DESIGN OF HORIZONTAL BEAM ENGINE

Mr. N. KONDAYYA[1], NANDIVADA TEJASWI[2], DUVVAPU MOHANA VENKATA DURGA PRASAD[3], NEERUKONDA LOKESH [4], VASA VENKATA TEJA GANGADHAR [5]

[1] Asst. Professor, Department Mechanical ENGINEERING, WEST GODAVARI INSTITUTE OF SCIENCE AND ENGINEERING, Prakasaraopalem, Avapadu, Nallajerla, East Godavari District, Andhra Pradesh, India
E-mail: kondayya330@gmail.com

[2] B.Tech, Department Mechanical Engineering, WEST GODAVARI INSTITUTE OF SCIENCE AND ENGINEERING, Prakasaraopalem, Avapadu, Nallajerla, East Godavari District, Andhra Pradesh, India
E-mail: tejaswinandivada@gmail.com

[3] B.Tech, Department Mechanical Engineering, WEST GODAVARI INSTITUTE OF SCIENCE AND ENGINEERING, Prakasaraopalem, Avapadu, Nallajerla, East Godavari District, Andhra Pradesh, India
E-mail: mohanprasaddj3@gmail.com

[4] B.Tech, Department Mechanical Engineering, WEST GODAVARI INSTITUTE OF SCIENCE AND ENGINEERING, Prakasaraopalem, Avapadu, Nallajerla, East Godavari District, Andhra Pradesh, India
E-mail: lokeshneerukonda143@gmail.com

[5] B.Tech, Department Mechanical Engineering, WEST GODAVARI INSTITUTE OF SCIENCE AND ENGINEERING, Prakasaraopalem, Avapadu, Nallajerla, East Godavari District, Andhra Pradesh, India
E-mail: tejagangadharvasa@gmail.com

ABSTRACT

This Project aim is to Design the 3D Beam engine. The 3D SolidWorks model of abeam engine represents a classic example ofearlyindustrialengineering.Theassemblycomprisesasturdybasesupporting a large beam, which pivots at its midpoint.Attached to one end of the beam is a piston mechanism, while the other end connects to a drive shaft. This shaft extends to a flywheel, symbolizing the engine's power source. The intricate network of gears and linkages captures the essence of mechanical ingenuity, showcasing the interplay of forces and motion essential for converting reciprocating motion into rotary motion. Through precise modelling and assembly in SolidWorks, the beam engine's functionality and historical significance are visually realized, offering insight into the evolution of early industrial machinery.The main objective of a beam engine is to convert reciprocating motion intorotarymotion.Thisconversionofmotionistypicallyachievedbyharnessingthepowerofsteamoranotherenergysourcetodriveapistonbackandforthin a straight line.The piston's movement is then transmitted to a beam, which pivots aroundacentralpoint.Oneendofthebeamisconnectedtothepiston,whilethe other end is linked to a drive shaft or other machinery. As the beam moves, it translates the linear motion of the piston into rotational motion, allowing the engine to perform useful work such as pumping water, powering machinery, or generatingelectricity.Thus,theprimaryobjectiveofabeamengineistoprovide a means of converting the energy from one form to another, enabling the engine to perform various mechanical tasks.
The main objective of creating a 3D design of a beam engine in Solid Works istoaccuratelymodelandsimulatethephysicalstructureandfunctionalityofthe beam engine within a virtual environment. This includes Visualization, Design Validation, Education, and training.

1. INTRODUCTION

The Project is to design and analyse the Beam engine by using the solid works and to

analyse their Power, Efficiency.
The Main Importance of this beam Engine is to convert reciprocating motion into rotary motion. This conversion of motion is typically achieved by harnessing the power of steam or another energy source to drive a piston back and forth in a straight line. The piston's movement is then transmitted to a beam, which pivots around a central point. One end of the beam is connected to the piston, while the other end is linked to a drive shaft or other machinery. As the beam moves, it translates the linear motion of the piston into rotational motion, allowing the engine to perform useful work such as pumping water, powering machinery, or generating electricity. Thus, the primary objective of a beam engine is to provide a means of converting the energy from one form to another, enabling the engine to perform various mechanical tasks.
The Main Importance of 3D design of a beam engine in SolidWorks is to accurately model and simulate the physical structure and functionality of the beam engine within a virtual environment. This includes Visualization, Design Validation, Education, and training.

- Visualization: Providing a detailed visual representation of the beam engine, including its various components, such as the base, beam, piston mechanism, flywheel, gears, and linkages.
- Design Validation: Ensuring that the design of the beam engine is structurally sound and mechanically functional by simulating its operation and performance under different conditions.
- Collaboration: Facilitating communication and collaboration among engineers, designers, and stakeholders by sharing the 3D model for review, feedback, and iteration.
- Documentation: Generating accurate engineering drawings, assembly instructions, and technical documentation based on the 3D model to guide manufacturing and assembly processes.
- Education and Training: Providing a tool for educational purposes, allowing students and enthusiasts to learn about the principles of mechanical engineering and the operation of historical machinery like the beam engine in a virtual environment.

2. LITERATURE SURVEY

Thomas Newcomen (1664–1729):

- While not the inventor of the beam engine itself, Newcomen developed the first practical steam engine in 1712. His engine was known as the Newcomen atmospheric engine and utilized the principle of atmospheric pressure to move a piston within a cylinder.

James Watt (1736–1819):

- Watt is often credited with significant improvements to the design of the steam engine, including the invention of the separate condenser in 1765. This innovation vastly improved the efficiency and power of steam engines. While he did not invent the beam engine, his improvements contributed greatly to its development and widespread use.

Richard Trevithick (1771–1833):

- Trevithick was a Cornish engineer and inventor who made significant contributions to the development of steam-powered machinery. In 1797, he built the first high-pressure steam engine and later developed various types of steam locomotives. Although he did not invent the beam engine, his work influenced its further advancement.

John Smeaton (1724–1792):

- Smeaton was a civil engineer renowned for his contributions to the field of engineering, including his work on waterwheels and watermill machinery. While not directly associated with the beam engine, his understanding of mechanical principles and expertise in engineering likely influenced the development of steam engines during his time.

Matthew Boulton (1728–1809):

- Boulton was a prominent industrialist and entrepreneur who partnered with James Watt in the latter's steam engine ventures. Together, they formed the firm Boulton & Watt, which became one of the most successful engineering businesses of the Industrial Revolution. Boulton's support and business acumen were instrumental in the commercial success of steam engines, including those employing beam designs.

3. PROPOSED SYSTEM

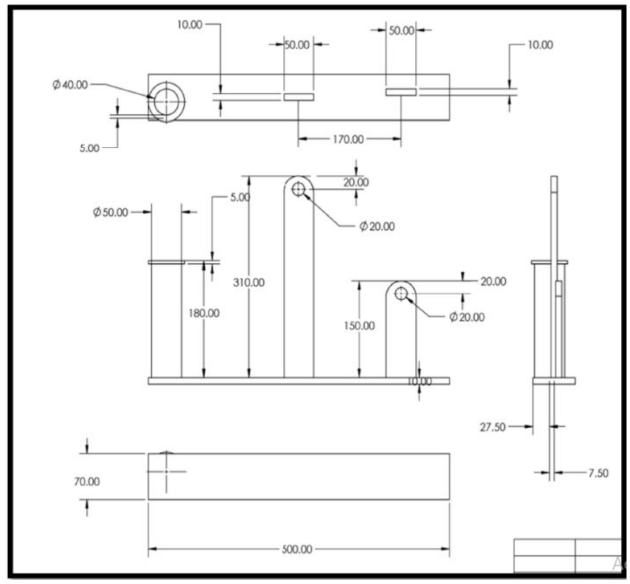
Design of Beam Engine:

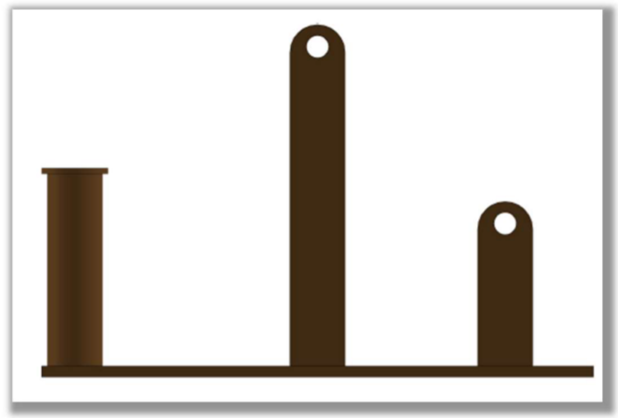
As per our design basis we are considering 6 Components of work. By using solid works tool, I constructed the Assembly of the Beam Engine

1) Frame
2) Crank
3) 2- Connecting rod
4) Lever
5) Piston

Frame:

Dimensional View





Frame refers to the structural framework that supports and houses the various components of the engine. Horizontal beam engines were early reciprocating steam engines used for pumping water or driving machinery during the Industrial Revolution.

Here is a breakdown of the components and uses of the frame in a horizontal beam engine:

Support Structure: The frame provides a sturdy support structure for the entire engine assembly, including the beam, cylinder, piston, and connecting rods. It ensures stability and rigidity during operation.

Beam Mounting: The frame typically includes mounts or bearings for the beam, which is a key component of the engine. The beam connects the piston to the pump or other machinery, transmitting the reciprocating motion generated by the piston to the desired work.

Cylinder Mounting: The frame houses the cylinder, which contains the piston. The cylinder
is securely mounted within the frame to maintain alignment and stability during operation.

Piston and Connecting Rods: The piston reciprocates within the cylinder, converting steam
pressure into mechanical motion. Connecting rods connect the piston to the beam,
transferring motion from the piston to the beam.

Guides and Supports: The frame may include guides and supports to ensure smooth and controlled movement of various components, such as the piston and connecting rods.

Valve Mechanism: In some designs, the frame may also house the valve mechanism
responsible for controlling the flow of steam into and out of the cylinder.

This is the frame here in this frame one hollow cylinder, 2 fillet edged bars are there where this cylinder the piston located in the cylinder and the wheel is in the small bar. The lever will connect in this above bar.

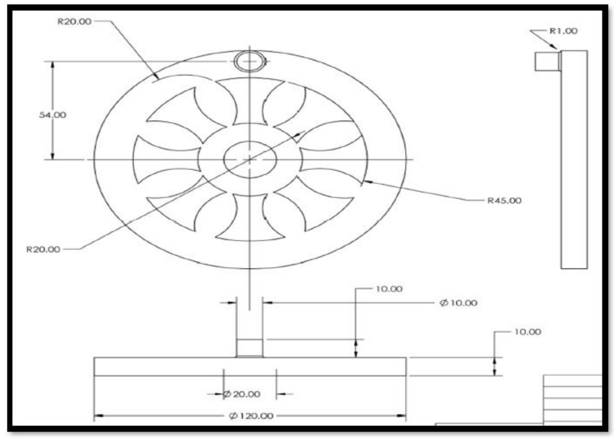
1) Base Length is 500mm and width is 70 mm
2) Diameter of the cylinder is 50mm
3) Large bar height is 310 mm and length 50 mm Hole diameter 20mm
4) Small bar length is 150 mm and length 50mm and hole diameter is 20mm

Here,

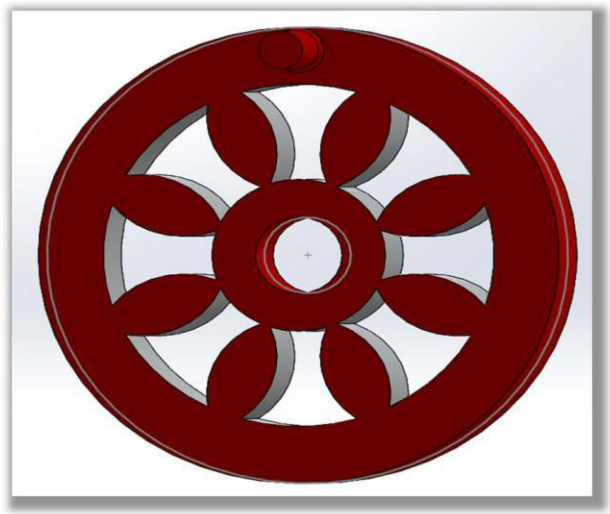
The distance between two bars is 170 mm and large bar is 7.5mm Infront of the smaller bar.

Crank:

Dimensional View



Original View



The crank is a mechanical component used to convert the reciprocating motion of the piston into rotational motion. This rotational motion can then be used to drive various machinery or pumps.

Here is how the crank works and its uses in a beam engine:

Conversion of Motion: The piston in a beam engine moves back and forth in a linear or reciprocating motion within the cylinder. The crank is connected to the end of the beam opposite the piston. As the beam rocks back and forth due to the motion of the piston, the crank converts this reciprocating motion into rotational motion.

Rotational Power Transmission: Once the crank converts the linear motion into rotational motion, this rotational power can be transferred to other machinery or devices. For example, the rotational motion can be used to drive a flywheel, which stores energy and helps regulate the speed of the engine, or it can be used to directly drive pumps, mills, or other equipment.

Efficiency Improvement: The use of a crank mechanism improves the efficiency and effectiveness of the beam engine. Without a crank, the reciprocating motion of the piston would be difficult to harness for most practical applications. The crank provides a means to efficiently convert this motion into a usable form of power.

Versatility: The crank mechanism allows for versatility in the types of machinery that can be driven by a beam engine. By connecting different types of equipment to the crankshaft, the engine can be adapted to perform a variety of tasks, such as pumping water from mines, driving factory machinery, or powering agricultural equipment.

This crank is looking like a wheel and this wheel will helps to give rotary motion of the connecting rod.

The Outer Dia of the wheel is 120mm and inner Dia is 20mm and extended boss circle is 10mm with a fillet 1mm.

Connecting Rod:

Connecting rods play a vital role in transmitting motion from the piston to the beam, and ultimately to the crankshaft for converting reciprocating motion into rotational motion. Here is a breakdown of connecting rods and their functions in a beam engine:

Linking Piston to Beam: Connecting rods are typically attached at one end to the crosshead, which is connected to the piston rod. The other end of the connecting rod is linked to the beam of the engine. As the piston moves back and forth within the cylinder, the connecting rod transfers this motion to the beam.

Transmitting Reciprocating Motion: The primary function of the connecting rod is to transmit the reciprocating motion generated by the piston to the beam. This motion causes the beam to pivot or rock back and forth around its fulcrum, which is typically located at or near the centre of the beam.

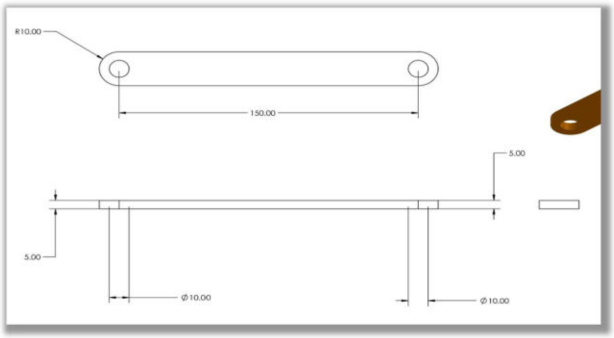
Maintaining Alignment: Connecting rods help maintain proper alignment between the piston, crosshead, and beam. Proper alignment ensures efficient transfer of motion and reduces wear and tear on the engine components.

Regulating Timing: The length and angle of the connecting rod can be adjusted to regulate the timing of the engine's operation. By changing the timing, engineers can optimize the engine's performance for different applications or operating conditions.

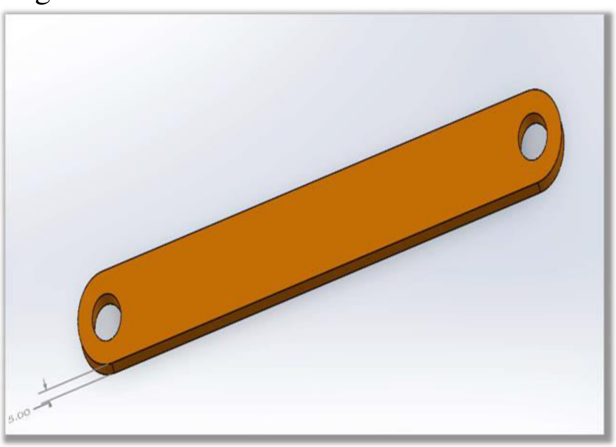
Strength and Durability: Connecting rods must be strong and durable to withstand the forces generated by the reciprocating motion of the piston. They are typically made of robust materials. such as steel and are designed to withstand high levels of stress and fatigue over extended periods of operation.

Balancing Forces: Connecting rods also help balance the forces acting on the piston and beam, ensuring smooth and stable operation of the engine. Properly designed connecting rods help minimize vibrations and fluctuations in engine performance.

Dimensional View:



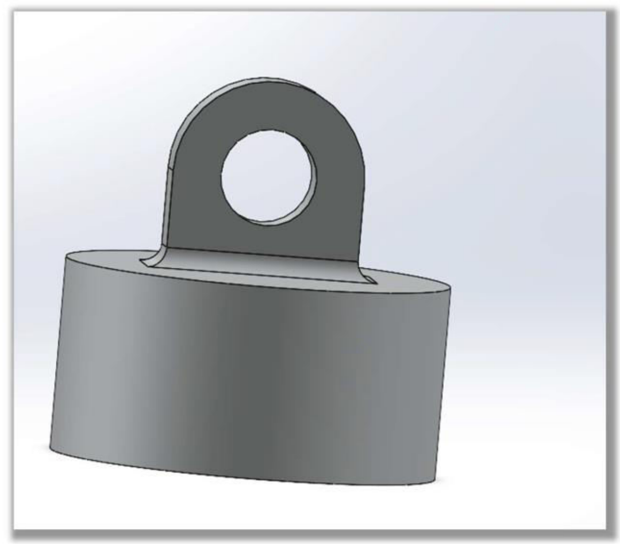
Original View:



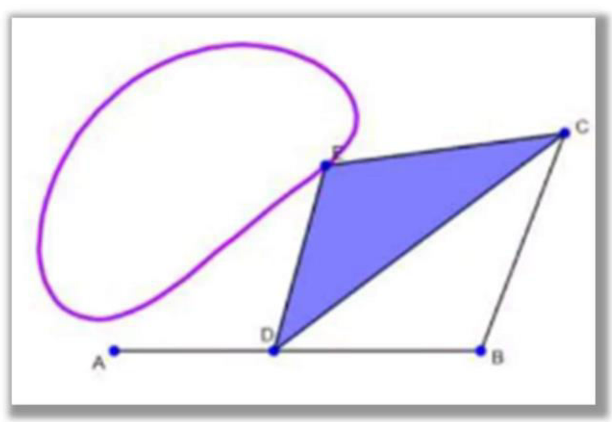
Two connecting rods are of different lengths. These rods are connected to lever, and one is crank other is piston based on this connecting rod it will gives the moment of the piston, Crank,
Lever

4. RESULTS

Hence the 3D Design of Beam Engine is drawn by using Solid works with their following Specifications. Building a beam engine involves a meticulous blend of historical research, engineeringprinciples,andpracticalcraftsmanship Bystudyinghistoricaldocumentationand engineering textbooks, enthusiasts can gain insight into the operation and design of beam engines, while also honing their understanding of thermodynamics, fluid mechanics, and machinedesign.Accessingplansorblueprintsforhi storicalbeamenginesprovidesapractical starting point for construction, supplemented by guidance from online communities, forums, and hands-on experience. Embracing a trial-and-error approach, enthusiasts iterate on their designs, refining them through practical experimentation and feedback. Prioritizing safety throughout the construction process is paramount, ensuring compliance with relevant regulationsandstandards.Ultimately,thecreationo fabeamengineisalabourofpassionand skill, marrying the artistry of historical craftsmanship with the precision of modern engineering.

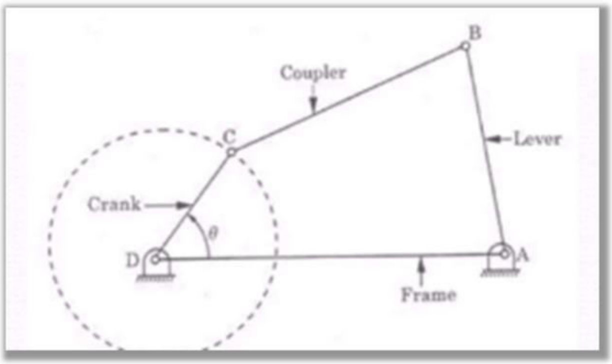


Inversions of Beam Engine:
Four Bar Mechanism:
It consists of four links Each of them forms a turning pair at A, B, C and D
The four links may be of different lengths.



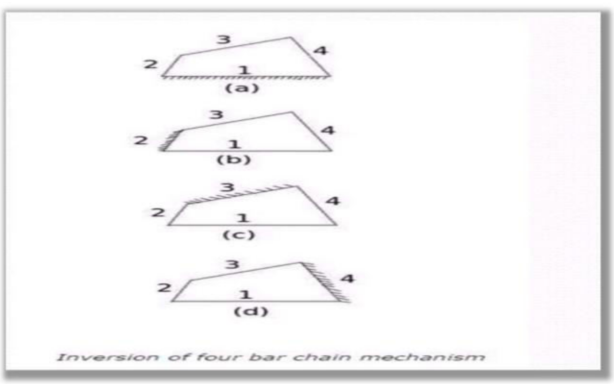
Grashoff 's law:

The sum of the shortest and longest link lengths should not be greater than the sum of the remaining two link lengths if there is to be continuous relative motion between the two links.



Inversion

Inversion is the method of obtaining different mechanisms by fixing different links in a kinematic chain, is known as inversion of the mechanism.



Inversions of four bar kinematic chain

- The four-bar chain mechanism consists of four turning pairs.
- The four different mechanisms are obtained by fixing one link at a time.
- Kinematically, all four inversions of kinematic chain are identical.
- However, their mobility can be varied by suitably changing the proportions of lengths of various links.

Beam engine (crank and lever mechanism).

A part of the mechanism of a beam engine (also known as crank and lever mechanism) which consists of four links, is shown in Fig. 5.19. In this mechanism, when the crank rotates about the fixed centre A, the lever oscillates about a fixed centre D. The end E of the lever CDE is connected to a piston rod which reciprocates due to the rotation of the crank. In other words, the purpose of this mechanism is to convert rotary motion into reciprocating motion.

- A part of the mechanism of a beam engine (also known as crank and lever mechanism).
- Beam engine introduced in Wanlockhead in 1745
- Consists of 4 links.
- The purpose of this mechanism to convert rotary motion into reciprocating machine.

Indicated Power & Efficiency Calculation

The power stroke points from the p-V diagram were identified and plotted separately. A fourth order polynomial was added to the plot using Microsoft Excel's trend line feature as this fitted the data well, and thus the curve equation was generated. For condensing engines, the effective pressure is defined as the difference in pressure between the piston side of the cylinder, and the back pressure, i.e., the vacuum on the condenser side.

The mean effective pressure was required to calculate the work done by the engine in one cycle, and hence its power rating. The total effective pressure was calculated by performing the definite integral to calculate the shaded area, then dividing by the cylinder volume (1.86 m3) to calculate the mean over the entire cycle, and finally subtracting the vacuum pressure (120 millibar absolute at time of testing)

$$\bar{P} = \left(\frac{1}{V_{max}} \int_0^{vmax} \text{Power Stroke } (dv) \right) - P_{condenser}$$

$\bar{P}$ = Mean Effective Pressure

V = Cylindrical Volume

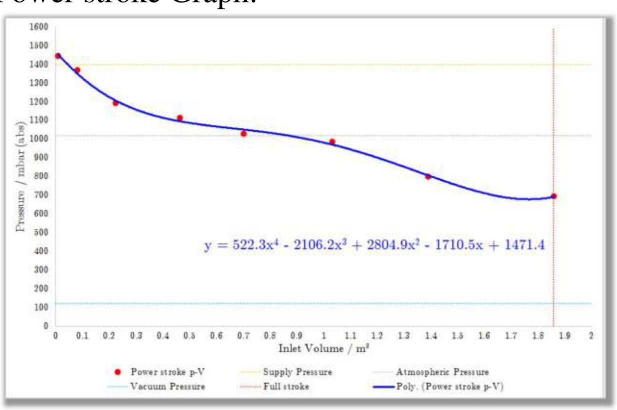
Power Output:
The work done by one engine cycle (Energy) was calculated by multiplying the mean effective
pressure of the power stroke (in Pascal), by the change in cylinder volume ($W=p\ \Delta V$). This resulted in a work done value of 159.3 kJ. To calculate the indicated power of the Engine, the work was divided by the time for an entire cycle. The cycle time was taken as 5 seconds, resulting in an estimated engine power of 31.86 kW, or 42.7 horsepower. The engine pumps 1.1 tonnes of water 12 metres vertically every stroke; therefore, the required output power was calculated as

Mechanical Efficiency: $\eta_{mechanical}$

The ratio of Input and output called Mechanical efficiency.

$$\eta_{Mechanical} = \frac{\text{Input}}{\text{Engine Output}}$$

Power stroke Graph:



5. CONCLUSION

We here by conclude that the 3D beam engine mechanism is generally used to convert reciprocating motion into rotary motion, but here we are using this mechanism to convert rotary motion into reciprocating motion. In conclusion, a beam engine represents a significant milestone in the history of engineering and industrialization. Its ingenious design allowed for the efficient conversion of steam power into mechanical motion, enabling a wide range of applications such as pumping water, driving machinery, and generating power. The beam engine's use of levers, pistons, and connecting rods exemplifies the principles of mechanical advantage and energy conversion, demonstrating how engineering innovation can revolutionize productivity and shape societies. While historical beam engines serve as inspiring examples of human ingenuity, modern interpretations and recreations continue to captivate enthusiasts and serve as educational tools for understanding the evolution of technology.

Future Scope:

The beam engine, while historically significant, has limited future scope in terms of practical applications due to advancements in technology. However, there are still some potential areas where the principles of beam engines could find

relevance or inspiration:
Education and Historical Preservation: Beam engines hold immense historical and educational value. They can be preserved and showcased in museums, historical sites, and educational institutions to illustrate the development of engineering and industrial

technologies. Tourism and Recreation: Restored beam engines can serve as tourist attractions, offering visitors a glimpse into the past and the opportunity to see these impressive machines in action through demonstrations and guided tours.

Engineering Inspiration: The design principles behind beam engines, such as mechanical linkages and reciprocating motion, can inspire innovation in modern engineering. Engineers may draw upon these principles when designing new mechanisms or solving mechanical challenges.

Steam Enthusiasts and Hobbyists: There is a vibrant community of steam enthusiasts and hobbyists who build, restore, and operate steam-powered machinery, including beam engines. While not for practical applications, these projects provide opportunities for hands-on learning and enjoyment.

Art and Sculpture: The intricate and imposing appearance of beam engines lends itself well to artistic interpretation. Artists and sculptors may draw inspiration from beam engines to create works of art that celebrate engineering achievements and industrial heritage.

Alternative Energy Research: While traditional steam engines are not considered a viable source of energy in today's context, concepts from steam power, such as thermal energy conversion and heat transfer, could inform research into alternative energy sources or efficiency improvements in existing systems.

Historical Reenactments and Events: Beam engines can be utilized in historical reenactments and events, providing immersive experiences for participants and audiences interested in reliving the past and understanding the challenges and innovations of earlier times.

REFERENCES

[1] S. S. Rattan [2009], Theory of Machines, TMH Publishers, New Delhi. [2] Sadhu Singh [2012], Theory of Machines, Pearson Education, New Delhi. [3] C.S. Sharma and K.Purohit [2010], Theory of Mechanisms and Machines, PHI Publishers, New Delhi 4. Ballaney [2005], Theory of Machines, Khanna Publishers, New Delhi. [4] Thomas Bevan [2005], Theory of Machines, CBS Publishers, New Delhi. [5] J.S. Rao and R.V. Dukkipati [2008], Mechanisms and Machine Theory, NAI Publishers, New Delhi. [6] J.E. Shigley [2010], Theory of Machines and Mechanisms, McGraw Hill Publishers, New Delhi. [7] S.K. Hajra Chowdhury & A.K. Haira Chowdhury [2004], Work shop technology Volume II, Media Promoters & Publishers, New Delhi. [8] P.C.Sharma [2006], Production Engineering, S. Chand Publishers, New Delhi. [9] R.K.Jain [2008], Production Technology, Khanna Publishers, New Delhi. [10] Prasad Rewade, Prakash S. Dabeer, Sandip A. Kale, V ishnu B. Ghagare and Deepak Patil, Structural Optimization of Rear Bumper Fog Lamp Punching Machine. International Journal of Civil Engineering and Technology, 8(2), 2017, pp. 607–617.