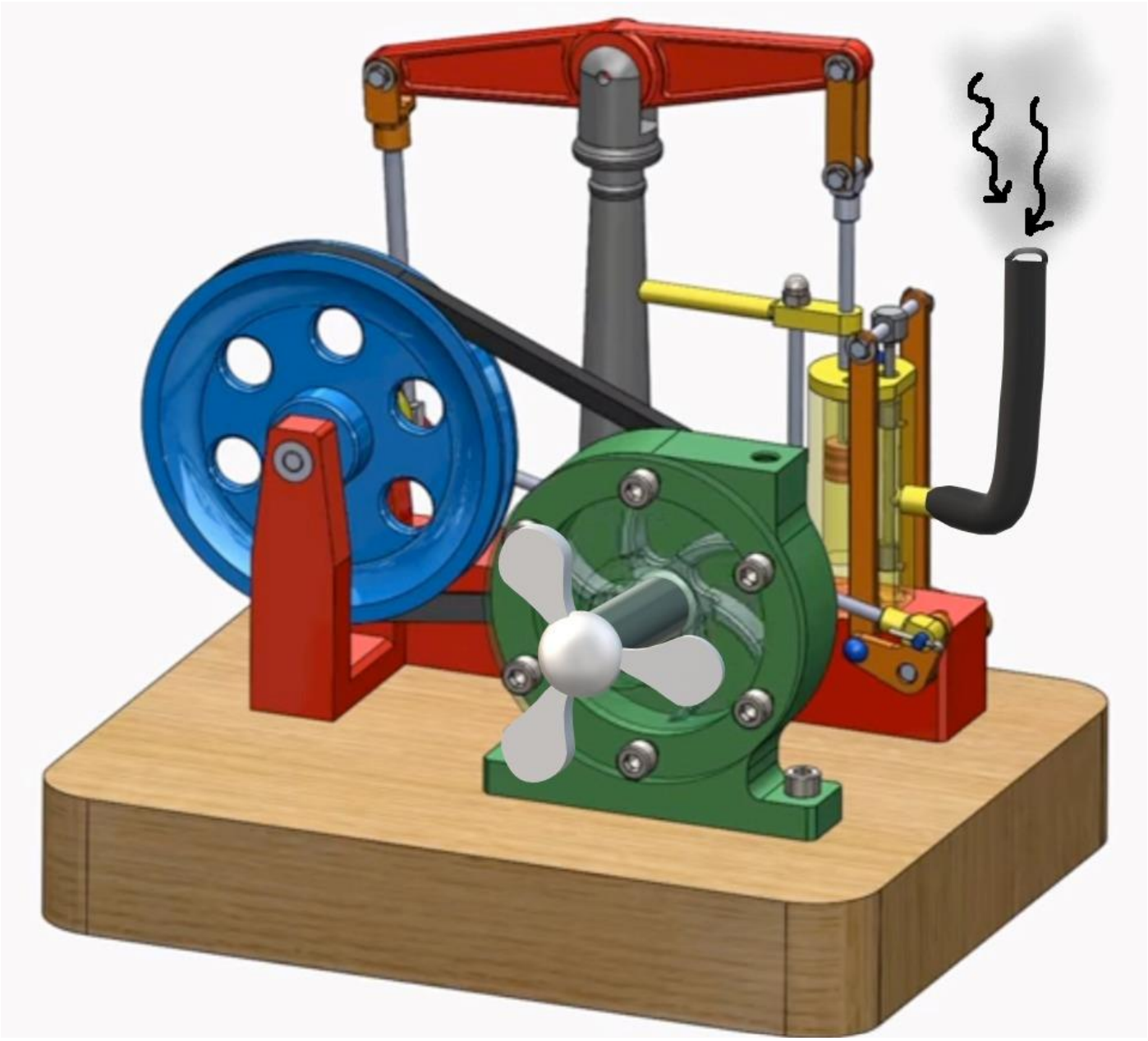
ES101

COOK'S STEAM ENGINE

PROJECT PROPOSAL



PREPARED BY GROUP 3

GROUP 3

SUBMISSION DATE: 14TH SEPTEMBER 2023

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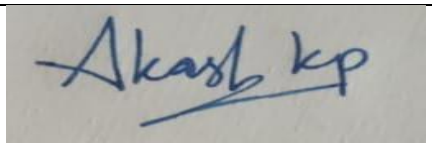
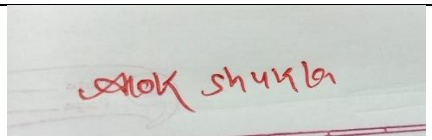
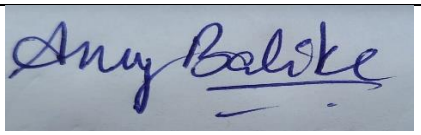
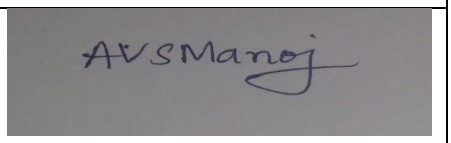
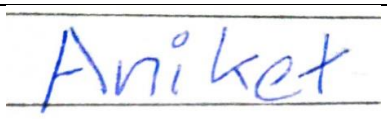
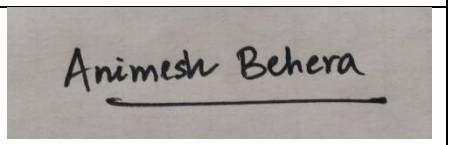
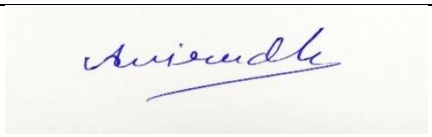
1	Akash KP(23110021)	
2	Alok Shukla(23110022)	
3	Ananya Balike(23110024)	
4	Manoj A.V.S. (23110025)	
5	Aniket Mishra(23110026)	
6	Animesh Behera(23110027)	
7	Anirudh Dagar(23110028)	
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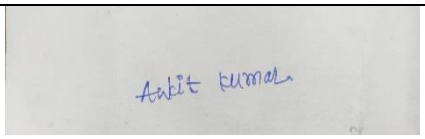
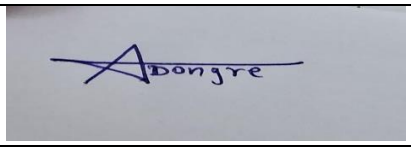
9	Ankit Kumar(23110030)	
10	Antariksh Dongre(23110031)	

Group Introduction and Motivation

Today's world, advances are made daily in fields like artificial intelligence, robotics, and semiconductor technologies. With Chat-GPT, Roombas, and high-power computers becoming household names, people have started calling this the "Age of Automation." But as we fling ourselves into unseen lands of innovation and exploration, we must remember the ideas and inventions that led us here, if for no other reason, to learn from and be inspired by the initiatives made to render them practical. In the spirit of Sir Isaac Newton's all-too-famous quote, "If I have seen further, it is by standing on the shoulders of giants."

Let's take this moment to step back and look at the history of automation. All the comforts we have access to today and the breakthroughs we make every second can be traced back primarily to one particular period of our presence on this earth: The Industrial Revolution. It marked a transformation from agrarian and handicraft manufacturing to more efficient and stable industry and machine manufacturing, enabling mass production of textiles and revolutionizing mediums of transport.

But importantly, this process was only possible because of the decisive role played by the coal-powered steam engine. First invented by Thomas Savery in 1698 and finally perfected by James Watt in 1763, it found widespread use in industry. Its introduction massively improved productivity and technology, paving the way for better and smaller engines.

Thus, our group has chosen to model the steam engine out of admiration for its historical significance. While it is true that we have come a long way since then, with Chandrayaan 3 recently making a successful soft landing on the moon, the steam engine has left its permanent mark on the time, and the process of its invention and its spread across the globe is essential to study. The same drive that motivated the inventors of the 18th century must encourage us in our journeys as engineers today, and without meticulously understanding the process of the development of the mechanism of the steam engine, we cannot completely understand the thought process behind the groundbreaking innovations they made.

We also hope that as we model the components of the steam engine, we also gain an intuitive understanding of some of the more fundamental principles behind engineering. Parts like the piston, the valve, and the centrifugal pump are more widely used in engineering projects everywhere, and understanding how these simpler parts come together to form the complex machine that is the steam engine also helps us gain insight into and strengthen our problem-solving capabilities. While we may be assigned different departments, engineering is ultimately an interdisciplinary field because of its broad applicability, making it necessary to focus on essential skills like this as we prepare for our careers ahead of us.

Putting it simply, a steam engine needs four things to function-

- Fuel - To generate heat to turn water into steam
- Water - To be turned into steam whose pressure is used to operate the steam engine
- A piston - To use the pressure from the steam and turn it into motion that is used to run the steam engine
- Connection to a machine - A mechanism to convert the back-and-forth motion of the piston in the cylinder to valuable work

In our model, we want to try to showcase the functioning of the piston and the intricacy with which its oscillatory motion is converted to rotational motion via a beam mechanism in such a manner that the engine can use its force to exhaust the steam and thus continuously transmit power to the machine. This phenomenon is achieved via the cylinder, the piston, the valve, the crankshaft, the eccentric sheave, and the centrifugal pump.

Steam taken in via an inlet in the cylinder pushes the piston back. The rod connected to it causes the beam to swing to one side, rotating the crankshaft. The crankshaft then causes the rotation of two components: the eccentric sheave and the centrifugal pump pulley. The centrifugal pump pulley provides output from the engine as it rotates the centrifugal pump via a belt. Meanwhile, the eccentric sheave converts its rotational motion to the linear movement of the valve, which is made to move upwards, thus letting out the steam inside the piston's chamber. The piston falls due to removing the steam's pressure, causing the beam to swing back to the other side, completing one oscillation. Due to the beam's motion, the crankshaft, eccentric sheave, and centrifugal pump pulley complete one full revolution. With everything back to its initial state, the process keeps repeating several times, thus continuously transmitting power to the machine.

Today, the coal-powered steam engine has become redundant. Commercial steam locomotives have been entirely decommissioned worldwide and replaced by superior diesel and electric locomotives. Ships of today use reciprocating diesel engines to power their propulsion. The world is interconnected through the internet and social media rather than mail lines and post trains. Yet, the efforts made by the scientists, engineers, and inventors of the 18th century have embedded themselves into the sands of time. Because even today, when the atom is split inside a nuclear reactor, raising temperatures to 540°C, its turbines only move because the reactor's water turns into steam.

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PART NAME-ENGINE BASE AND ENGINE BLOCK

AKASH K P- 23110021

INTRODUCTION :

A steam engine is based on zeroth, the first and second laws of thermodynamics, which converts 'high pressure' steam into mechanical work. It uses force exerted by vapor, oscillating the piston inside a cylinder. This force is transformed into work by adding other parts, like connecting rods, cranks, etc. I have been assigned two parts: -

1)Engine base and Engine block

2)Connecting rod link and inlet

The engine's base, which supports each component, is often built of wood. The engine block consists of pistons, cylinders, and other internal engine components arranged in the engine block. The bottom of an engine is called the engine block.

WORKING

Engine Base:

- The base provides stability to the steam engines and prevents unwanted movement, which ensures the least possible error during any experiments.
- It absorbs vibrations caused during the experiments.
- It helps in distributing the weights equally throughout the base.
- It protects the engine from any damage caused by friction or rust.

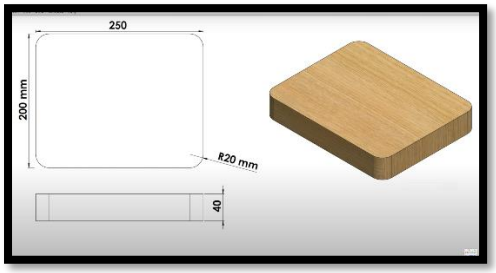
Engine Block:

- The engine block is a vital structure that contains holes that connect with the column, bearing support, cylinder, piston support rod, valve linkage rocker, and valve dual linkage rocker with the help of rods, nuts, screws, etc.

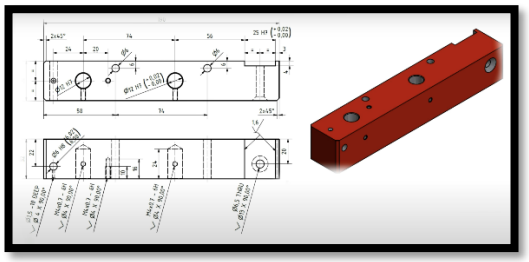
STRUCTURE

ENGINE BASE:

It is made up of wood, cuboidal in shape, and round at the corners.



Engine base



Engine block

ENGINE BLOCK:

It is generally made up of cast iron or aluminum alloy with many holes of different dimensions and cuboidal in shape with chamfers at three corners.

CHALLENGES CAN BE FACED

For Engine base:

Dimension is to be taken care of; otherwise, this part is straightforward and relatively easy to make.

For Engine block:

It is much of a challenge to make the engine block precisely as there are many vertical and horizontal holes, functions like chamfer and thread are also used, and the dimension of everything is tricky.

PART NAME- CONNECTING ROD LINK AND INLET

WORKING

CONNECTING ROD LINK:

The connecting rod link links the connecting rod head and crankshaft (assembly of crankshaft rod + rocker + nut + bolt), and it helps rotate the pump pulley in sync with the beam.

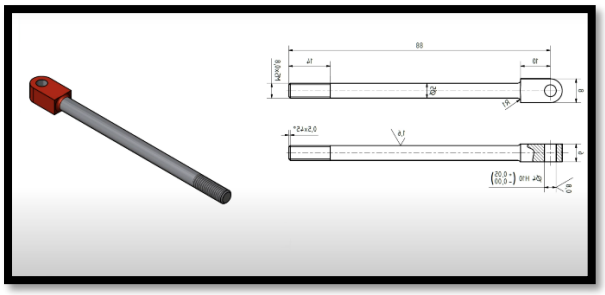
INLET:

The inlet is a part that connects with the cylinder from one side, and the other is associated with a pipe supplying the steam to the steam engine. Steam is provided through an inlet, which leads to the motion of the piston, thus producing work.

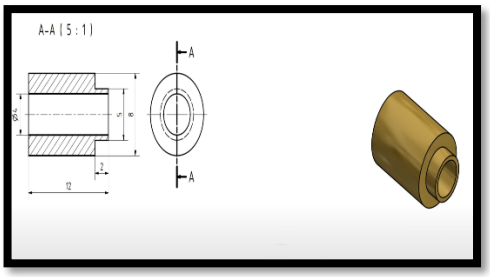
STRUCTURE

CONNECTING ROD LINK:

A connecting rod link is generally made up of forged or cast steel. It contains threads and chamfers also.



Connecting rod link



Inlet

INLET:

The inlet is made up of nickel-chromium steel.

CHALLENGES CAN BE FACED

For connecting rod link:

Challenges may occur to make the connecting rod link, like using Autodesk features like fillet and thread; it should align with other team parts.

For inlet:

It is relatively easy to make the inlet; the challenge can be making the hole and measurements precisely.

CONCLUSION

Both parts are essential for the project as they connect to the claims made by my other teammates. By completing this task, I will learn about teamwork and more features of Autodesk.

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PART NAME – CENTRIFUGAL PUMP SYSTEM

ALOK SHUKLA(23110022)

INTRODUCTION

Our team has decided to make a Steam Engine. The steam engine was first developed between the 18th and 19th centuries, bringing many significant advantages. It became a reliable source of mechanical power. It revolutionized transportation, used in agriculture and mines, as they can pump out water from the mines and power machinery to extract minerals and operate year-round in all seasons, providing constant power. In a steam engine, the centrifugal pump system is vital in circulating water to maintain the machine's proper temperature and cooling control. It supports and regulates the temperature, safeguards the engine from overheating, maintains efficiency, and contributes to the engine's longevity and performance. Proper cooling is necessary for the efficient operation of a steam engine; overheating can cause a reduction in the version of the engine and can damage the engine's parts. So, we can assume that the centrifugal pump is like vitamins and minerals for the steam engine, which is essential for its health**.**

FUNCTIONING

The centrifugal pump in a steam engine is mainly for regulating the temperature by circulating water, reducing the heating effect, and maintaining the engine's efficiency. The functioning of a centrifugal pump is explained step by step below the following points:

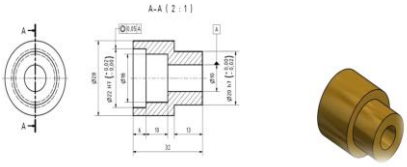
1. Steam engine parts: Inside the steam engine, there are many different parts and components, such as the boiler, cylinder head, and cylinder, which generate heat continuously. Excessive heat may reduce the efficiency and also lead to damage to the engine.
2. Impeller Rotation: The centrifugal pump is connected to a coolant reservoir and the engine's cooling system. When the engine starts working, the pump is activated. The centrifugal pump also consists of a central part, the impeller- a rotating part with a curved blade. It starts spinning rapidly, creating a centrifugal force propelling the coolant outwards.
3. Heat exchange: The outward-flown coolant creates a low pressure and draws in coolant from the reservoir within the engine. Now, the hot and cold coolant mixture flows through the engine passage and absorbs the heat of the hot engine components. So, in this way, the heat exchange process helps regulate the engine's temperature.
4. Continous cycle: After the coolant has absorbed heat, it goes back to the centrifugal pump, and like this, the pump maintains a continuous process of drawing in hot coolant and cools it down to maintain and regulate the engine's temperature. It prevents overheating and ensures the machine operates at a safe temperature.
5. Efficiency of the engine: A safe temperature is very important for the proper efficiency and longevity of the engine. The centrifugal pump system plays a vital role in maintaining the temperature on the safer side, thus keeping the performance level high and contributing to the engine's efficient operation.

Hence, the centrifugal pump in a steam engine works as a coolant circulator by using the principles of centrifugal force to regulate the temperature and facilitate the engine's performance.

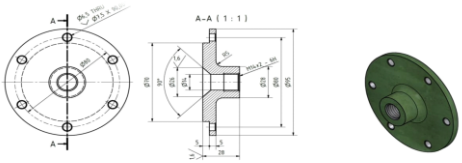
STRUCTURE

In this section, we will be discussing the structure and parts of the centrifugal pump system and also be attaching the 3D diagram with its rough sketch:

I. Centrifugal pump bearing:
This part plays a vital role in centrifugal pumps as it supports the rotation of the shaft and allows it to spin with minimum friction. The material chosen for making the bearings is mainly based on factors like speed, load, and the type of coolant used as the pumps are used to convert steam energy to mechanical energy. The centrifugal pump bearings also play a crucial role in maintaining the engine's efficiency.



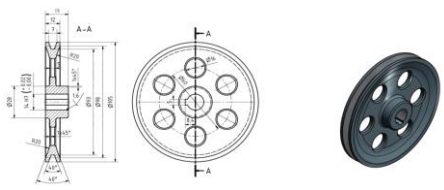
Centrifugal pump cover



Centrifugal pump bearing

II. Centrifugal pump cover:
This part is also known as the pump casing or pump housing. The primary function of this part is to protect the internal components of the centrifugal pump. Pump covers are generally made of cast iron, various plastics, or stainless steel. It also plays a vital role in creating the necessity of flow and pressure inside the pump. Its shape and design can affect the efficiency and performance of the pump.

III. Centrifugal pump pulley:
It is a crucial component of the pump's drive system. The primary function of this part is to transfer rotational energy from the source, which is connected to the pump's shaft. The dimension of the diameter of the pulley and the ratio of the sizes play a critical role in determining the pump's performance. They are typically made of cast iron or aluminum, so they can avoid mechanical stress and provide durability and longevity.



Centrifugal pump pulley

Possible Challenges:

1. While the pressure in the pump goes down, the vapor pressure of the liquid is also pumped, which may lead to a bubble formation. After that, the pump can collapse, causing damage to the impeller and more internal components.

2. The centrifugal pump can also start operating at a meager flow rate, which may lead to issues like flow recirculation and thus cause a reduction in the efficiency of the pump.
3. The leakage of the seals can also be a significant issue as it will result in fluid loss, so proper seal maintenance is essential to maintain the pump's efficiency.
4. The fluid that will be pumped should also be chosen carefully, which may lead to corrosion in many pump components made of iron, aluminum, etc.

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PART NAME: - VALVE LINKAGE ROCKER, VALVE LINKAGE DUAL ROCKER

ANANYA BALIKE (23110024)

INTRODUCTION

We have decided to design a 3-dimensional model of a piston-powered steam engine. A piston-powered steam engine is a type of steam engine that operates using reciprocating pistons to convert the energy generated by steam pressure into mechanical work. In 1775, James Watt developed an engine-building and engineering partnership with industrialist Matthew Boulton. This partnership served as an innovative technical center for the British economy. The development and widespread use of piston-powered steam engines was a turning point in the Industrial Revolution, transforming society, powering factories, and enabling long-distance transportation by rail and sea. These engines found applications in various industries during the early days of steam power, including mining, manufacturing, transportation (e.g., steam locomotives), and agriculture.
I have been assigned two parts to the model: - a valve-linkage rocker and a valve-linkage dual rocker. Both factors play a different yet essential role in the engine's functioning.

Valve Linkage Rocker and Valve Linkage Dual Rocker

In a piston-powered steam engine, the valve linkage rocker is a critical component responsible for controlling the admission and exhaust of steam in and out of the cylinder, enabling a locomotive to move under its power. This linkage system is essential for regulating the engine's operation and ensuring efficiency.

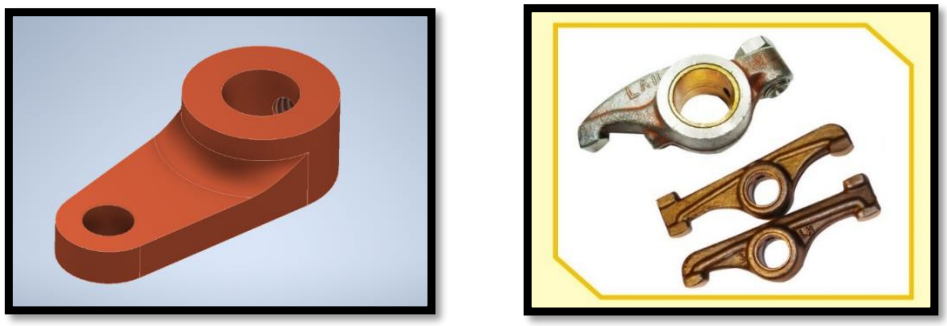
FUNCTION AND IMPORTANCE

1. The valve linkage rocker is a mechanism to control the opening and closing of the engine's inlet and exhaust valves. It determines when and for how long steam is allowed to enter the cylinder and when exhaust steam is released. Maintaining an open inlet valve throughout the power stroke is the key to maximizing the steam engine's peak power output while also causing the boiler pressure to increase, which minimizes transmission loss against the piston throughout the stroke. However, peak efficiency is achieved by briefly opening the inlet valve and then letting the steam expand in the cylinder. This is called expansive working.
2. Cutoff is when steam stops being admitted to the cylinder. The optimal position for this varies depending on the work being done and the trade-off desired between power and efficiency. The valve linkage rocker ensures that the movements of the valve mechanisms are synchronized with the piston's motion.
3. In many piston-powered steam engines, reversing the engine's direction (changing from forward to reverse or vice versa) is critical. The valve linkage rocker allows for this reversal by altering the timing of valve actions.

APPEARANCE

A valve linkage rocker in a steam engine typically consists of a sturdy, elongated lever arm made of cast iron or steel. One end connects to an eccentric on the engine's crankshaft, while the other pivots on a bearing or bushing. The pivot point allows the rocker arm to rock back and forth. It connects to the engine's valve mechanism through a linkage system, facilitating the control of steam admission and exhaust. Adjustments may be present for fine-tuning valve timing. These rockers vary in size depending on the

engine's scale, with larger industrial machines featuring more substantial rockers and smaller engines having more compact ones.



Valve Linkage Rocker

Valve Linkage Dual Rocker

POSSIBLE CHALLENGES

Achieving a snug fit with the engine's bolts could be a potential challenge when creating the tapped hole of the valve in Autodesk. Dimensions and threading must be selected according to those of the bolts. The angle between the hands of the dual rocker must be precise concerning the other parts of the engine.

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Image-Valve linkage dual rocker

PART NAME: BEAM AND FAN

MANOJ A.V.S (23110025)

INTRODUCTION :

The steam engine is one of the most remarkable inventions of all time. It played a significant role in turning the wheels of the world during the Industrial Revolution. This idea revolved around the world and led to many derivations and applications. These include ships, trains, complex equipment in factories, etc.… Our project is the improvised version of the steam engine by James Watt. The spontaneous steam engine prevented the unnecessary wastage of steam. This model is called the beam engine, containing an oscillating beam.

But we made a slight modification in this model so that it is helpful in daily life. This is a miniature model of the steam engine. It takes the steam from the pressure cooker into the steam engine's steam inlet through a pipe to heat the gas trapped below the piston. It utilizes this energy produced by the steam engine to rotate a fan to give air to the person near the pressure cooker.

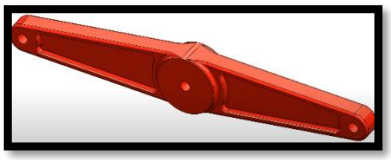
In this model, the parts assigned to me are the Beam, Cylinder, and piston support beam. I am interested in this project as we can learn about one of the most fundamental engineering models in the world. This project will help us build a deeper understanding of the basic concepts. I also hope that it helps in developing good sketching skills. These parts are some of the basic but essential elements of the steam engine.

BEAM :

STRUCTURE AND FUNCTIONS:

The beam is the topmost part of the steam engine. It is pretty huge and is mainly composed of iron or wood. It is one of the steam engine's most important parts. The piston, which produces oscillatory motion, is attached to one end of it. On the other side, it is connected to the rotatory part of the steam engine, which provides the required external power to the machinery associated with it. As the piston moves up during its oscillatory motion, The beam moves up on that side, causing the opposite side to go down. And it's followed by the reverse action.

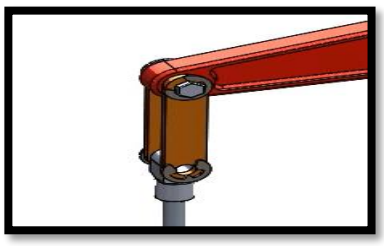
The beam is supported in the middle by a stand directly attached to the base. It has two vertical rods attached to both ends at precisely equal distances.

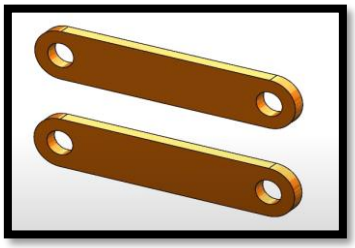


Beam

BEAM LINKAGE :

The beam linkage is a subpart of the beam. Two beam linkages are attached to the shaft, the back and front of the side of the beam, which is attached to the piston by the piston rod. The beam linkages can rotate about one end of the shaft and up and down with the beam. Due to the rotatable joint with the beam, they remain vertical despite the oscillatory motion of the beam. This helps to keep the piston rod straight. These are only on one side of the shaft.





Beam Linkage

POSSIBLE CHALLENGES TO FACED :

The beam part has a susceptible shape and curvature associated with it. Apart from that, there are hardly any challenges that I might face in this part of the project model.

FAN :

The steam supplied from the pressure cooker is the input given to the device. The steam engine converts this thermal energy to mechanical energy. The fan is the output part of this project model. The fan provides air to the person near the pressure cooker.

Fan

CONCLUSION

I feel excited to do the project with my teammates. I believe this helps me improve Autodesk inventor editing skills and develop awareness regarding basic engineering models.

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PARTS - BEARING SUPPORT, CYLINDER, CYLINDER HEAD

ANIKET MISHRA (23110026)

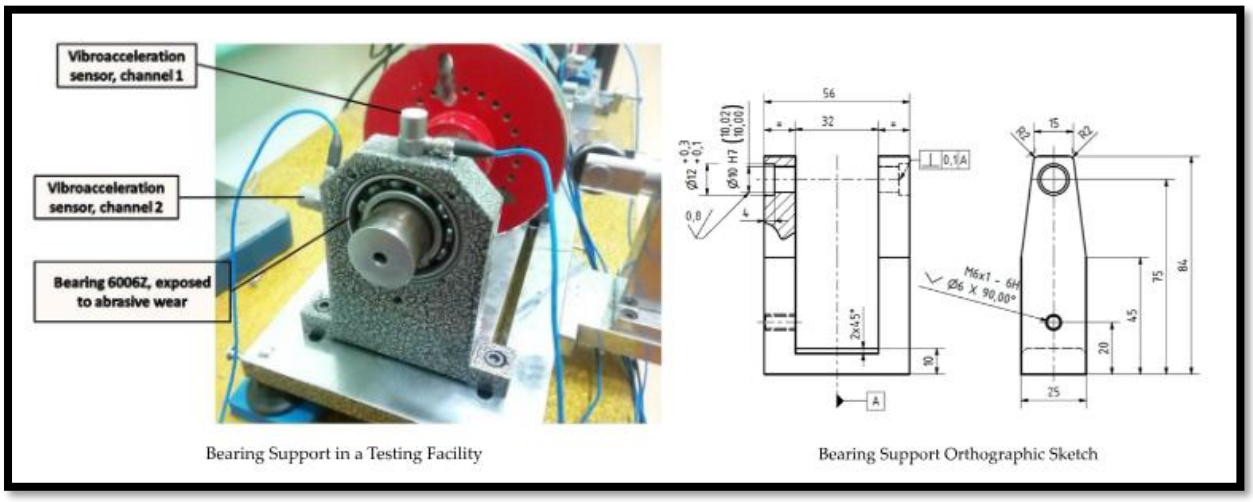
INTRODUCTION

Alongside the wheel, the light bulb, and the printing press, the steam engine is one of the most impactful inventions in human history. Being used everywhere, from mines to mills, the Industrial Revolution sparked the world into a new age where we could work, live, and produce many times more comfortably than before. Thus, we have chosen to model the steam engine because of its all too significant role in our development as a species. We are sporting a piston-powered steam engine. Being one of the first commercially viable steam engine models to transmit continuous power to a machine, it uses steam pressure to push a piston back and forth inside a cylinder. It transforms the force into rotational motion using a connecting rod and a crank.

I have been assigned three parts to model:- the bearing support, the cylinder, and the cylinder head. Each of these parts plays a different yet essential role in the operation of the steam engine. It is my hope with this project that as I work on modeling and sketching these parts, not only will I learn more about how to make appropriately detailed sketches and how to work with Autodesk Inventor, but I will also gain a deeper understanding of the history behind these machines that are so fundamental to the field of engineering.

Bearing Support -

Since their use by the Egyptians circa 2600 BCE, bearings have been a crucial tribological component of various forms of machinery, big and small. A bearing arrangement supports and locates a shaft, radially and axially, relative to other components in the machine. In the steam engine that we are modeling, the bearing support houses the crankshaft with the help of two plain bearings, thus ensuring both structural integrity and smooth functioning of the entire machine as the back-and-forth movement of the piston causes the rotation of the crankshaft via the motion of the beam.



Bearing Support in a Testing Facility

Bearing Support Orthographic Sketch

Its U-shaped structure helps in supporting the crankshaft, with two holes in the upper part of the arms to allow it to pass through.

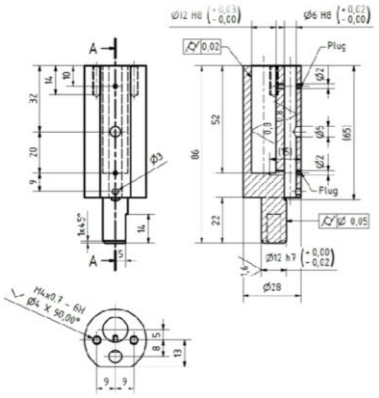
Cylinder & Cylinder Head -

For the piston to transmit power to the steam engine, its back-and-forth movement must be facilitated via a tube alongside a valve to control the admission of steam into the cylinder, enabling it to move under its

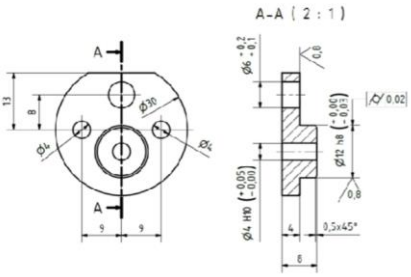
power. Thus, the cylinder is a vital component of the steam engine, serving both in the intake of force and the outtake of steam.

While the cylinder may seem simple from an outside glance, it is a much more complicated structure from the inside, with multiple intersecting holes being a part of its inner composition. They are needed to make space for the valve, the piston, the cylinder head, and the bolts that fix the structures together so that they don't accidentally slip out.

The cylinder head makes up the upper surface of the cylinder. It helps to fix the valve and piston rod into their respective vertical axes so that there is no leakage during the admission or exhaust of steam into or from the engine, ensuring smooth and efficient functioning. It is a near-circular structure with holes made in it to allow rods and bolts to pass through it.



Orthographic Sketch of Cylinder



Cylinder Head Orthographic Sketch

CHALLENGES TO BE FACED-

Learning to read and draw detailed sketches for complicated structures will be tricky as I've never done it before. It looks like something that needs meticulous attention. Alongside, modeling the parts in Autodesk Inventor and assembling them to be functional is something I look forward to doing. Even in the past two weeks, there have been problems in managing and communicating within the team while meeting multiple deadlines. As our exams approach, I expect to face such difficulties more frequently.

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PART NAME: TURBINE PULLEY AND PISTON VALVE

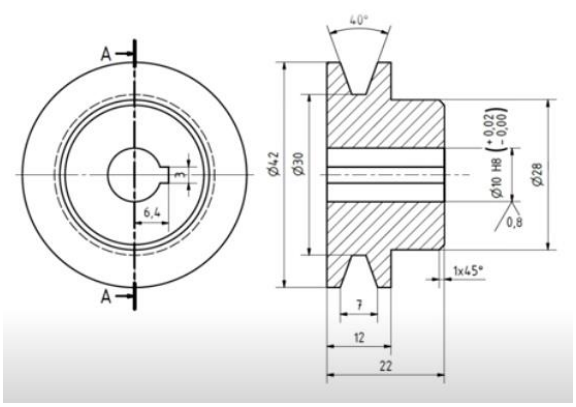
NAME: ANIMESH BEHERA (23110027)

INTRODUCTION

As a member of group 3, whose project is to make a model and present a vertical steam engine, I am assigned the following parts mentioned above.

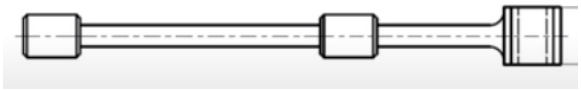
Before elaborating on that, a steam engine is a heat engine in which steam is used as its working substance to perform mechanical work. The impact of the steam engine is needless to mention because it had various applications in the printing press, electric power, telegraphy, and the telephone, the latest being the computer, as inventions that have resulted in a dramatic and pervasive influence on our earth.

A **pulley** is a wheel on an axle or shaft constructed for moving and changing the direction of a **belt** or **a taut cable** to **transfer power** between the **post** and the strap or rope. Pulleys, in general, are essential but effective tools that have been used for many years to decimate task difficulty. The turbine pulley helps in the transmission of power to other machinery. It can be used for driving machines such as dynamos and pumps.



Pulley

A **piston valve is a vital component of a steam engine.** It assists **the flow of steam within the steam** engine **or a locomotive.** It controls the flow of smoke into the chamber and its subsequent exhausting, enabling a locomotive to move using its power.



Piston Valve

CONSTRUCTION & WORKING

TURBINE PULLEY

The pulley in a steam engine is a unit of the flywheel mechanism. The flywheel is a sizeable, heavy wheel attached to the piston through a connecting rod. The piston moves backward and forward in the cylinder due to steam pressure. This motion is transmitted to the flywheel, due to which it rotates.

The pulley is fixed onto the outer rim of the flywheel. When the flywheel rotates, the pulley starts spinning. A belt or a rope attached to this pulley is beneficial for driving other machinery or equipment.

In short, the pulley in a steam engine is a vital part of the process in which the reciprocating motion of the piston gets transformed into rotational motion that can be used to do work. It is a significant component that makes good use of the power generated by the steam engine.

PISTON VALVE

The valve comprises two piston heads laid on the same spindle moving inside the steam chest, a mini-cylinder present either above or below the main cylinders of the locomotive.

The piston valve is then opened by moving it to the right, which permits the clear space in the middle of the valve to align with the channel in the cylinder above it.

Usually, piston valves are of the "inside admission" type, in which fresh steam is introduced from the boiler through the space between the two piston heads of the valve, and exhaust steam escapes through the distance between a piston head and the end of the steam chest.

POSSIBLE CHALLENGES

TURBINE PULLEY

While designing a turbine pulley in Autodesk Inventor Professional 2024, one must be careful with the dimensions and angles. The groove needed in the pulley could be tricky.

PISTON VALVE

While making the piston valve, one must be careful with the dimensions. The curved parts are also to be taken care of. There is no major issue.

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PART:- PISTON
ANIRUDH(23110028)

INTRODUCTION

The Steam Engine was an invention in the 18th century that revolutionized the transportation and the automobile industry. The device used steam to generate power and run machinery, revolutionizing manufacturing and many other sectors during the Industrial Revolution. It further lays the line for future projects like Steam Turbines, an advanced form of Steam Engine still used in many power plants to generate electricity. Influenced by its massive role in modern society, our group has decided to make the project.

I have been assigned the part Piston and its parts to make in the project. A Piston is a fundamental part of a Steam Engine, mainly used to convert energy in the Steam Engine.

PISTON :

Introduction and Working

A Piston is crucial in reciprocating engines, like the Steam Engine. It is a movable part contained inside a cylinder and is made sure not to let gas escape by being airtight through valves. Its primary function in the engine is to transfer the force generated inside the cylinder to the Crankshaft through the connecting rod. In Steam Engine, the Piston controls gas flow through the slide, Piston, or poppet valves.

Now, the working of the

Piston:- Its primary use is to transform the heat energy of steam into mechanical work, making it one of the most crucial parts of Steam Engine. For the transformation of heat into work, Piston must complete the cycle.

The gas is first heated, making steam so that it expands inside the cylinder, pushing the Piston away, and in doing so, the Piston does some work. After removing the heat from the cylinder, the pressure of steam decreases, resulting in contraction, and the Piston will return to its original position and complete its cycle, repeating the same process repeatedly.

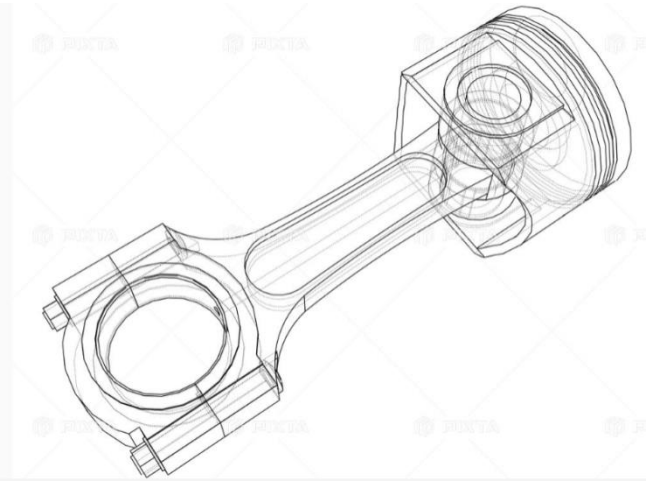
Apart from this, another primary function of the Piston is to control the steam flow. During the working of the Piston, it opens and closes alternately, which makes steam entering and exiting the cylinder easier. It improves the engine's efficiency significantly.

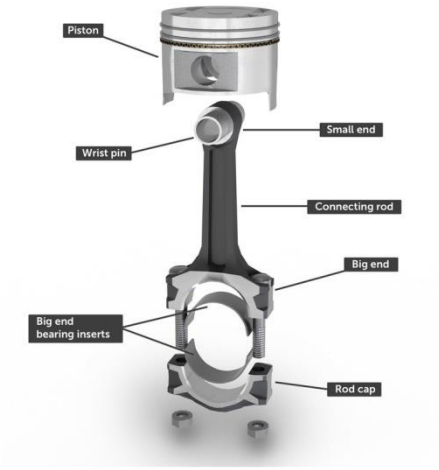
From the above information, we know that the Piston is a crucial part of a Steam Engine or any form of engine, But it is also the one that is in the worst condition of all components. Due to regular thermal and mechanical stress, pistons can come to their worst state quickly and sometimes might fail. So, using a material to make a good piston is necessary for working.

Cast iron and aluminum alloy are the most commonly used materials to make pistons. However, using Grey cast iron, aluminum alloy, and nickel carbide graphite increases the life cycle of a Piston. These materials have:-

1 High Resistance
to Deformation
2 Resistance to oxidation
3 High Resistivity to Temperature and Pressure
4 Corrosion Resistance

To ensure it can handle the tensile and mechanical stress and withstand the high steam pressure inside the cylinder.





Piston

Science behind it

The basic principles used in working pistons are thermodynamics and laws of motion. The contraction and expansion of steam in a cylinder follow the rules of thermodynamics, and the laws of motion govern the movement of the piston. By coordinating all these laws, the Piston can create a continuous cycle.

CONCLUSION

In conclusion, the Piston is crucial in working the steam engine. It serves as the heart power conversion process. Understanding the topic and mechanism is essential for Piston to run the steam engine. In summary, the Piston's role in the steam engine should not be overstated, as it embodies the essence of mechanical power generation during the Industrial Revolution and even now.

POSSIBLE CHALLENGES

Making the Piston is easy, as the components are pretty straightforward. Assembly of those parts might be complex, and we hope to learn it. Making corresponding dimensions with others is also essential so the engine assembly goes as smoothly as possible.

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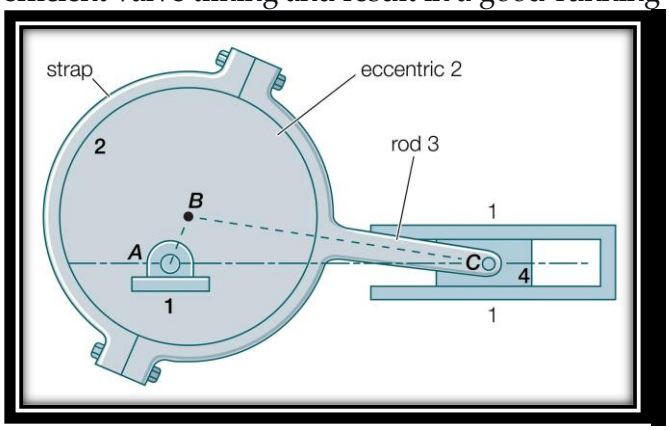
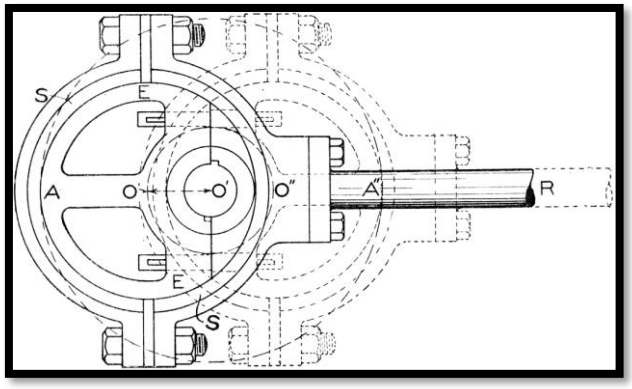
PART NAME – ECCENTRIC SYSTEM
ANIRUDH MITTAL (23110029)

INTRODUCTION

As group 3, we have decided to work on a steam engine. According to Britannica, a Steam engine is a mechanical machine that transfers steam to work by the heat channel. In a steam engine, steam vapors from a boiler expand under pressure, and some heat energy gets converted into work. For higher efficiency, steam should fall through an extensive temperature range because of its expansion inside the engine. I have been assigned an eccentric system. An eccentric system is a thin, circular, cylindrical disk (eccentric sheave) fixed on a rotating axle with its center offset from the axles. The eccentric System includes an eccentric hub, eccentric strap rod, eccentric strap head, and eccentric strap. Correctly set eccentrics are essential to efficient valve timing and result in a good-running and powerful steam engine.





Eccentric system

FUNCTIONING

Eccentrics often convert rotating motion into linear reciprocating motion to translate a sliding valve in steam engines. Its coating is made of cast iron and is present on the crankshaft. The axis of the eccentric is near the axis of the crankshaft, parallelly aligned to it, and is known as the radius of the eccentric. A groove is present on the circumference of the eccentric, which is fitted onto a circular collar (eccentric strap). An eccentric rod attached to an eccentric strap is current, which suspends so that its other end may impart the essential back and forward motion. The eccentric strap is necessary to fully variable valve lift control connected to an eccentric rod. The valve lift moves continuously from the highest point to almost zero by rotating/pivoting the eccentric strap employing an electric motor. The position of the eccentric axis concerning the crankshaft controls the slide valve in the chamber and ensures its proper up-down oscillatory motion.

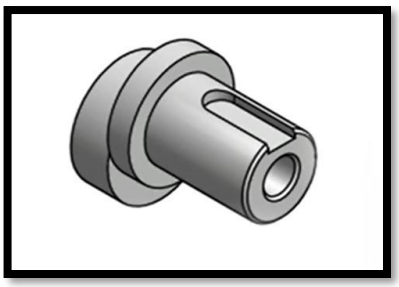
The relative position of the eccentric axis concerning the axis of the crank pin gives the required arrangement of the valve system, further providing the connecting position of the piston.

A return crank possesses the same functions, except it can work only at the axle tip or on the peripheral outings of a wheel, but in eccentric, one might fit the body of the axle between the wheels. Unlike a cam, which converts rotatory motion into translatory motion at all the rates of acceleration and retardation, an eccentric or return crank may only approximate simple harmonic (oscillatory) motion. Eccentrics are used

to transmit/supply large amounts of force as friction loss might be high. They are mainly used to drive the valve gears of engines.

STRUCTURE

- **Eccentric hub** - It comprises two thin(different thickness) cylindrical plates stuck to each other, one kept slightly above the other. A long, thick, hollow, rod-shaped cylinder bulges through the second thin cylinder with a semicylindrical groove on its upper surface. It is a simple-to-make structure but is essential in the steam engine.



Eccentric hub

- **Eccentric Strap rod**- a long, thin steel rod made of curved semicircular edges with friction threads for gripping.
- **Eccentric strap:** It is a ring-like structure with thick edges and a connecting hole at the periphery to connect with the eccentric strap head.
- **Eccentric strap head:** The structure comprises a semicircular cylindrical upper part with a circular deep hole. The lower part includes a cylindrical lock-like design with inner threads to lock up with the lines of the Eccentric strap.

Eccentric straps/rods

CHALLENGES

These parts contributing to the Eccentric hub may bring some difficulties, including several holes (some slanting), threads, and many cylindrical works. Though this structure might appear complex, ensuring the proper workflow of the steam engine is essential.

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PARTS NAME- CENTRIFUGAL PUMP SHAFT, CONNECTING ROD HEAD, AND COLUMN SHAFT.

ANKIT KUMAR (23110030)

INTRODUCTION

In mechanical engineering, a captivating innovation has been instrumental in shaping the course of human history—the steam engine. This ingenious mechanical device, often regarded as one of the most transformative inventions of the Industrial Revolution, has revolutionized transportation, manufacturing, and energy production. With its intricate mechanisms and powerful capabilities, the stream engine stands as a testament to human ingenuity and the relentless pursuit of harnessing the forces of nature for the betterment of society. In this exploration, we delve into the remarkable world of steam engines, uncovering their history, inner workings, and enduring impact on modern industry and technology.

I have been assigned three parts to the model: -Column shaft, connecting rod head, and centrifugal pump shaft.

CENTRIFUGAL PUMP SHAFT:

Structure and Functions :

Main Shaft: The main shaft is the central, elongated portion of the pump shaft. It spans the distance between the prime mover and the centrifugal pump. It's designed to be straight and precisely machined to ensure proper alignment within the pump housing.

Couplings: At each end of the main shaft, there are couplings. These specially designed connectors secure the pump shaft to the prime mover's output shaft and the pump impeller. Collars are essential for transmitting rotational motion efficiently and securely.

Bearings: Bearings are located along the length of the pump shaft to support and guide it while it rotates. These bearings reduce friction and wear on the post, ensuring smooth and efficient operation. They are often lubricated to prevent overheating and reduce wear.

Rotating the Impeller: The pump impeller, mounted on the other end of the pump shaft, is a crucial component of the centrifugal pump. It consists of curved blades that spin rapidly when the pump shaft rotates. This rotation creates a centrifugal force that propels the fluid outward, creating a low-pressure region at the center and suction at the inlet. As a result, liquids are drawn into the pump and then expelled at higher pressure through the discharge outlet.

Maintaining Alignment: Proper alignment of the centrifugal pump shaft is crucial to prevent excessive vibration and wear. Misalignment can lead to premature failure of bearings, couplings, and other components. Hence, the pump shaft must align precisely with the prime mover's output shaft and the impeller.

Handling Axial and Radial Loads: The pump shaft must withstand axial and radial loads generated by the hydraulic forces within the pump. These loads can be substantial, especially in high-flow or high-pressure

applications. Robust materials and proper design ensure the shaft can handle these loads without deformation or failure.

Possible challenges:

Designing a centrifugal pump shaft in Autodesk Inventor Professional presents several challenges. The process involves handling complex geometries, conducting stress analyses to ensure safety, selecting suitable materials for durability, achieving proper balance to reduce vibration, integrating seamlessly with other pump components, and considering manufacturability for cost-effective production.

COLUMN SHAFT:

Structure and Functions:

The column shaft is typically a large, cylindrical metal shaft made from materials known for their strength and durability, such as cast iron or steel. It is usually positioned vertically in the engine and can extend from its base to its upper components. The structure of the column shaft can vary depending on the specific type and design of the steam engine, but it generally consists of the following key elements:

Base and Foundation: The bottom end of the column shaft is securely anchored to the engine's ground or foundation. This ensures stability and prevents excessive vibrations during operation.

Bearings: The column shaft is supported by bearings at various points along its length. These bearings reduce friction and allow the shaft to rotate smoothly. Depending on the design, the bearings can be plain or rolling element bearings.

Couplings and Joints: There are often couplings and joints to connect the column shaft with other engine components, such as the crankshaft or flywheel. These mechanisms allow for the transmission of power and motion between different engine parts.

Diameter Variation: In some steam engine designs, the diameter of the column shaft may vary along its length. This variation can be necessary to accommodate different loads and stresses at various points within the engine.

Power Transmission: One of the primary functions of the column shaft is to transmit power from the steam source (usually a boiler) to various engine components. In many steam engines, the steam is used to drive a piston or turbine, and the resulting mechanical energy is transferred to the column shaft.

Torque Distribution: The column shaft distributes torque generated by the engine's power source to different machine parts. This torque is essential for driving auxiliary components, such as generators, pumps, or mechanical systems.

Synchronization of Components: In multi-cylinder steam engines, the column shaft plays a critical role in synchronizing the motion of multiple pistons or turbines. It ensures that all components work together in a coordinated manner to maximize efficiency and reduce vibration.

Load Balancing: The column shaft can also counterbalance to reduce vibrations and ensure smooth operation. This is particularly important in large and powerful steam engines.

Support and Stability: The column shaft's bearing supports provide stability and prevent excessive deflection or bending during operation. Proper alignment and support are essential to maintain the longevity and efficiency of the post.

POSSIBLE CHALLENGES:

Designing a column shaft in Autodesk Inventor Professional presents several challenges. Complex geometry, material selection, and structural analysis demand precision. Ensuring alignment, assembly, and dynamic behavior in complex systems can be time-consuming. Manufacturing feasibility, documentation, and sustainability analysis require attention to detail. Collaboration with multidisciplinary teams is essential. Despite these challenges, leveraging Inventor's features, accurate material data, and simulation capabilities can lead to a well-designed and functional column shaft. Staying updated with software advancements and training resources is crucial for proficiency in addressing these design complexities.

Connecting rod head:

Structure and Functions:

The connecting rod head is typically a sturdy metal component that connects the piston rod to the crankshaft in a reciprocating steam engine. Its structure is designed to withstand high stresses and repetitive motion. Here are the key structural elements of a connecting rod head:

Body: The main body of the connecting rod head is typically a solid or hollow metal piece, often cast or forged from materials like cast iron or steel. It has a distinct shape, typically resembling a T or an I, depending on the design and purpose of the engine.

Bearing Surface: At one end of the connecting rod head, a bearing surface or "big end" houses a bearing or bushing. This bearing allows the connecting rod head to pivot smoothly at the crankshaft's crankpin. The path is often lined with bronze or babbit metal to reduce friction and wear.

Wrist Pin: At the opposite end of the connecting rod head is the wrist pin or "small end." The wrist pin connects to the piston rod, allowing it to pivot or oscillate as the piston moves up and down within the cylinder. Like the significant end bearing, the small end may have a bushing or bearing surface to minimize friction.

Fasteners: Connecting rod heads are secured to the crankshaft and piston rod using fasteners like bolts or studs. These fasteners are essential for maintaining the assembly's structural integrity and ensuring that the connecting rod head remains securely attached to both the piston and crankshaft.

Force Transmission: The connecting rod head is responsible for transmitting the force generated by the expanding steam in the cylinder to the crankshaft. This force ultimately powers the engine and drives other mechanical components, such as a flywheel, generator, or pump.

Alignment and Stability: Proper alignment and stability of the connecting rod head are crucial for smooth and efficient engine operation. Any misalignment or instability can lead to increased friction, wear, and vibration, negatively impacting engine performance and longevity.

Load Distribution: The connecting rod head plays a role in distributing the load and stresses evenly between the piston rod and crankshaft. This helps prevent excessive wear and ensures the engine operates reliably under varying loads and conditions.

Lubrication: Many connecting rod heads have provisions for lubrication to reduce friction and heat generation at the bearing surfaces. Adequate lubrication is essential to prevent premature wear and maintain the efficient operation of the engine.

Maintenance and Inspection: Regular maintenance and inspection of the connecting rod head are critical to identify signs of wear, misalignment, or other issues that may compromise the engine's performance and safety.

POSSIBLE CHALLENGES:

Designing a connecting rod head in Autodesk Inventor Professional poses numerous challenges. Key hurdles include complex geometries, material selection for strength and fatigue resistance, stress and thermal analysis, dynamic balancing, and ensuring proper assembly and tolerances. The need to address high-cycle fatigue, manufacturability, and the creation of comprehensive documentation further complicates the process. Overcoming these challenges requires expertise in Autodesk design, engineering, and materials, as well as careful collaboration and iteration. The precision needed for successful connecting rod head design in the context of engine functionality demands meticulous attention to detail and simulation tools to ensure structural integrity and performance.

Centrifugal pump shaft

Column shaft

Connecting rod head

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PARTS: COOKER AND CENTRAL PUMP HOUSING

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INTRODUCTION :

The steam engine is a simple device that turns energy into mechanical work. It was crucial to the Industrial Revolution and significantly impacted various industries, transportation, and the overall development of modern society. Let's break down the boiler and centrifugal pump housing in a steam engine's relevance, operating principle, and significance. The following are some aspects of its importance.

1. The Industrial Revolution: The steam engine was a major driving force behind the Industrial Revolution, allowing factories to run more efficiently and cost-effectively by providing a consistent power supply for machines.

2. Transportation: The first railways and steamboats were powered by steam engines, transforming transportation and making it quicker and more accessible. The invention of the simple machine, the steam engine, increased trade and the movement of people and products over large distances.

3. Mechanization: The employment of steam engines in different industrial applications such as textile plants, mining, and agribusiness resulted in higher output and the automation of labor-intensive operations.

4. Urbanization: As factories and industries expanded, the availability of steam power aided in the rise of cities and the migration of people from rural to urban regions.

WORKING OF STEAM ENGINE

A steam engine transfers the energy contained in steam into mechanical work. Below is mentioned how it works:

1. Boiler: Water is heated in a boiler to generate steam. The boiler is essential because it produces the high-pressure steam needed for the engine to run effectively.

2. Expansion of Steam: The high-pressure steam is channeled into a piston cylinder. Steam expands as it enters the cylinder, forcing the piston outward.

3. Mechanical Work: The piston's outward movement is linked to a crankshaft, which turns the piston's linear motion into a rotating motion. This rotating motion may be used to power numerous machinery forms, such as locomotive wheels or a manufacturing flywheel.

4. Exhaustion: The steam is discharged from the cylinder once it has completed its task. To increase efficiency, some engines employ a separate condenser to turn the moisture back into water for reuse

Importance of Boiler and Centrifugal Pump Housing:

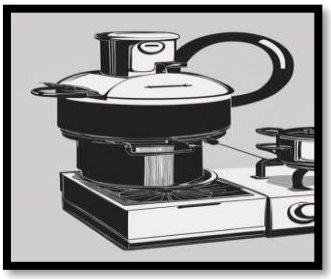
1. Boiler: The boiler is an important part of a steam engine because it produces the high-pressure steam required to power it. Its working decides the efficiency and power production of the steam engine. Proper boiler design and maintenance are needed to maintain a consistent steam supply.

2. Centrifugal Pump Housing: Centrifugal pumps supply water into the boiler in several steam engines, notably steam locomotives and marine engines. The centrifugal pump's housing is crucial because it contains the impeller, which generates the pressure required to deliver water into the boiler against the high steam pressure. A reliable water supply is essential for steam engines' safe and efficient functioning.

1. COOKER

In the case of the steam engine, the cooker is an important part known as a boiler or steam generator. Its primary function is to convert water into steam, which is required for a steam engine to operate. Below, it is mentioned how it works and how it is used.

The cooker (boiler) plays a vital role in a steam engine as it acts as a steam source. It acts as a heat source by heating water, which creates high-pressure steam. This high-pressure steam is then sent to a steam turbine, which expands and does mechanical work, usually used to power machinery locomotives or generators.



Cooker

WORKING:

Several critical steps are involved in the operation of the cooker:

1. Water Intake: A feedwater system supplies water to the boiler.

2. Heating: To heat the water inside the boiler, a heat source is required, which often includes coal, wood, oil, or natural gas. Heat energy is transferred to water, leading to boiling and condensing into steam.

3. Steam Production: When water boils, it produces high-pressure steam. This steam is captured and stored in the boiler until it is required.

4. Steam Release: When the engine demands power, a valve is opened to enable high-pressure steam to flow to the turbines or pistons of the steam engine

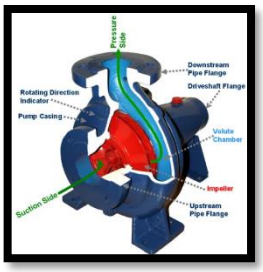
5. Expansion: Within the engine, high-pressure steam expands, causing mechanical components to do beneficial work.

6. Condensation: After the steam has done its job, it is condensed back into water in a condenser and returned to the boiler to resume the cycle.

In summary, the cooker, or boiler, in a steam engine produces steam by heating water. This steam is then utilized to power the machine, resulting in a never-ending cycle of water heating, steam creation, expansion, and condensation that powers mechanical activities. This technology was critical to the Industrial Revolution and the early transportation networks.

2. CENTRIFUGAL PUMP HOUSING

A centrifugal pump housing, also known as a casing or volute, is essential for steam engines and other uses. Its primary role is to confine and guide fluid flow, increasing the pump's efficiency. The housing is a crucial component of a steam engine's boiler feed pump system.



Centrifugal pump housing

Several critical processes are involved in the operation of a centrifugal pump housing:

1. Inlet: The center inlet allows fluid to enter the housing.

2. Impeller: The casing surrounds a quickly rotating impeller with curved blades. The impeller contributes kinetic energy to the fluid as it turns, resulting in a high-velocity flow.

3. Volute: The housing progressively grows like a spiral or volute. This design turns kinetic energy into pressure by slowing the fluid and raising its pressure as it flows towards the outlet.

4. Outlet: The pressurized fluid departs the housing via the outlet and is directed to the desired use, such as the boiler of a steam engine or other machinery.

In conclusion, the centrifugal pump housing is critical in converting kinetic energy into pressure energy, allowing for efficient fluid conveyance in steam engines and other systems.

CONCLUSION :

Finally, to conclude, group 3 will finish our project using Autodesk before the deadline. We will work together and use all the tools required. Through this project, we learned as many features as possible. Thank you.

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