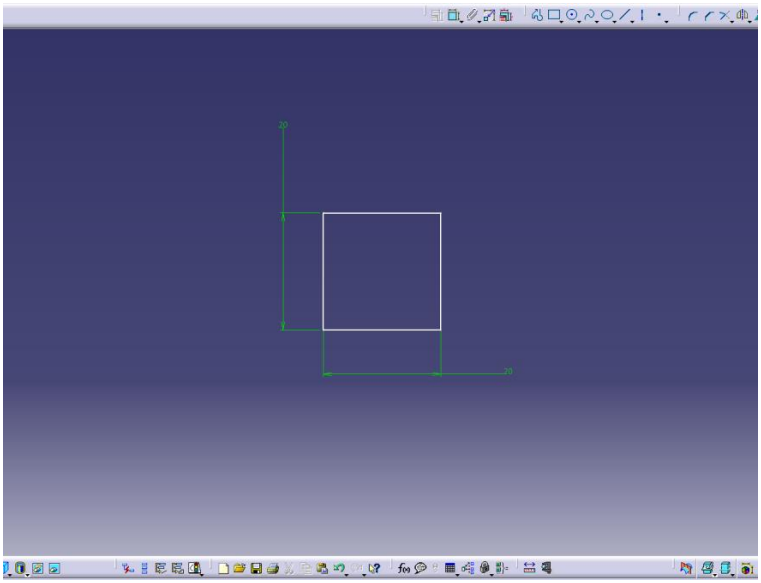

Fig (3.1.12) 20mm square sketch

We have given pad command to the sketch to develop a square pipe of length 200mm as shown in figure (3.1.13).

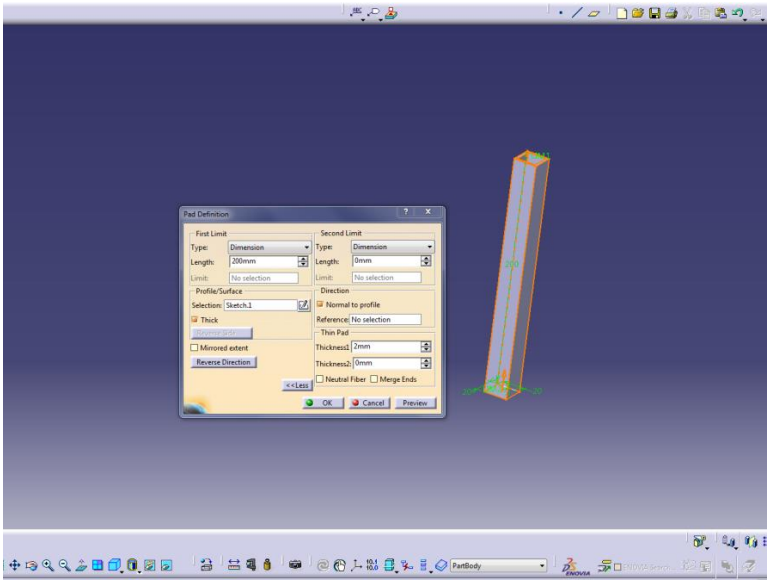

Fig (3.1.13) pad for length 200mm

We have drawn circle of diameter 6mm at distance 10mm from one edge as shown in figure (3.1.14).

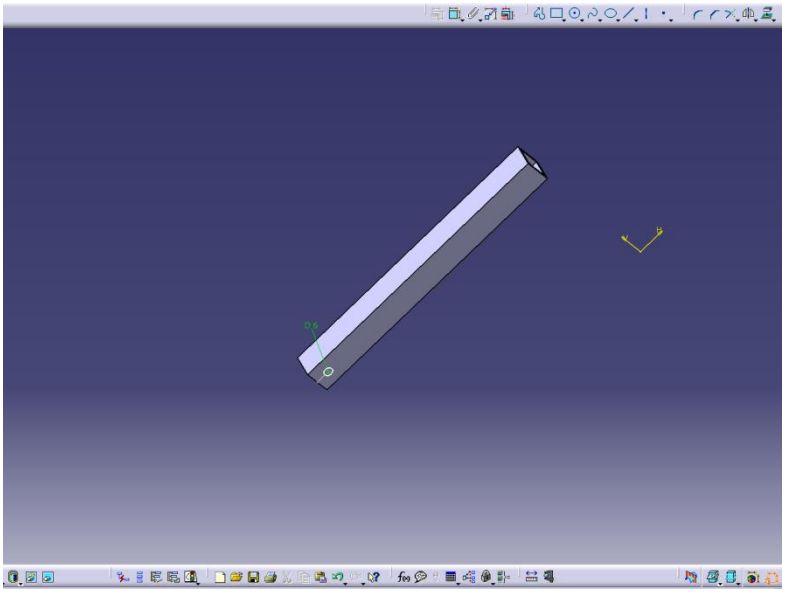

Fig (3.1.14) circle sketch

We have used pocket command to make a hole of 6mm on the pipe as shown in figure (3.1.15).

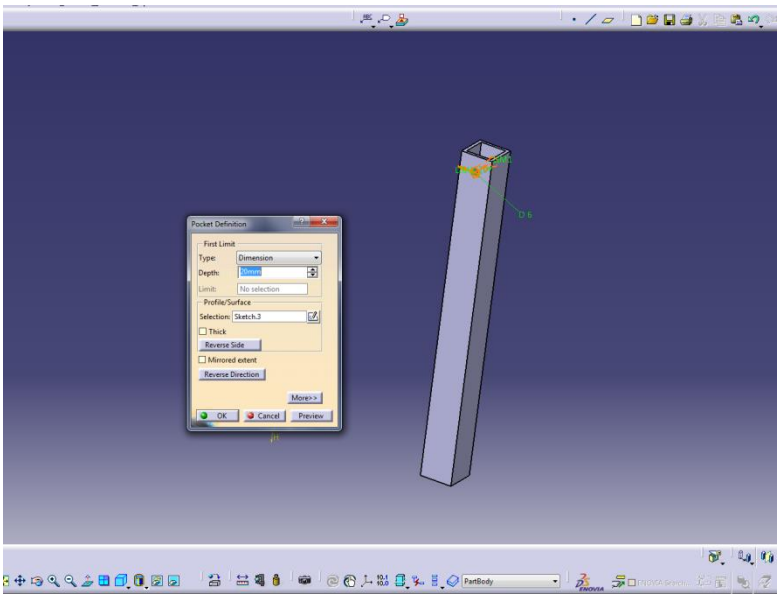

Fig (3.1.15) hole on pipe

We have developed another 20m square pipe perpendicular to the given pipe as shown in figure (3.1.16).

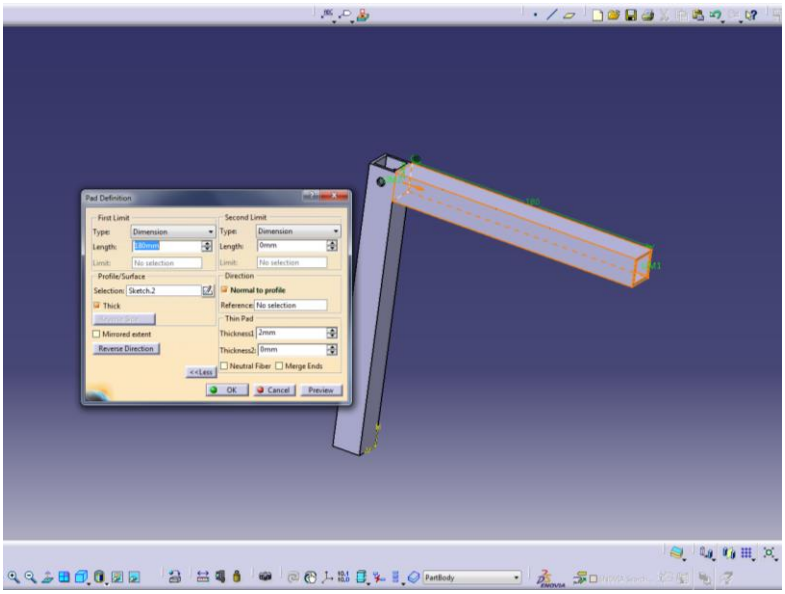

Fig (3.1.16) square pipe generation

We have developed motor support plates on the ends of rocker as shown in figure (3.1.17).

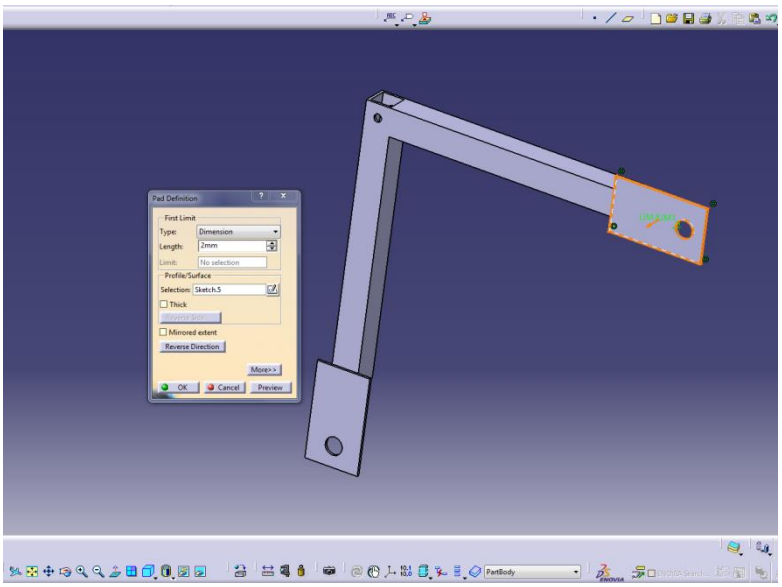

Fig (3.1.17) motor support plate

3.1.3 ROTATION MECHANISM

We have developed rotation mechanism by using various commands as shown in figure (3.1.18).

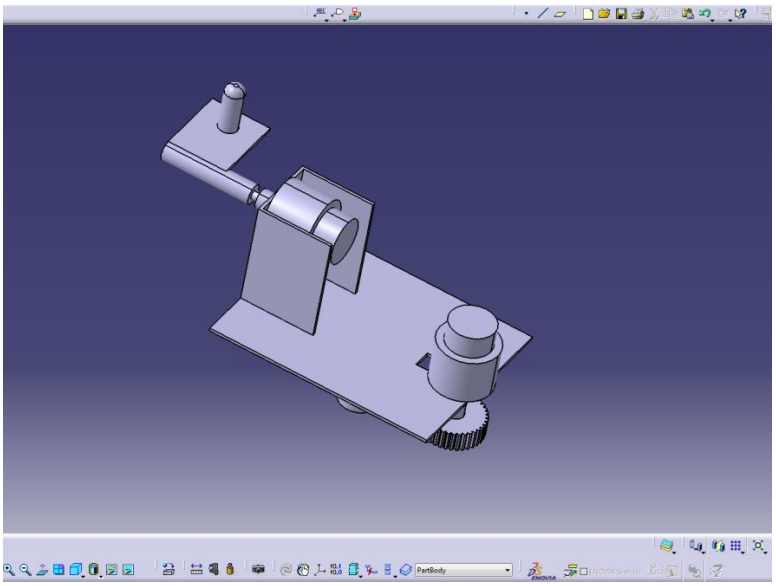

Fig (3.1.18) rotation mechanism

We have developed the wheel of diameter 70mm and 40mm with shaft diameter 6mm as shown in figure (3.1.19).

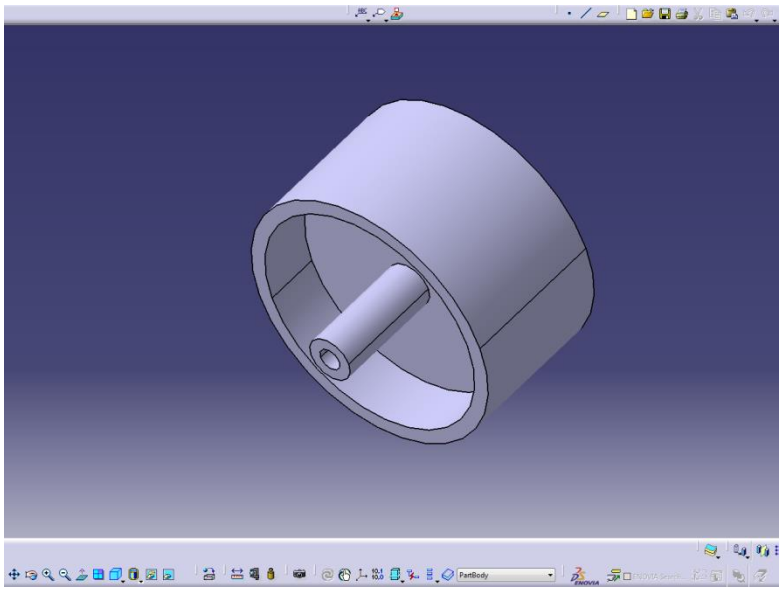

Fig (3.1.19) wheel

3.2 ASSEMBLY DESIGN

We have assembled all the parts together using various methods as shown in figure (3.2.1).

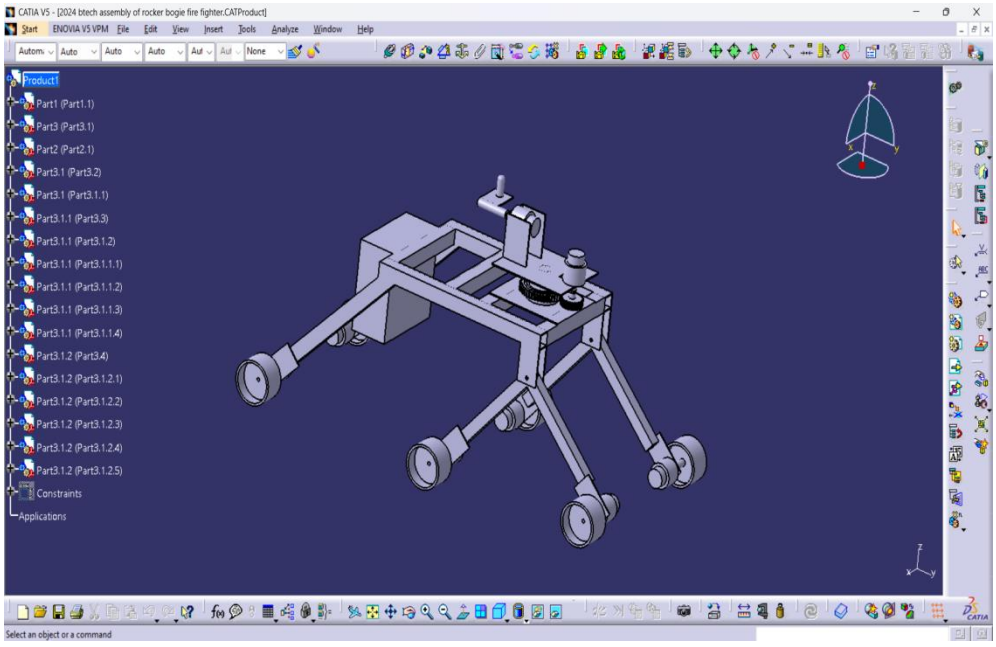

Fig (3.2.1) Assembled design.

3.3 Analysis using CATIA V5

Applied Load 50N.

Max Von-mises stress 2.4 x 10^5N-m2

Yield strength of MS (Mild steel) 210 to 240 x 10^6N-m2

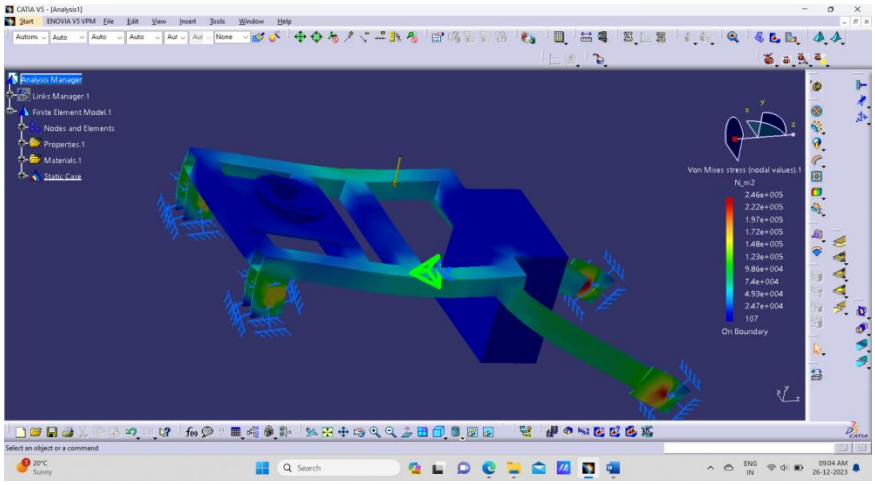

Fig (3.2.2) Von-mises stress diagram

Max transitional displacement upon application of 50N is 0.000325mm which is negligible.

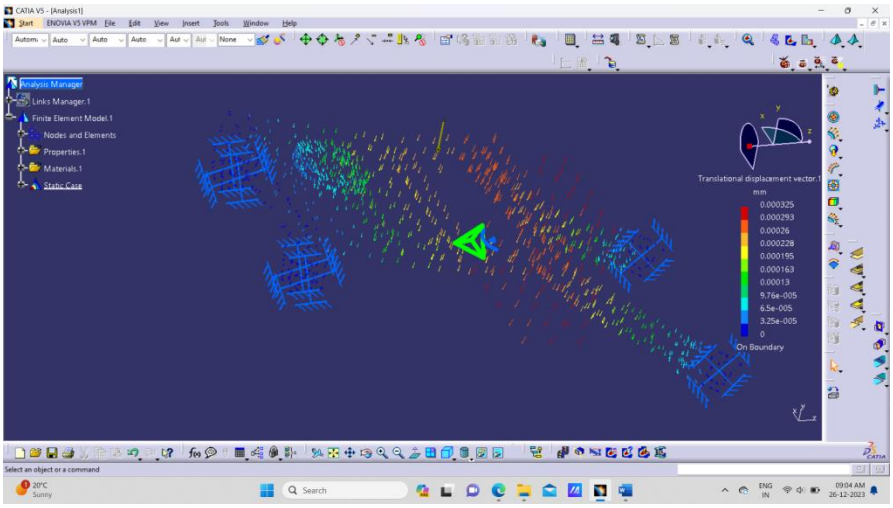

Fig (3.2.3) Transitional Displacement Di

CHAPTER 4

FABRICATION AND WORKING

4.1 PARTS PREPARATION

We have taken a mild steel (MS) plate of thickness 2mm long as shown in figure 4.1.1.

Fig 4.1.1 MS plate.

We have marked the plate at a distance 60 x 55 x 60 mm from its edge using measuring and marking tools as shown in figure 4.1.2.

Fig 4.1.2 Marking on MS Plate.

We have performed a cutting operation using an angle grinder with respect to the markings as shown in figure 4.1.3.

Fig 4.1.3 Cutting operation on plates.

We grinded the plate using an angle grinder to remove cutting chips and better surface finish.

Fig 4.1.4 Grinding operation on plates.

We have obtained plate of width 175 mm thickness 2 mm as shown in figure 4.1.5 by following above mentioned process.

Fig 4.1.5 Motor case plate

We have marked the plate at a distance 55 mm from its edge using measuring and marking tools as shown in figure 4.1.6.

Fig 4.1.6 Marking on MS Plate.

We have marked the plate at a distance 60 mm from its edge and 55 mm from previous point using measuring and marking tools as shown in figure 4.1.7.

Fig 4.1.7 Marking on MS Plate

We have performed drilling operation on the MS plate with the help of using radial arm drilling machine with 6 mm drill bit and gradually increased drill sizes to form 13 mm diameter hole as shown in figure 4.1.8.

Fig 4.1.8 Drilling of MS Plate

We are slightly cutting marked plate for bending into C- shape and grinding the drill surface part as shown in figure 4.1.9.

Figure 4.1.9 Cutting notch on plates.

We have obtained Motor case by cutting and bending at specified dimensions and it is checked by Tri square measuring tool as shown in figure 4.1.10.

Figure 4.1.10 Motor case measured with tri square.

4.2 ROTATING PLATES

We have taken a mild steel (MS) plate of width 150 mm and thickness 2mm as shown in figure 4.2.1.

Figure 4.2.1 MS plate.

We have marked the plate at a distance 150 mm from its edge using measuring and marking tools as shown in figure 4.2.2.

Figure 4.2.2 Marking on MS Plate.

We have performed a cutting operation using an angle grinder with respect to the markings as shown in figure 4.2.3.

Fig 4.2.3 Cutting operation on plates.

We grinded the plate using an angle grinder to remove cutting chips and better surface finish as shown in figure 4.2.4.

Fig 4.2.4 Grinding operation on plates.

We have marked the plate at a distance 55 mm from its edge using measuring and marking tools as shown in figure 4.2.6.

Fig 4.2.5 Marking on MS Plate.

We have performed a cutting operation using an angle grinder with respect to the markings as shown in figure 4.2.6.

Fig 4.2.6 Cutting operation on plates.

We have marked a rectangular slot of 13 x 40 mm(s) from one side plate and cutting to obtain the rectangular slot and for another plate we have marked centre and made a square hole of dimensions 25 x 25 mm(s) and cut the square part.

Fig 4.2.7 Marking and cutting operation on two plates.

We have taken a hollow pipe for rotating operation and a sleeve of 20 mm long ,50 mm internal diameter of 3mm thickness and Deep groove bearing of inner diameter 25 mm and outer diameter 52 mm as shown in figure 4.2.8.

Fig 4.2.8 Hollow pipe, Sleeve, Deep groove bearing.

We are Chamfering the hollow pipe using Angle grinder at an angle to attain the requirements of chamfer.

Fig 4.2.9 Chamfering the Hollow pipe.

We have performed welding operation of sleeve over square plate, and hollow pipe over another square plate as shown in figure 4.2.10.

Fig 4.2.10 Welding Operation on square plates.

We have performed grinding using angle grinder and the finished product is as shown in figure 4.2.11.

Fig 4.2.11 Welding operation on square plates.

We have taken a steel pipe of thickness 6.2 mm long as shown in figure 4.1.12.

Figure 4.2.12 Steel pipe.

We have marked the pipe at a distance 55 mm from its edge and 10 mm from the same edge for a hole of 3mm diameter using measuring and marking tools as shown in figure 4.2.13.

Figure 4.2.13 Marking on Steel pipe.

We have performed a cutting operation using an angle grinder with respect to the markings as shown in figure 4.2.14.

Figure 4.2.14 Cutting operation of the pipe.

We have taken a plate and marked the plate as 40 x 55 mm(s) from one side plate and making a drilling operation of 13 mm diameter from a distance 10 mm from on edge of plate as shown in figure 4.2.15.

Figure 4.2.15 MS Plate.

We have performed welding operation by joining steel pipe and plate by arc welding as shown in figure 4.2.16.

Figure 4.2.16 Welding operation.

We have taken plastic spur gear 75 and 25 teeth's i.e., in 1:3 and M-Seal and attached to the sleeve for rotation mechanism as shown in figure 4.2.17.

Figure 4.2.17 Plastic spur gear with sleeve of deep groove bearing.

4.3 CHASSIS FABRICATION

We have taken a square pipe of thickness 25 mm long as shown in figure 4.3.1.

Figure 4.3.1 Square pipe.

We have marked on the square pipe of distance 200 mm from its edge using measuring and marking tools as shown in figure 4.3.2.

Figure 4.3.2 Marking on square pipe.

We have performed a cutting operation using an angle grinder with respect to the markings as shown in figure 4.3.3.

Figure 4.3.3 Cutting operation on pipe.

We grinded the pipe using an angle grinder to remove cutting chips and better surface finish as shown in figure 4.3.4, and we obtain four square pipes by cutting the pipe by following above mentioned process.

Figure 4.3.4 Grinding operation on plates.

We have performed drilling operation on the square pipe with the help of using radial arm drilling machine with 6.2 mm drill bit as shown in figure 4.1.8 for two square pipes.

Figure 4.3.5 Drilling of square pipe.

We have performed welding operation of square pipe at an angle of 45 degrees using tri square as shown in figure 4.2.6.

Figure 4.2.6 Welding operation on square pipes.

We grinded the plate using an angle grinder to remove cutting chips and better surface finish as shown in figure 4.2.7.

Figure 4.3.7 Grinding operation on pipes.

We have taken a mild steel (MS) plate of width 100 mm and thickness 2mm as shown in figure 4.3.8.

Fig 4.3.8 MS plate.

We have marked the plate at a distance 55 mm from its edge and 6mm drill bit from 10 mm from the same edge using measuring and marking tools and We have performed a cutting operation using an angle grinder and radial arm drilling machine with 6 mm drill bit with respect to the markings and obtain the the four plates as shown in figure 4.3.9.

Figure 4.3.9 cutting and drilling operation

We have taken a square pipe of thickness 2mm long as shown in figure 4.3.10.

Figure 4.3.10 Square pipe.

We have marked the square pipe at a distance 180 mm from its edge of 3 units, 350 mm of 2 units and 238mm of 2 units using measuring and marking tools as shown in figure 4.3.11.

Figure 4.3.11 Marking on square pipe.

We have performed a cutting operation using an angle grinder and required square pipes are obtained with respect to the markings as shown in figure 4.3.12.

Figure 4.3.12 Cutting operation on square pipes.

We have performed welding operation on joining square pipes to form chassis and joining with the square plate as shown in figure 4.3.13.

Figure 4.3.13 Chassis welding.

We have taken a mild steel (MS) plate of width 40 mm, thickness 2mm and respective drilling operation of 13mm diameter drill bit shown in figure 4.3.14.

Figure 4.3.14 Drilling operation on MS plate.

We have marked the plate at a distance 70 mm from its edge using measuring and marking tools and we have performed a cutting operation using an angle grinder with respect to the markings and obtaining six pieces of plates as shown in figure 4.3.15.

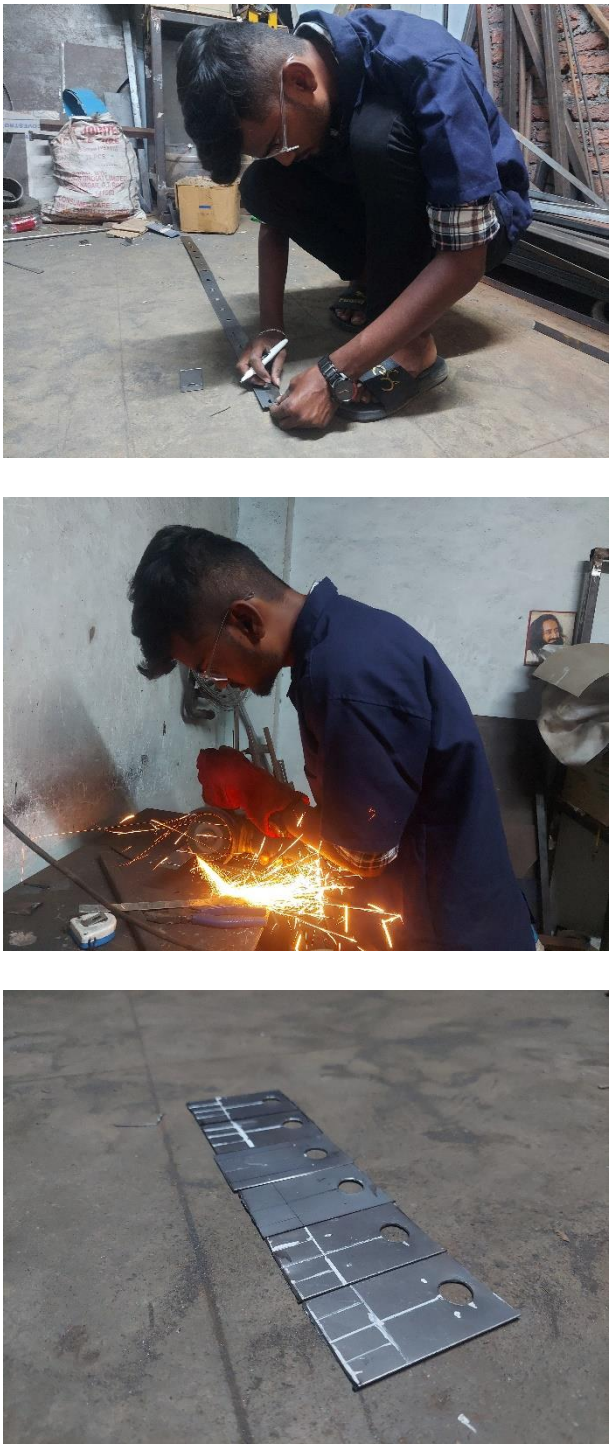

Figure 4.3.15 Marking on MS Plate and Cutting operation on plates.

We have performed welding operation of the six pieces to the vehicle as shown in figure 4.3.16.

Figure 4.3.16 Welding Operation of plates to square pipe.

We have marked the MS plate of thickness 5 mm at a distance 7.5 mm from its edge and by drilling operation on MS plate with the help of using radial arm drilling machine with 3 mm drill bit a hole is made from 3 mm from its edge as shown in figure 4.3.17.

Figure 4.3.17 Marking and drilling operation.

We have performed a cutting operation using an angle grinder by obtaining 2 plates with respect to the markings as shown in figure 4.3.18.

Figure 4.3.18 Cutting operation on plates.

We have obtained the plates, and the tank of 1½ litre capacity is fixed to it by screw and nut and welding operation is performed as shown in figure 4.3.19.

Figure 4.3.19 Tank.

4.4 WIRING, MOTORS, AND WHEEL ASSEMBLY

We have taken remote with respective switches and wiring of 5 meters long as shown in figure 4.4.1.

Figure 4.4.1 Remote, switches and wires.

We have joined wiring as per vehicle requirements of movement and spraying of water switch as shown in figure 4.4.2.

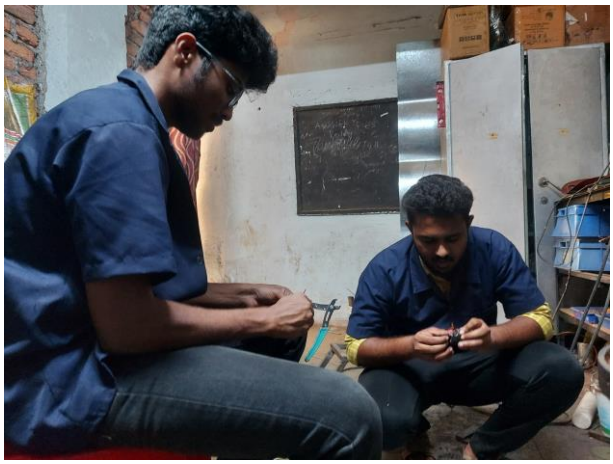

Figure 4.4.2 Wiring of switches.

We have performed wiring to the remote controller as shown in figure 4.4.3.

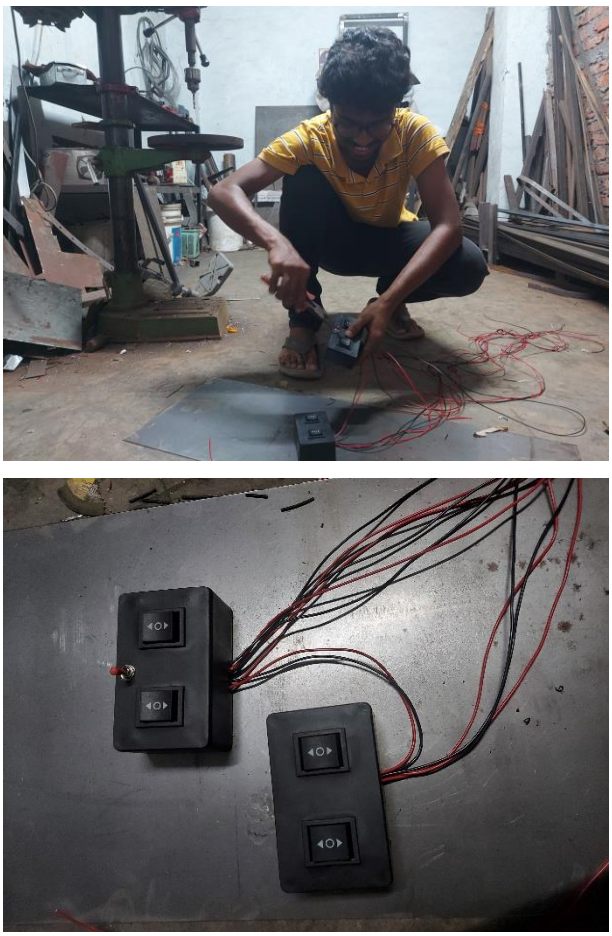

Figure 4.4.3 Wiring to the remote controller.

We have taken a positive displacement diaphragm pump of 12 volts and pipe of thickness 3mm as shown in figure 4.4.4.

Figure 4.4.4 Diaphragm pump with pipe.

We have taken six drive wheels of 3.0 rpm, and another two for rotation and tilting of 3.5 rpm with wheels of 70 mm diameter and joining them as shown in figure 4.4.5.

Figure 4.4.5 Motors, wheels, assembly of wheels.

We have taken a brass nozzle and performed drilling operation of drill 1.5 mm and arranging the wire in proper order by taping as shown in figure 4.4.6.

Figure 4.4.6 Nozzle drill, taping.

4.5 PROTOTYPE OF MULTI-TERRAIN FIRE FIGHTER VEHICLE

We have obtained the prototype of wired-remote for better assistance of vehicle as shown in figure 4.5.1.

Figure 4.5.1 Prototype of Multi-Terrain Fire Fighter Vehicle.

CHAPTER 5

RESULTS AND DISCUSSIONS

5. RESULTS AND DISCUSSIONS

Nozzle Tilting Power Calculation:

Mass of Nozzle Tilting arrangement(m_n)	=	0.75Kg
Radius of nozzle rotation(m)	=	25/1000
Force on shaft (F_n)	=	m x g
	=	0.75 x 9.81
	=	7.3575 N
Motor Speed of nozzle tilting (N_n)	=	3.5 rpm
Torque T	=	F x r
	=	7.3575 x 0.025
	=	0.1839N-m
Nozzle Tilting Motor Power P_n	=	2 x 3.14 x N x T/60
	=	2 x 3.14 x 3.5 x 0.1839/60
	=	0.068 Watts

The total power required for the nozzle tilting mechanism is 0.068 watts.

Nozzle Rotation Power Calculation

Mass of Rotating arrangement	=	1.5Kg
Radius of rotation(r)	=	150/1000
	=	0.15 mm
Force F	=	m x g
	=	1.5 x 9.81
	=	14.715N
Motor Speed	=	3.5 rpm
Gear Ratio (G)	=	1:3
Torque T	=	F x r
	=	14.715 x 0.15
	=	2.20725N-m
Speed of Rotating Plate (N)	=	3.5 x 1/3
	=	1.166 rpm
Power P_r	=	2 x 3.14 x N x T/60
	=	2 x 3.14 x 3.5 x 2.20725/60
	=	0.8086 Watts

The total power required for the nozzle rotating mechanism is 0.8086 watts.

Pumping Power Calculation:

Flow Rate (Q)	=	1LPM
	=	1 x 60 /1000
	=	0.06 m^3 /hr
Density of water (ρ)	=	1000 kg/ m^3
Head of the pump (h)	=	1bar
		10 meters
Acceleration due to gravity (g)	=	9.81 m/s2
Power (P_p)	=	Q x ρ x g x h /3.6 x 1000
	=	0.06 x 1000 x 9.81 x 10 / 3.6 x1000
	=	1.635 Watts
Total power consumption = P_n+ P_r+ P_p	=	0.068 + 0.8086 + 1.635
	=	2.511 Watts
Range of spraying water	=	10 meters.

The total power required for the pumping operation is 1.635 watts.

The total power required for tilting, rotating, pumping is 2.511 watts.

That means after charging the battery for ½ hour we can use the vehicle for (30min /1.635 Watts) = 20 minutes, which is sufficient for the vehicle to spray water at the fire.

CHAPTER 6

6. CONCLUSION

Through direct contact with firefighters, it was possible to acquire knowledge about which would be the most relevant vehicle to fight forest fires. The selection was unanimous, and the target vehicle of study was the Forest Fire Fighting Vehicle (FFFV).

In order to study the general mechanical condition of the FFFVs, it was necessary to begin by deepening the knowledge about them, investigating their main equipment and the procedures used to maintain them in proper operating condition. It was quickly perceived that, although vehicles from different manufacturers and with different ages were being analysed, most of the main equipment was similar and the inspections and maintenance carried out on each vehicle were the same within the same fire brigade (FB).

Additionally, when contacting different FBs, it was found that there are no standardised inspection and maintenance programmes, leaving it up to each fleet manager to execute his own plan. This way, some of the tasks that should be performed to maintain the vehicle's competence end up being neglected (or performed in excessively long-time intervals).

Research was then carried out on which failures could occur in the components of the different systems of these vehicles, what their potential causes were and what treatment action should be taken. Through the collaboration of firefighters from the different FBs, a degree of severity, probability of occurrence and detectability was assigned to each fault, thus forming a Failure Modes, Effects and Criticality Analysis (FMECA).

Next, it was essential to perform a new analysis with the same data, but this time using fuzzy logic since the data used was mostly linguistic, where information could be imprecise, vague, uncertain or incomplete.

Through the analyses carried out, it was found that many of the potential failures represent a risk, not only for the functioning of the FFFV, but also for the safety of its operators (firefighters). For these faults and for those that have a low detectability, which means that specialised personnel are needed to identify them, preventive

maintenance should be carried out. On the opposite hand, when the severity of the fault is low and detectability is high, corrective maintenance can be executed.

Along this study, the importance of carrying out inspections, maintenance programmes and recording the interventions carried out was proven.

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