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CHAPTER 1

FLUID MECHANICS AND FLOW BEHAVIOUR IN DIAPHRAGM PUMP

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1.1 INTRODUCTION

Diaphragm pumps are commonly used their ability to handle a wide range displacement pump because the flow rate vary significantly with the pump's expulsion. They are used to transport fluids with various types of viscosity and fluids with a high particle count. Diaphragm pumps can withstand a wide range of harsh chemicals, including acids, since they are made up of various diaphragms and body materials (Agarwal, 2019).

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Another name for this pump is a membrane pump. They use a combination of the reciprocating action of the rubber, thermoplastic, or Teflon diaphragm, and appropriate valves on any face of the diaphragm to push a liquid. These pumps are widely used in various industries to handle a wide range of fluids with various types of viscosity (Agarwal, 2019). These pumps are commonly utilized in industries to handle various types of fluids because they have different diaphragms and body materials.

These pumps can push fluids with high, low, or medium viscosity. In addition, they can handle a variety of aggressive substances such as acids (Agarwal, 2019).

1.2 THE BACKGROUND HISTORY OF THE INDUSTRY

Diaphragm pumps are utilized in commercial, industrial, and scientific applications that require high pressure. For example, they are utilized as metering pumps in the water treatment industry and act as vacuum pumps in numerous industries such as chemical, food and beverage, and pharmaceuticals. Filter presses, dewatering, spraying, and cleaning are only a few of the other applications.

The demand for diaphragm pumps is rising in tandem with the rise of the water, chemical, and wastewater and sanitation industries. Increasing industrialization, rising demand for proper sanitization, emerging urbanization, organizations investing in water infrastructure, and high living standards drive the diaphragm pump market. Their low maintenance operating mechanism and durability are also contributing to the market's growth. The Asia-Pacific region controls a large portion of this industry. Although diaphragm pumps have been used in the power generation business, pulsation-related concerns and the slump in the oil and gas industries may limit the market's growth (Agarwal, 2019).

According to the report, the mechanism, action, discharge pressure, end-user, and geography are dividing the diaphragm

pump market. The market is divided into mechanical, hydraulic, solenoid, and air segments based on the mechanism. The market is classified into single acting and double acting based on action. The market is divided into three categories based on discharge pressure: up to 80 bar, 80 bar to 200 bar, and greater than 200 bar. The market is divided into end-user sectors such as water and wastewater, ceramics, oil and gas, food and drinks, chemicals, pharmaceuticals, etc. For North America, Europe, Asia-Pacific, and Latin America, Middle East and African (LAMEA), there is a geographic breakdown and in-depth examination of each segment mentioned earlier. Asia-Pacific now leads the market in terms of demand and is projected to continue to do so in the future (Agarwal, 2019).

Further developments, such as the usage of diaphragm pumps in artificial hearts and the boating industry and their expanding use in process applications in a variety of industries, are assisting the market's growth. For example, in 2015, Graco Inc. introduced the Husky I 050e, a double diaphragm pump that combines the features of both the air and electric pumps. In addition, Hillenbrand, Inc. bought ABEL Pumps LP, a major diaphragm pump producer, in 2015 to join the flow control sector.

1.3 WORKING PRINCIPLE OF DIAPHRAGM PUMP

Figure 1.1 shows a diaphragm pump. A diaphragm pump creates a temporary hall through which liquid is received and ejected using two bending diaphragms that respond back and forth. The pump operates on the principle of air displacement, which is similar to a fluid-air separation partition (Agarwal, 2019).

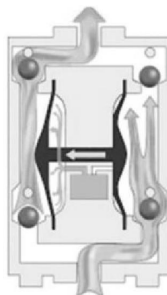


Figure 1.1: Adiaphragmpump [1]

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The suction cycle and discharge cycle are the two primary parts that make the system work. Compressed gas enters the left inner chamber throughout the suction cycle, inflicting the opposing diaphragm to make suction and lift the lower valve ball, ingestion fluid in at the inlet. However, the left fluid chamber is within the discharge cycle (Rockwell, 2020). This causes compressed air to enter the right lumen during the injection cycle, pushing the top ball of the valve open and releasing liquid. In this case, the left ventricle is in a suction cycle.

1.3.1 COMPONENTS OF DIAPHRAGM PUMP

Air-operated double-diaphragm (AODD) pumps are among the most potent workhorses in the business and one of the essential sorts of technologies found within factories and plants. Pumps with AODD can handle the roughest fluids in the worst conditions. In addition, AODD pumps are dependable and require less maintenance because they have a few parts. It is also adaptable and may be used in various industries ranging from mining to food and beverage processing (Rockwell, 2020).

These are the essential components of an AODD pump that can be seen through fluid side components and air side components. Figure 1.2 shows the components of the diaphragm pump.

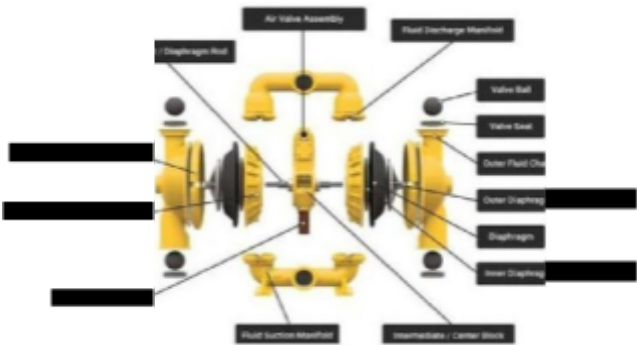


Figure 1.2: Components of Diaphragm Pump (Rockwell, 2020).

The first component on the liquid side is the liquid suction/discharge manifold, which is screwed or connected to the outer chamber to provide a seal and liquid passage. The seal/valve seat secures the ball in the manifold. The ball cage provides an airtight seal between the manifold and the outer fluid chamber (Rockwell, 2020).

Next is the outer fluid chamber. It is a part of the fluid path of the pump. The seat seals are additionally joined and sealed at the suction and discharge manifolds. Between the diaphragm's bead and the inner chamber/air chamber, it is likewise sealed. Furthermore, the revolving diaphragms pull the fluid in on one side and push it out on the other to provide the pumping action (Rockwell, 2020).

The third part is the diaphragm. It acts as a barrier between the liquid side and the air side of the pump. The standard diaphragm supports the seal in two locations: on the centre hole of the diaphragm and the seal. The outer diaphragm plate is connected to the main shaft in the centre hole of the diaphragm. When tightened correctly, a tight seal will be formed. The membrane is sealed around the outer ring, usually in moulded sealing beads or sealing grooves in the inner air chamber and outer liquid chamber. Tightening the screws of the outer chamber (a screw-in pump) or fixing the band clamp (clamp pump) will achieve compression.

The inner and outer diaphragm plates are over-moulded in some bonded polytetrafluoroethylene (PTFE) diaphragm designs, so there is no centre hole. These bonded diaphragms can be manually tightened onto the threaded diaphragm shaft without the separate diaphragm plates. For many hazardous chemical applications, this design is the best option. On the auxiliary side of the pump, the diaphragms are dynamic components that activate (bend) when air pressure is applied behind them. The adjusted air pressure generates a force on the air side of the diaphragm, which is then transferred to the pumped medium. Diaphragms are available in various materials and designs to meet various applications, including chemical compatibility, temperature, abrasion resistance,

and certification.

1.4 AIR SIDE COMPONENTS

There is a component on the air side. Assemble the spindle/diaphragm by connecting the rod first. Next, connect the membrane components (plate and inner/outer membrane). The shaft thread can be external or internal and is connected to the external plate (Rockwell, 2020). The inner chamber/air chamber is the second part of the airside components. When the pressurized air is delivered into either side alternately, it forms a seal with the diaphragms. This situation puts pressure on the diaphragms' backsides, which in turn puts pressure on the fluid.

The third part is that the air valve. By causing compressed gas into one in all the two air chambers, it shifts the diaphragm/connecting rod assembly. The air valve additionally guides air from the opposing air chamber to the intermediate/centre block exhaust port, permitting it to be ventilated to the atmosphere. The fourth and final block is that the intermediate/centre block. Seals and bushings ordinarily guide the most shaft/diaphragm rod. The most shaft conjointly referred to as the pilot shaft provides alternate pressure to the air valve, inflicting the main valve spool to maneuverer and the pump to reciprocate, causing the pump to pump.

Air is discharged from the intermediate block through the outlet, and in most cases, from the air outlet muffler.

The exhaust muffler is the last component. It helps reduce the noise of the air pump; it comes in different characters, substances, and measurements. The muffler can also be removed to divert the exhausted air from the pump so that it can be immersed in water or just suck in the air in a safe place or outdoors to reduce the noise in the workplace (Rockwell, 2020).

1.5 INVOLVED PARAMETERS THAT CAN BE OBTAINED FROM DIAPHRAGM PUMP

1.5.1 Flowrate Rate or Pumped Volume

The pumped volume, also known as the flow rate of a pump, is the amount of fluid that flows out of the pump in the same time interval. The flowrate was traditionally stated as:

- i. m³/s (cubic meters per second)
- ii. l/min (liter per minute)
- iii. GPM (gallon per minute)

1.5.2 Dispensing

The use of a pneumatic diaphragm pump or an air-operated diaphragm pump ensures smooth service in beverage dispensing. It is intended for the dispensing of smoothies and juice mixes containing fruit pulp and other particles. The pump's smooth flow channel allows pulp-containing liquids to pass through without being trapped on moving parts of the pump or emulsion into the finished product. As a result, it can dispense strawberry and banana smoothie mixes, condiments, frozen beverages, or frozen drinks such as Slurpee and acidic seasoning like pizza sauce Comet, (2019, October 31). Figure 1.3 shows an example of dispensing process.

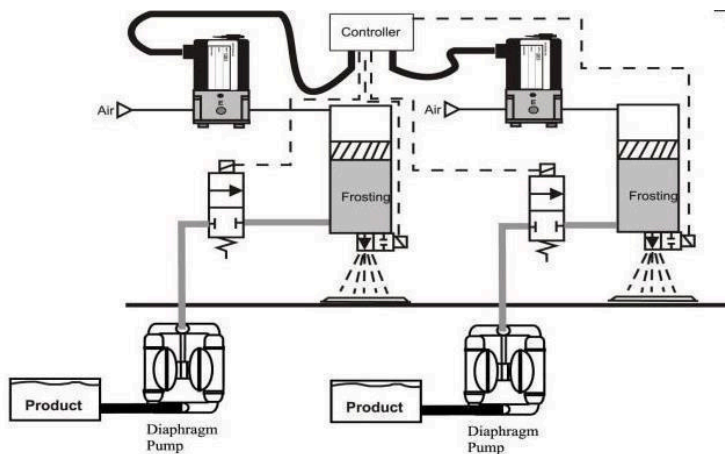


Figure 1.3: Example of dispensing process using the diaphragm pump (Smith, 2021).

1	Number of participants in each group	Five
	Equipment	Pen and papers
	Procedures	1. All participants will be brief about the name of each component of the pump. 2. After the briefing, each group will be presented with the component of the pump on the table. 3. The components were labelled as 1, 2, etc. 4. Participants from each group must name the parts correctly.

.6 ACTIVITIES HAND ON RELATED TO DIAPHRAGM

Activity 1: Labelling the components of diaphragm pump objectives as shown in Table 1.1:

- To be to know each component of the diaphragm pumps
- To be able to memorize the shape for each component on the diaphragm pumps

Table 1.1: Activity 1



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1.7 CONCLUSION

Positive displacement pumps, such as the diaphragm pumps, combine the reciprocating motion of thermoplastic, rubber, or Teflon diaphragms with appropriate valves on each side of the diaphragm. The two primary components that make the system work are the suction cycle and the discharge cycle. Then, it is divided into two sides: the fluid side and the air side. The flow rate or pumped volume and pressure are two significant characteristics derived from diaphragm pumps. Next, the construction of the piping system must have a great future enabled pipe layout with the fewest components possible while still ensuring optimal pump performance. There are several methods for positioning and installing diaphragm pumps. Methods include self-priming, double suction manifolds, and immersion. Other than that, the diaphragm pump has some advantages and disadvantages. Some of the benefits are self-prime, running dry, and not being prone to overheating and being explosion proof. At the same time, the drawback includes being less consistent in fluid distribution and not providing high pressure. Diaphragms are used in a variety of applications, including dewatering, dosing, and

dispensing.



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