Design And Development of Hydraulic Solar Tracking System

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ABSTRACT

Nowadays solar power is considered as a reliable energy source for power generation and for many other applications. The challenge is to fetch the maximum amount of energy from solar radiation in which the sun is continuously changing its position in the sky. There are many problems associated with conventional solar panels because they are fixed in one direction. The position of the sun keeps on changing every day, and along with the sun, the solar panel must move in the same direction. The other system is also used for solar tracking, but they consume most of the energy produced by solar panels for tracking, which affects the efficiency of solar panels.

INTRODUCTION:

The basic problem associated with conversion of solar energy into useful form is that the solar modules used are stationary so during the morning and evening hours the sun rays fall at an angle upon the module. This decreases the efficiency of the system. Thus, the conversion efficiency of solar panels to charge the batteries in solar farms is not up to the mark.

The key components of hydraulic solar tracking systems include hydraulic actuators, a control system, and a fluid reservoir with a pump. Hydraulic actuators convert hydraulic pressure into mechanical force, enabling smooth and accurate movement of solar tracking mechanisms. The control system integrates sensors and algorithms to govern the operation of the system, ensuring precise tracking of the sun's position based on real-time data.

Hydraulic solar tracking systems offer several advantages, including enhanced efficiency, robust performance in harsh environmental conditions, and precise tracking capabilities. These systems find applications in utility-scale solar power plants, concentrated solar power (CSP) systems, and off-grid solar installations, contributing to the widespread adoption of solar energy worldwide.

Hydraulic Actuators: Hydraulic cylinders or motors serve as the primary actuators in hydraulic solar tracking systems. These actuators convert hydraulic pressure into mechanical force, allowing for smooth and precise movement of solar panels or mirrors.

Control System: A sophisticated control system governs the operation of hydraulic solar tracking systems. It integrates sensors, algorithms, and hydraulic valves to accurately position solar tracking mechanisms based on real-time data on

the sun's position and environmental conditions.
Fluid Reservoir and Pump: A fluid reservoir stores the hydraulic fluid, while a pump pressurizes the fluid and circulates it through the hydraulic system to drive the actuators. Hydraulic fluid is typically chosen for its excellent lubricating properties and resistance to temperature fluctuations.

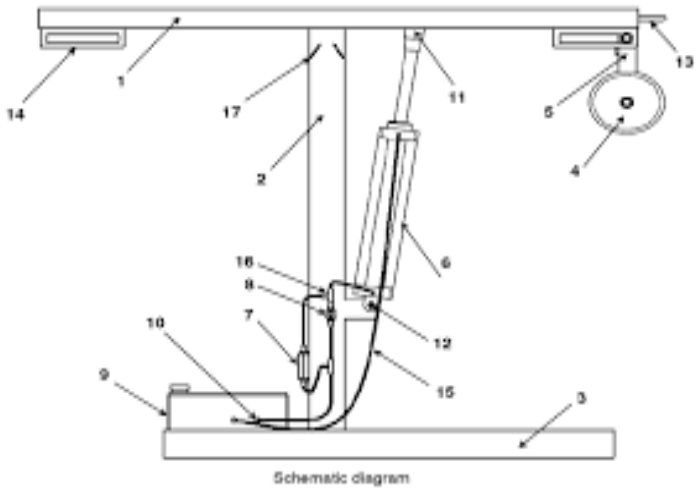


Fig-1 Schematic Diagram

1) Panel seat
2) Column
4) Weight
3) Base
5) Weight holder
6) Double acting cylinder
7) Check valve
8) Flow control valve
9) Reservoir
10) Filter
11) Rod end mounting
12) Piston end hinge
13) Handle
14) Counterweight platform
15) Connecting hose
16) T Connector
17) Stopper

Tracking mechanism:

The mechanism selected for the tracking system is based on the lever principle. The type of lever used to manipulate the required load is the Second type lever. Basically, a lever is a rod or bar capable of turning about a fixed point called fulcrum. It is used as a machine to lift / transmit a load by the application of small effort. The ratio of load lifted to the effort applied is called mechanical advantage. A lever may be Straight or curved and the forces applied on the lever (or by the lever) may be parallel or inclined to one another.

Application of Levers in Engineering Practice:

The load (W) and the effort (P) may be applied to the lever in three different ways.
The Fulcrum is denoted by F and direction of reaction is indicated by an arrow mark.

Off-Grid Solar Installations: Hydraulic solar tracking systems can be employed in off-grid solar installations, such as remote telecommunications towers or agricultural facilities, to ensure efficient energy generation and maximize the use of available solar resources.

1. First type/First class lever:

In the first type of lever, the fulcrum is in between load and effort. These levers are commonly used in railway signaling, rocker arms, hand pumps, foot levers etc. As shown in figure.

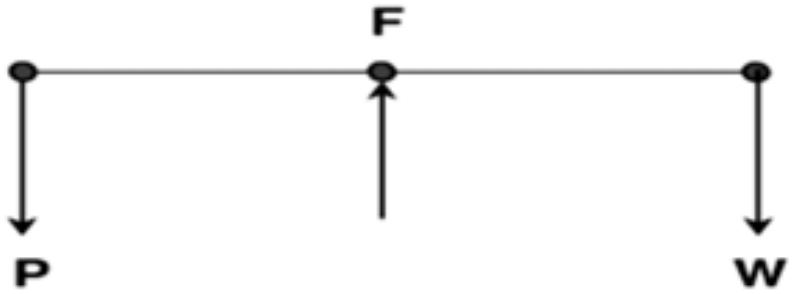


Fig-2 First class lever

2. Second type/Second class lever:

this type, the load is in between the fulcrum and effort. The application of this type of lever is found in levers of loaded safety valves. As shown in figure.

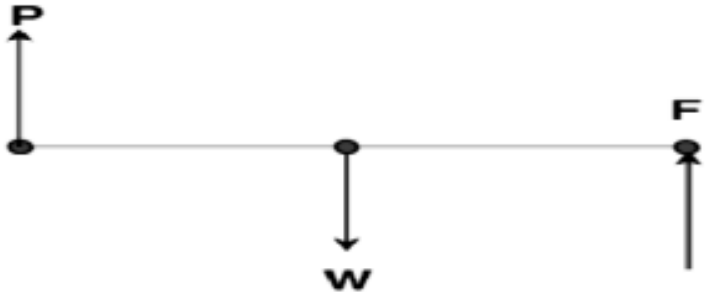


Fig-3 Second class lever

3. Third type/Third class levers:

In this type of levers, the effort is in between the fulcrum and load. The use of such a type of levers is not recommended in engineering practice. However, a pair of tongs, the treadle of a sewing machine, is an example of this type of lever. As shown in figure.

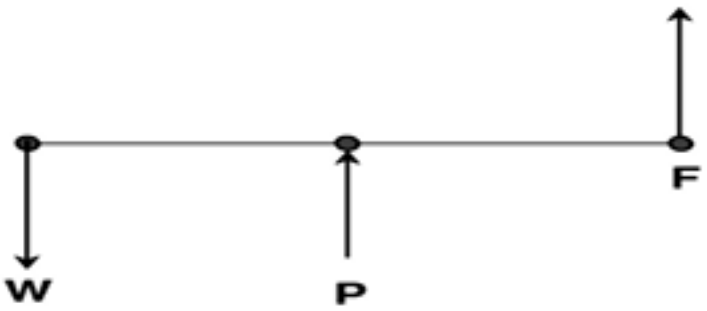


Fig-3 Third class lever

Working procedure:

The working procedure of the designed tracking system is explained by the hydraulic circuit diagram and by the schematic diagrams. Each duty cycle of the system contains two steps.

a. Tracking:

As the tracking weight acts on the piston through the piston rod, it pushes the oil out of the cylinder and the oil flows towards the reservoir. While, due to the restricted cross-sectional area at flow control valve the piston moves with a velocity equal to calculated tracking velocity. During this action the check valve remains closed, hence oil is allowed to flow only through the flow control valve. At the rod end of the cylinder, the oil is sucked into the cylinder due to the vacuum pressure created by the applied weight. As shown in fig.

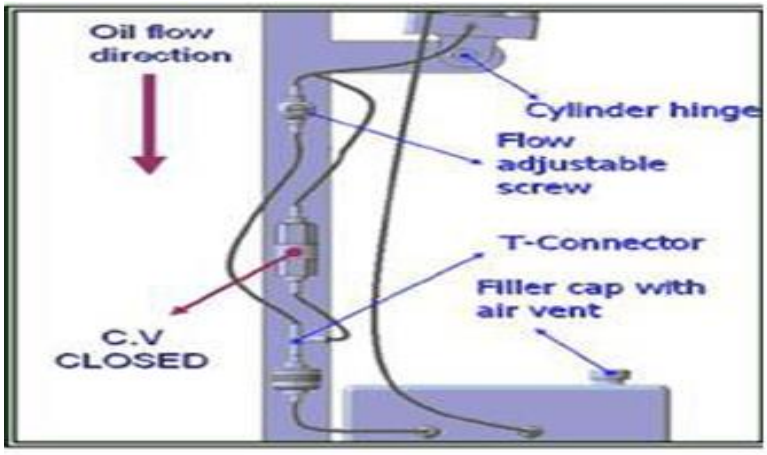


Fig-4 Tracking

b. Return:

As the tracking time finishes, the panel seat must be rotated by applying the torque, manually, to bring it back into initial position. The vacuum pressure is created at the piston end chamber and oil from the reservoir rushes towards the cylinder. As soon as the system pressure exceeds the cracking pressure of the check valve, the check valve opens and allows full flow of oil from it, reducing the time required for repositioning operation.

The flow control valve also allows the oil to flow from it, increasing rate of flow and reduced panel repositioning time. At the rod end of the cylinder, the piston forces the oil. The oil pressure increases and oil flows out of the cylinder. Oil returns to the reservoir through a filter placed in the return line. As shown in fig

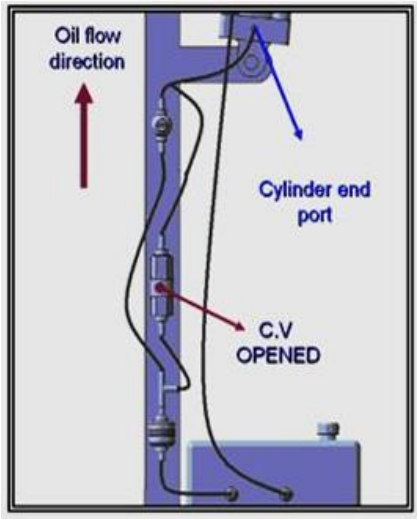


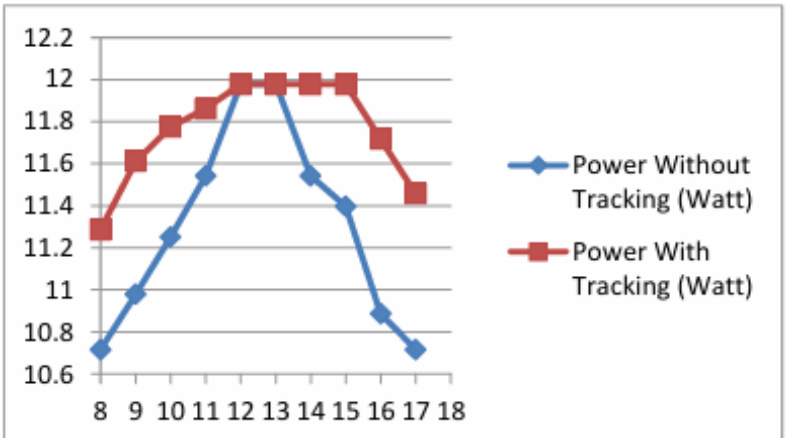
Fig-5 Return

Advantages:

a) Hydraulic solar tracker is easy to design, and manufacture compared to other tracker systems.
b) Increased reliability and robustness of the hydraulic control system compared with another solar tracker.
c) Hydraulic solar trackers generate more energy than other tracking systems like electric solar trackers.

Disadvantages:

a) Structurally less rigid than permanent mounts and hence can be vulnerable to storm damage.
b) More chances of leakage of hydraulic oil.
c) Required manual power to pump the oil in the cylinder.



Graph

CONCLUSION:

This is the first attempt made towards utilizing gravitational energy as a driving force for solar tracking systems and in providing a suitable tracking system for remote places. In view of increasing demand for electrical power, this tracking system can contribute a little (around 87.6 kW-hr per year) in the fulfillment of this demand.

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