

Overview of Peristaltic Pump Suitable For Various Slurries and Liquids

Student Atish
A. Chavan

Student Amol A.
Patil

Student
Aashish S. Patil

Student Vaishnav N.
Chougale

Student Lecturer N. S.
Patil

Department of Mechanical Engineering, Sharad Institute of Technology, Polytechnic, Yadrav, Ichalkarnji,
Maharashtra, India

Corresponding Author: atishchavan30@gmail.com

Abstract – A peristaltic pump is a type of positive displacement pump used for pumping a variety of fluids. The fluid is contained within a flexible tube inside a circular pump casing. A rotor with a number of “rollers”, “shoes” or “wipers” attached to the external circumference compress the flexible tube. As the rotor turns, the part of the tube under compression closes, thus forcing the fluid to be pumped to move through the tube. Additionally, as the tube opens to its natural state after the passing of the cam (restitution) fluid flow is induced to the pump. In this paper construction, basic principle of working and pump design specification has been discussed. The advantages and critical application have been presented.

Keywords – Occludes, Positive displacement pumps, Peristalsis, Restitution, Rollers, Tubes.

I. INTRODUCTION

The word Peristalsis originated from the Greek word ‘Peristalticos’, which means compressing and expanding. Peristalsis is symmetrical contraction and relaxation of muscles which moves in the form of a wave down a muscular tube. Peristaltic transport is nature’s way of moving the content within hollow muscular structures by successive contraction, expansion of muscular fibers. This mechanism is responsible for the pumping of physiological fluids through the different parts of the human body.

Pump is mechanical device that lifts fluid from lower level to higher level, by converting the mechanical energy supplied to it, into hydraulic energy. This pump is a positive displacement pump which is used for pumping variety of fluids through a flexible tube, by successive contraction and expansion of the tube by the rollers or shoes.

The pump consist of a tube which is squeezed flat by a roller and then the content of the tube is pushed forward. Behind the roller the tube will acquire its normal shape because of the elastic property of the tube. In this way a vacuum is created and hence the tube is refilled and ready for the next squeezing.

The flexible pipe should be capable of withstanding large amount of heat that is generated because of friction between the roller and the pipe, which calls for usage of special pipe materials. Some of the flexible pipe materials are silicone rubber, fluoro polymers, Natural Rubber, Nitrile Buna Rubber(NBR), Food grade Nitrile Buna Rubber.

Factors which affect the flow of fluid in the peristaltic pump are flexible tube inner diameter, viscosity of the fluid, pump speed and suction pressure. Main application

of peristaltic pump is in dialysis machine. Open heart bypass pump machine, food manufacturing, beverage and pharmaceutical production.

Peristaltic pump unique advantages are that, there is on risk of cross-contamination, the change over time is less than five minutes. They are self prime pumps and can be used to pump heavily corrosive, abrasive and viscous fluids. Main disadvantages are that the tube will tend to degrade with time and require periodic replacement and the flow is pulsed at low rotational speeds.

1. Need of Peristaltic Pump:

Various devices have been proposed in the past for pumping viscous fluids and slurries. Such slurries are frequently very corrosive and abrasive to machinery and pumping operation involving them have presented serious problems in many instances because of the suspended solids they contain. The slurry commonly comprises a gelled liquid media in which solid particles are suspended. These viscous materials have corrosive and abrasive action on the pump parts, hence it is necessary to separate pump moving parts from the slurry to avoid blockage and corrosion and wear of the parts.

2. Peristaltic Pump:

- Positive displacement pump
- Fluid is contained within a flexible tube fitted inside a circular pump casing
- A rotor with a number of "rollers", attached to the external circumference compresses the flexible tube.
- As the rotor turns, the part of tube under compression is pinched closed forcing the fluid to be pumped to move through the tube.
- Flow Rate depends on tubing I.D., length of tubing, and motor rpm.



Fig.1. Rotor with no. of rollers.

3. Prototype Fabrication Model of Peristaltic Pump:

An advanced rotary peristaltic pump is designed with solid works figure no 1. It consist of pump case, rotating disc, rollers, Silicon tube, speed reduction gear and motor. The maximum speed of the motor is 1440 rpm, and reduced to 9 rpm with speed reduction gears, the rotary peristaltic pump is different from the linear peristaltic pump. In rotary peristaltic pump motor is used to rotate the shaft whereas in case of linear peristaltic pump cam is used to control the motion of shaft. The rotor shaft is attached to the speed reduction gears then that connected to the motor.

The Pump case has rotor that lay down at shaft that support by its bearing. Normally two shoes will at rotary peristaltic pump have two flange. This flange will be connecting input fluid and output. Tube is a part of the peristaltic pump, which is squeezed and released by the rollers to create vacuum for drawing the fluid enter into the tube.



Fig.2. Setup of Peristaltic Pump.

4. Basic operation and working Principle:

The basic operation for an advanced rotary peristaltic pump and its Working Principle and operation is very easy. It has variable speed reduction gears, AC motor and adjustable roller arm with same up to 24 mm of ID. When rotor is rotate, fluid is enter the tube because of attraction force from vacuum produce after tube is fully pressed by

rotor along the tube and flow to the output. This operation stay repeatedly until the power of motor is off.

The tubing is fixed between the tube-bed and the rotor at each roller location the tubing is squeezed at position.

The tubing is continuously squeezed by the rollers which push the liquid in the direction of the revolving rotor.

The rollers on the revolving rotor move across the tubing. The tubing behind the rollers recovers its shape, creates a vacuum and draws liquid in behind it.

5. Main types of peristaltic pump:

Higher pressure peristaltic hose pumps which can typically operate against up to 16 bar in continue service, use shoes (rollers only used on low pressure types) and have casings filled with lubricant to prevent abrasion of the exterior of the pump tube and to aid in the dissipation of heat, and use reinforced tubes, often called "hoses". This class of pump is often called a "hose pump".

The hoses in a hose pump are typically reinforced, resulting in a very thick wall. For a given ID the hoses have much bigger OD than tubing for the roller pump. This thicker wall, combined with a stiffer material typically used in the hoses make the forces necessary to occlude the hose much greater than for the tubing. This results in a bigger and slower pump (up to 50/60 RPM) and motor for a given flow rate with the hose pump than the roller pump, consuming more energy to run.

The biggest advantage with the hose pumps over the roller pumps is the high operating pressure of up to 16 bars. With rollers max pressure can arrive up to 12 Bar without any problem. If the high operating pressure is not required, a tubing pump is a better option than a hose pump if the pumped media is not abrasive. With recent advances made in the tubing technology for pressure, life and chemical compatibility, as well as the higher flow rate ranges, the advantages that hose pumps had over roller pumps continues to erode.

6. Tube pumps:

Lower pressure peristaltic pumps typically have dry casings and use rollers along with non-reinforced, extruded tubing. This class of pump is sometimes called a "tube pump" or "tubing pump". These pumps employ rollers to squeeze the tube. Except for the 360 degree eccentric pump design as described below, these pumps have a minimum of 2 rollers 180 degrees apart, and may have as many as 8, or even 12 rollers. Increasing the number of rollers increase the frequency of the pumped fluid at the outlet, thereby decreasing the amplitude of pulsing. The downside to increasing number of rollers it that it proportionately increases number of squeezes, or occlusions, on the tubing for a given cumulative flow through that tube, thereby reducing the tubing life.

Two kinds of roller design in peristaltic pumps:

- **Fixed occlusion** -- the rollers have a fixed locus as it turns, keeping the occlusion constant as it squeezes the tube. This is a simple, yet effective design. The only downside to this design is that the occlusion as a

percent on the tube varies with the variation of the tube wall thickness. Typically the wall thickness of the extruded tubes varies enough that the % occlusion can vary with the wall thickness (see above). Therefore, a section of tube with greater wall thickness, but within the accepted tolerance, will have higher percent occlusion, which increases the wear on the tubing, thereby decreasing the tube life. Tube wall thickness tolerances today are generally kept tight enough that this issue is not of much practical concern. For those mechanically inclined, this may be the constant strain operation.

- **Spring-loaded rollers** -- As the name indicates, the rollers are mounted on a spring. This design is a bit more elaborate than the fixed occlusion, but helps overcome the variations in the tube wall thickness over a broader range. Irrespective of the variations, the roller imparts the same amount of stress on the tubing that is proportional to the spring constant, making this a constant stress operation. The spring is selected to overcome not only the hoop strength of the tubing, but also the pressure of the pumped fluid.

II. PERISTALTIC PUMP SPECIFICATIONS

The most specifications provided by a manufacturer for a peristaltic pump are either related to design or performance

- **Design specification:** A number of design parameters should be considered when selecting peristaltic pumps.
- **Tubing size** - The diameter and wall thickness of the casing used to house the media, typically given in inches (in) or millimetres (mm). It affects the discharge and the size of tubing needed for replacement. Pumps may be designed to allow multiple sizes of tubing.
- **Number of rollers** - The number of rollers or shoes used in the drive mechanism. More rollers reduce pulsation and provide a smoother flow. Number of channels - the number of separate tubes in the pump which operate simultaneously.

1. Performance Specifications:

The primary specifications to consider when selecting peristaltic pumps are flowrate, pressure, horsepower, power rating, outlet diameter, and operating temperature. Flow rate describes the rate of volume discharge through the pump, usually given in gallons per minute (gpm) for industrial applications and gallons per hour (gph) or millilitres per minute (ml/min) for low-flow applications. Pressure is the force per unit area handled by the pump. It is usually given in pounds per square inch (psi) or bar. Horsepower indicates the output power of the pump, measured in units of horsepower (hp). This determines the type of motor or power source needed to operate the pump.

Power rating indicates the power required to operate the pump, measured in Watts (W) or horsepower (hp).

Outlet diameter is the size of the discharge or outlet connection of the pump. It determines the size of connections made between the pump and the system.

Operating temperature defines the range of temperatures at which the pump can operate or the temperature limit of the tubing within the pump.

2. Peristaltic Pump Tubing:

The compatibility of a peristaltic pump with a certain type of fluid is almost completely dependent on the design of the tubing. This is why, when selecting a peristaltic pump, it is important not to overlook the selection of the pump tubing. There are many factors that should be considered in this selection process.

- **Chemical compatibility** - the tubing material must be chemically compatible with the pumped fluid. Engineers should use a chemical compatibility chart designed specifically for pump tubing (not a general use chart) to aid in this decision. When a chart is not sufficient, immersion tests may be used to determine its compatibility or resistance to corrosion. For some applications, it is better to line the inner part of the tubing with a chemically inert material to maintain both structural and chemical compatibility.
- **Pressure** - the tubing material must be able to withstand the system pressure without leakage or failure. It must also be able to adequately handle abrasive media and suspended solids.
- **Temperature** - the tubing material must be able to operate within the temperature range of the system. Users should identify the minimum and maximum temperatures reached in the system and select a material with an appropriate corresponding temperature range.
- **Size** - the tubing must be correctly sized in order to fit within the pump head and operate effectively. Closer dimensional tolerances will result in more consistent and repeatable performance.
- **Life expectancy** - the tubing material must have a tolerable rated life expectancy to reduce downtime and costs associated with replacement.
- **Transparency** - if the media needs to be viewed during pumping, the tubing material should be transparent.
- **Gas permeability** - for application where the media must be isolated from gases in the environment, the tubing material must have an acceptably low gas permeability rating.
- **Regulatory approval** - for certain industries, such in pharmaceuticals, the tubing material must meet and conform to certain standards and certifications.
- **Cost** - The cost of the tubing material must be acceptable in conjunction with its intended life expectancy, since it must be routinely replaced.

A few tube materials include:

- **Silicone** - A translucent medical/food grade tubing which is odourless, non-toxic, and has FDA and USP Class VI approvals. It is auto cleavable and has a temperature range up to 220°C. Used in most general applications.
- **Autoprene** - This is an opaque thermo-plastic rubber with unmatched wear resistance when long tube life is required. This material has FDA food grade approval, and has been further enhanced to meet the requirements and approval standards of USP Class VI criteria for medical bio-compatibility.
- **Viton** - A black, shiny, synthetic rubber with resistance to concentrated acids, solvents, ozone, radiation and temperatures up to 200o C. Viton is expensive, and while it has excellent chemical compatibility, Viton is not renowned for durability and will have a limited service life.
- **Tygon** - This tube has excellent chemical resistance, handles virtually any inorganic chemical, and is one of the families of non-toxic tubes. Tygon has a clear finish and is available in a limited size range.
- **Prothane II** - A transparent blue polyester polyurethane tubing which is resistant to ozone, diesel fuel, kerosene, motor oil, mild solvents, aromatic hydrocarbons, petrol and concentrated acid and alkaline solutions.
- **Vinyl** - The least expensive of any pump tubing type, but is not widely chemically compatible and has a below average service life. It cannot be autoclaved and cannot handle temperatures above 80°C.
- **Fluor polymer** - The most chemically inert tubing material, but with an extremely short service life. It is auto clavable.

Factors influencing the flow rate:

The factors influencing the flow rate are:

1. Type of fluid – Newtonian and Non – Newtonian
2. Viscosity
3. Chain speed
4. Suction pressure
5. Rescue height

The applications of these types of pumps are widely used in Bio-medical, food processing industries where the fluid is not directly contact with casing of the pump. These applications towards industry have certain influence in the above said influencing features. Hence, the design of the peristaltic pump made with certain pre assumed conditions. Initially, the pump characteristics are evaluated with Newtonian and then with non-Newtonian fluids, which then depends on the viscosity of the fluid and of course the development initial suction pressure which cause the fluid to flow.

- **Flow Rate of Peristaltic Pump:**

Flow rate is an important parameter for a pump. The flow rate in a peristaltic pump is determined by many factors, such as:

1. Tube ID - higher flow rate with larger ID
2. Pump head OD - higher flow rate with larger OD

3. Pump head RPM - higher flow rate with higher RPM
Increasing the number of rollers doesn't increase the flow rate, instead it will decrease the flow rate somewhat by reducing the effective (i.e. fluid-pumping) circumference of the head. Increasing rollers does tend to decrease the amplitude of the fluid pulsing at the outlet by increasing the frequency of the pulsed flow.

The length of tube (measured from initial pinch point near the inlet to the final release point near the outlet) does not affect the flow rate. However, a longer tube implies more pinch points between inlet and outlet, increasing the pressure that the pump can generate.

III. CONCLUSION

This paper presents the brief idea of the peristaltic pump such as basic principle, construction and working, literature survey gives idea of present status of work and challenges in design and developments of peristaltic pumps. Also other advantages are cleared from above stated constructions. That are, Seal-less design: The main feature of the peristaltic pump is the tube/hose: because this is the only part of the pump to come in contact with the product it means the pump avoids corrosion and is leak-free. Dry running: Many pump users face difficulties when the pump runs dry, peristaltic pumps are able to do this without any lubrication from outside. Self priming: The pumps are capable of self-priming and can handle products that are likely to “air” or “gas”. Gentle pumping action: In addition, because of the tube/hose and the pumps gentle action, the product being pumped is not damaged in the process thus making peristaltic pumps ideal for shear sensitive products. High suction lift: The pumps also have high suction capabilities and can provide high discharge pressures meaning they are suitable for use where the product being pumped needs to be moved away from the area of the pump. Reversible: Due to the action of the pump it can be used to empty lines or clear blockages by reversible rotation. Non slip pumping: The pumps have no internal backflow giving accurate dosing without slip Accurate dosing: The pumps are accurate in dosing, with repeatability and metering capabilities. Enhanced Hose Life - Abrasion resistant: Tube/Hose life is not related to products abrasive qualities. The tube/hose only fails due to fatigue or chemical action. Low Life Cycle Costs: When the tube/hose does need replacing the cost is minimal compared to other pumps maintenance costs, in addition the time needed to replace the tube/hose is much less then that needed to repair other pump types.

REFERENCES

- [1]. David B. Parker, Positive displacement pumps-performance and application, 11th international pump users symposium.
- [2]. http://en.wikipedia.org/wiki/Peristaltic_pump
- [3]. http://beta.globalspec.com/learnmore/flow_transf_er_control/pumps/peristaltic_pumps

- [4]. Dr S. Venkateswarlu, Performance Study of A Peristaltic Pump International Journal of mechanical engineering and technology, 9(11), 2018, pp. 1799-1807 – <http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=9&IType=11>
- [5]. P. Srinivasa Rao, G. Bhanodaya Reddy, and V. Diwakar Reddy. Design and development of advanced rotary peristaltic pump. International journal of mechanical engineering and technology, 8(6),2017,pp.695-703 - <http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=8&IType=6>
- [6]. An Overview of Peristaltic Pump Suitable For Handling of Various Slurries and Liquid E. N. Aitavade , S. D. Patil , A. N. Kadam , T .S. Mulla