Test Rig For Vane Pump

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Abstract - *The vane pump test rig is a versatile experimental setup designed to evaluate the performance and characteristics of vane pumps. Vane pumps are commonly used in various industrial applications to deliver fluids with high efficiency and reliability. The test rig provides a controlled environment to measure and analyze the pump's parameters, such as flow rate, pressure, power consumption, and efficiency, under different operating conditions. The test rig consists of several key components, including a vane pump, a motor, a flow measurement system, a pressure measurement system, and an instrumentation and control system.*

Key Words: Vane Pump, Test Rig

1. INTRODUCTION

When we are required to lift fluid from a lower elevation to a higher elevation, external equipment is required. This equipment is the pump. Around 18 – 20% of the world's electrical power is consumed by pumps in many ways. A Pump is a device that uses to transfer different fluids from one location to another. It is a mechanical equipment which lifts or transfers fluids from a lower elevation region to a higher elevation region, by converting electrical energy to hydraulic energy

1.1 Working of Pumps:

Pumps are mechanical devices used to move fluids from one place to another. They work by creating a pressure difference that propels the fluid through the pump. Pump systems may include control mechanisms and monitoring devices to regulate flow rates and protect against pressure variations. Selecting the right pump for an application is crucial for efficient and reliable operation.

1.2 Main Types Of Pumps

Pumps are classified into two main groups, and it is further classified into many groups.

1. Positive Displacement Pump.
2. Dynamic Pump.

2. Major Types of Rotary Pumps

Gear pumps are positive displacement pumps that use interlocking rotating gears to move fluids. They offer high volumetric efficiency and can handle viscous liquids

Lobe pumps are positive displacement pumps that use intermeshing lobes to move fluids. They offer high volumetric efficiency and can handle viscous liquids without causing shear. Lobe pumps are commonly used in hygienic applications and can be designed for clean-in-place (CIP) operations. They have limited pressure capability and self-priming ability.

Vane pumps are positive displacement pumps that use rotating vanes to move fluids. They offer self-priming capability, high volumetric efficiency, and a smooth flow

A screw pump is a type of positive displacement pump that uses rotating screw- like elements to move fluids. It consists of one or more rotating screws or rotors that intermesh within a cylindrical pump casing. The screw profiles create sealed chambers as they rotate, trapping and displacing the fluid

1. Types Of Vane Pumps

As mentioned earlier, vane pumps are positive displacement pumps that use vanes mounted to a rotor to increase the pressure of the flowing fluid. The vanes of the vane pumps can be variable in length or tensioned to maintain contact between the vanes and the pump wall as the vanes revolve. There are mainly three types of vane pumps, each type has its own set of benefits :

a) Unbalanced Vane Pumps
b) Balanced Vane Pumps
c) Variable Displacement Vane Pumps

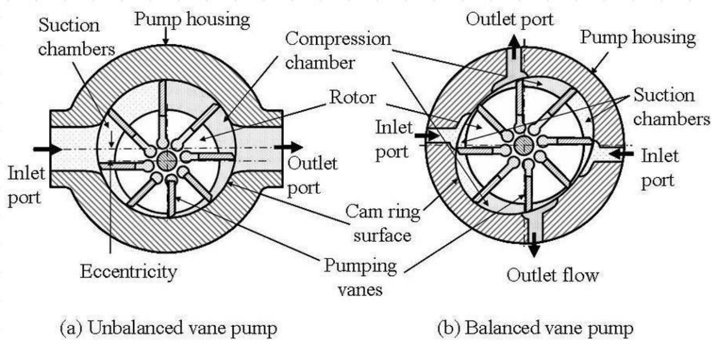

Fig -1: Types of Vane Pumps.

Balance type variable vane pump is taken shape from balance type available vane pump by improving certain structure, which is mainly composed of stator, rotor, vane, oil inlet, oil outlet, floating block and connecting spring etc., the stator is set in the hull, and the rotor is put in the stator. 12 groups of vane is distributed on rotor evenly, 12 groups of floating block are put between two adjacent vanes. The floating block is structured by a block and a connecting spring, the block is installed in the block trough, and the connecting spring is set in the spring trough. Description of the balance type variable vane pump working principle

The variable principle of balance type variable vane pump is the block of the floating block is elastic in the trough in the rotor. Decided by the different speed of the rotor, the block can slither in the block trough, the space taken by the block has a bearing on the speed of the pump, so the pump is variable. When the rotor speeds up the blocks consume more space, at the same time the oil inlet the pump reduces. When the rotor speed is reduced, floating block experience within shift, pump the effective volume of the space, the pump per turn, absorbing oil content increase.

The balanced type variable vane pump, specifically designed for energy-saving purposes in automobile steering systems, operates by adjusting the pump's displacement to compensate for speed changes and flow variations. This adjustment is achieved through the vane pump variable mechanism. By dynamically changing the pump displacement, the balanced type variable vane pump can increase the output flow to match the increased speed and reduce excess flow generation. As a result, it helps to minimize the consumption of reactive power in the steering system.

3. CIRCUIT LAYOUT OF THE TEST RIG:

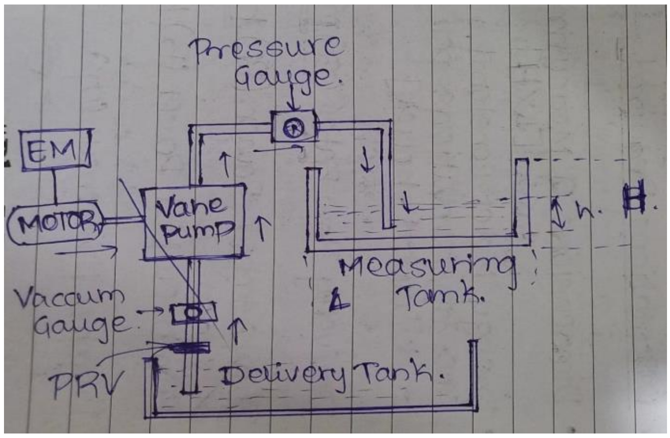

Fig -2: Circuit Layout of Test Rig.

The frame is usually made of mild steel. It is strong enough to withstand all types of loads in working condition. All other parts are fitted to the frame. Frame is helping the supporting of the various light load support. Frame shows the good aesthetic loop. Every machine should have required the good frame design. Frame material should have high strength because frame balancing of another machine load. In ours project the frame showing important role. The vertical pulley and sprocket are mounted on vertical support of the frame.

Main whole project assembly our project mounted on frame. The proper selection of material for the different part of a machine is the main objective in the fabrication of machine. For a design engineer it is must that he be familiar with the effect, which the manufacturing process and heat treatment have on the properties of materials. Properties of Mild Steel: M.S. has a carbon content from 0.15% to 0.30%. They are easily wieldable thus can be hardened only. They are similar to wrought iron in properties. Both ultimate tensile and compressive strength of these steel increases with increasing carbon content. They can be easily gas welded or electric or arc welded. With increase in the carbon percentage weld ability decreases. Mild steel serves the purpose and was hence was selected because of the above purpose.

DESIGN MODELS

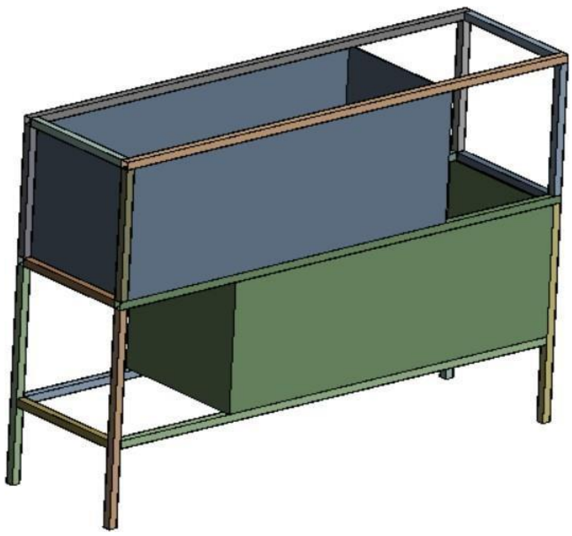

FIG 1.3 CAD OF FRAME

FIG 1.4 BOUNDARY CONDITIONS FOR ANALYSIS

Using a CAD program that either comes with the FEA software or 3D CAD modeling tools like Pro-E, Catia, and solid Edge etc. provided by another software vendor, the structure is modeled. The final FEA model consists of several elements that collectively represent the entire structure. The elements not only represent segments of the structure, they also simulate its mechanical behaviour and properties.

Regions where geometry is complex (curves, notches, holes, etc.) require increased number of elements to accurately represent the shape; whereas, the regions with simple geometry can be represented by coarser mesh (or fewer elements). The selection of proper elements requires prior experience with FEA, knowledge of structure's behaviour, available elements in the software and their characteristics, etc. The elements are joined at the nodes, or common points.

In the pre-processor phase, along with the geometry of the structure, the constraints, loads and mechanical properties of the structure are defined. Thus, in pre-processing, the entire structure is completely defined by the geometric model. The structure represented by nodes and elements is called "mesh". In this step, the geometry, constraints, mechanical properties and loads are applied to generate matrix equations for each element, which are then assembled to generate a global matrix equation of the structure. The equation is then solved for deflections. Using the deflection values, strain, stress, and reactions are calculated. All the results are stored and can be used to create graphic plots and charts in the post analysis. This is the last step in a finite element analysis. Results obtained in step 2 are usually in the form of raw data and difficult to interpret. In post analysis, a CAD program is utilized to manipulate the data for generating deflected shape of the structure, creating stress plots, animation, etc. A graphical representation of the results is very useful in understanding behaviour of the structure.

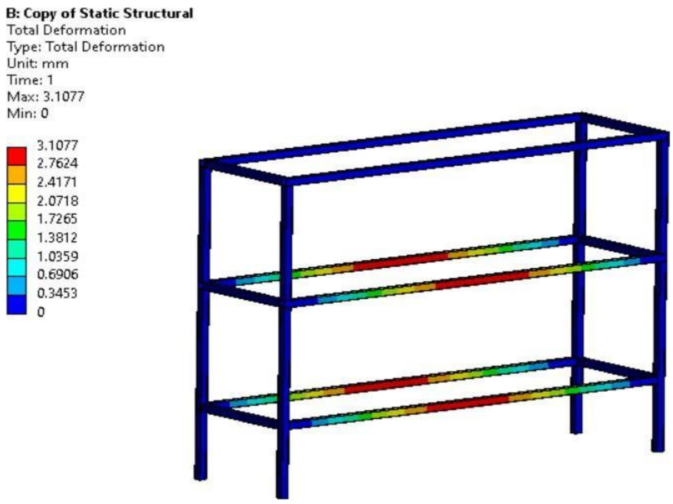

FIG 1.5 TOTAL DEFORMATION IN FRAME

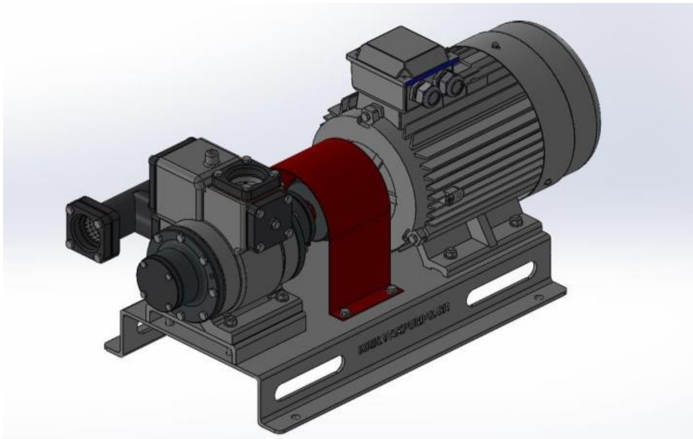

FIG 1.6 VANE PUMP CAD MODEL

Vane pump calculations involve determining parameters such as flow rate, power requirements, and pump efficiency. The volumetric flow rate is calculated by multiplying the displacement per revolution by the pump speed. Power requirements are determined by multiplying the pressure by the flow rate and dividing by the pump efficiency. Pump efficiency is calculated by dividing the output power by the input power. The specific speed of the vane pump can be found using a formula that considers pump speed, flow rate, and head. It is important to consult the pump manufacturer's specifications for accurate calculations and consider any additional factors specific to the pump model being used.

EXPERIMENTAL PROCEDURE:

1. After completion of installation, system will be ready for experiments.
2. Switch on the mains supply. Let the system run for 2-3 minutes for stabilizing.
3. Put OFF the return line cock, so the water level in measuring tank will start rising.
4. Note the reading as per reading table.
5. Put ON the return line cock for draining the water in measuring tank.
6. Adjust the delivery pressure to 0 Kg/cm2.
7. Put OFF the return line cock. So the water level in measuring tank will start rising.
8. Note the readings as per observation table.
9. Put ON the return line cock for draining the water in measuring tank.
10. Subsequently note down readings for further pressure range in the interval of 5 BARS.

CALCULATIONS

1) Delivery Flow Rate: -

Initial Reading of Measuring Tank = 'A'

Final Level of Measuring Tank = 'B'

Time taken = t

Height (h) = A – B

Volume of rise of fluid is,

=> Volume (V) = L * W * h

Delivery Flow Rate;

=> Delivery Flow Rate (Q) = Volume / t ... (m3/sec)

2) *For Pump Input Power:* -

P_i = 3600/ (x * tm)

t_m - Time for 10 Pulses

3) *Pump Output Power:* -

Po = Delivery Pressure * Flow rate

4) *Efficiency:* -

Efficiency;

η = (Output Power) / (Input Power)

REAL TIME TEST RIG SET UP

Discharge Flow Rate: The discharge of the vane pump remains fairly constant, indicating a consistent flow output. However, as the pressure increases, there may be a reduction in the discharge flow rate. This suggests that higher pressures can slightly limit the flow capacity of the pump.

Efficiency: The efficiency of the vane pump shows an increasing trend with an increase in pressure up to a certain point. This implies that the pump operates more efficiently at higher pressures within a specific range.

CONCLUSION

The analysis of the vane pump revealed several conclusions. Firstly, the discharge of the pump remains fairly constant, although higher pressures may cause a slight reduction in the flow rate. Secondly, the pump's efficiency exhibits an increasing trend with increasing pressure up to a certain point, beyond which it may start to decrease. Lastly, the power required to drive the pump shows a linear relationship with the pressure, indicating that power consumption is directly proportional to the pressure. These findings provide valuable information for understanding the performance characteristics of the vane pump and can aid in optimizing its operation and assessing its power requirements in different applications.

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