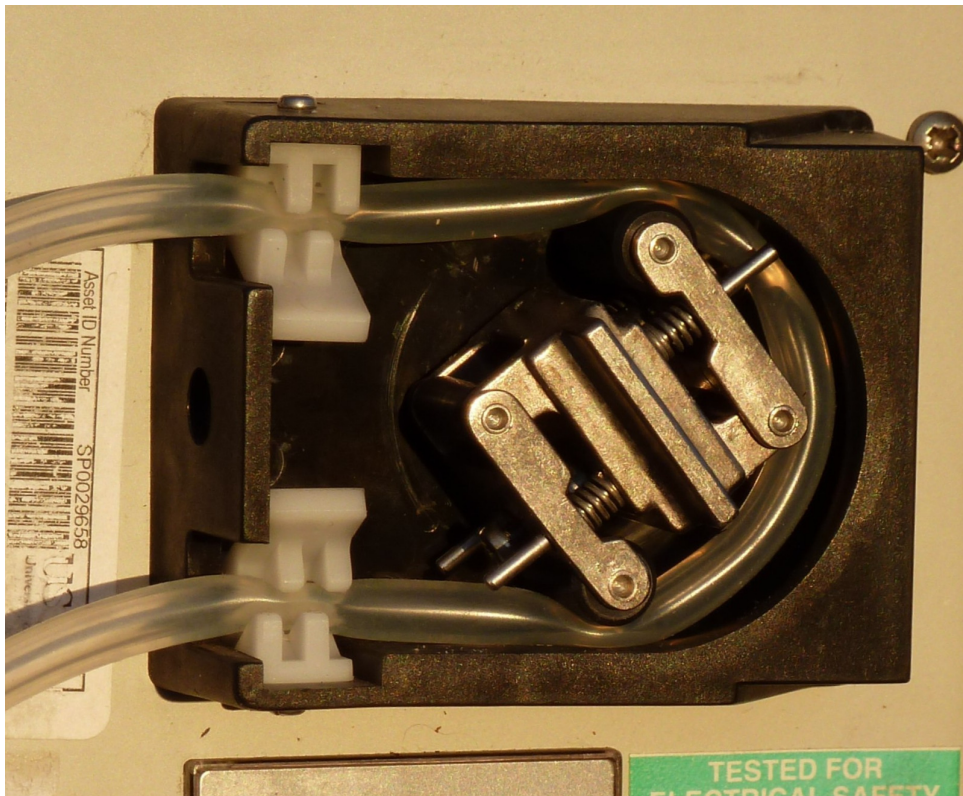


Introductory Project Report of Peristaltic Pump

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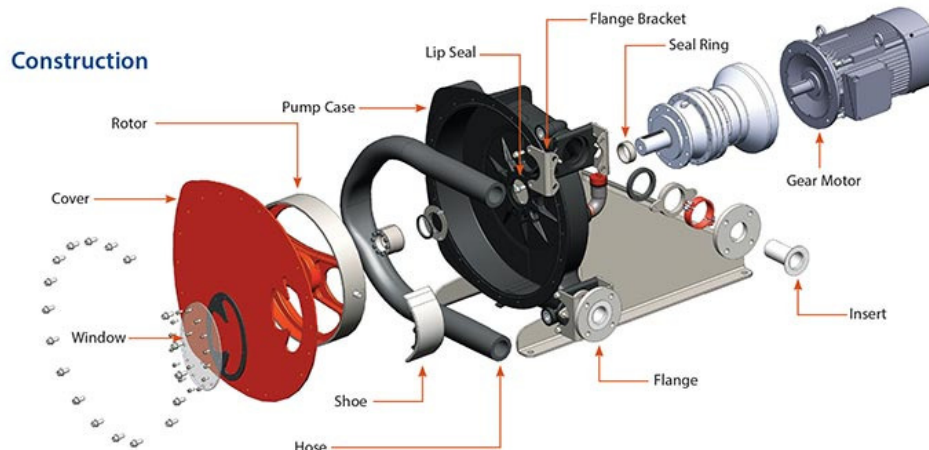


Sector - Industrial And Manufacturing

1 Application description

Peristaltic pumps are a type of positive displacement pump used in various industries for the controlled transfer of fluids. They operate on the principle of peristalsis, which mimics the way our muscles contract to move substances through our digestive system. In a peristaltic pump, a flexible tube or hose is compressed by rollers or shoes, creating a series of sealed chambers that move fluid through the tube. Here's a comprehensive description of peristaltic pumps in industry:

1.1 Processes Involved



1. **Tubing or Hose:** The fluid to be pumped is contained within a flexible tube or hose. This tube is placed inside the pump housing.
2. **Rotor Assembly:** The rotor assembly usually consists of rollers or shoes that compress and release the tubing sequentially. This action creates a series of isolated chambers along the length of the tube.
3. **Drive Mechanism:** The rotor assembly is driven by a motor, causing it to rotate. As the rollers or shoes move along the tubing, they squeeze it at various points, creating a peristaltic motion similar to the way our digestive system moves food through the esophagus.
4. **Fluid Movement:** The peristaltic action causes the fluid within the tubing to be pushed through the tube, one chamber at a time. This gentle, pulsatile flow prevents shear and turbulence, making it ideal for shear-sensitive and delicate fluids.

1.2 Fluids which are handled

1. **Biofuel production:** Biomass-based biofuel production may involve the transfer of biomass slurries, such as algae or lignocellulosic feedstocks. **In the following report, we have done a case study on this.**
2. **Chemicals:** They are often used to transfer corrosive and aggressive chemicals safely due to the isolation of the fluid from the pump components.
3. **Food and Beverage:** Peristaltic pumps are used in the food industry to transfer sensitive liquids such as sauces, juices, and dairy products without contamination or damage.
4. **Pharmaceuticals:** Precise dosage and control make peristaltic pumps suitable for pharmaceutical manufacturing, especially for handling sensitive drugs and biologics.
5. **Biotechnology:** They are used in bioprocessing to transfer and meter cell cultures, media, and other biologically active materials.
6. **Water Treatment:** Peristaltic pumps are used to inject chemicals like chlorine or acids for water treatment applications.

1.3 Importance of Precise Fluid Control

Precise fluid control is crucial in industrial and manufacturing sectors for several reasons:

1. **Quality and Consistency:** Many manufacturing processes require precise control over fluid flow to ensure product quality and consistency. Any variation in fluid dosage can lead to defects or subpar products.
2. **Cost Efficiency:** Accurate metering and control help minimize material waste and reduce production costs, making operations more cost-efficient.
3. **Safety:** In applications involving hazardous or toxic materials, precise control prevents leaks, spills, and exposure to harmful substances, ensuring a safe working environment.
4. **Regulatory Compliance:** Industries like pharmaceuticals and food production are subject to strict regulations. Precise control helps ensure compliance with dosage and quality standards.
5. **Reduced Maintenance:** Peristaltic pumps are known for their reliability and low maintenance requirements. Precise control contributes to the longevity of the pump and reduces downtime.

2 Needs

- **Gentle Fluid Handling:** Peristaltic pumps are non-shearing and gentle on the fluids they transport. This makes them suitable for handling delicate or shear-sensitive materials like biological samples, cells, and viscous fluids in the food and beverage industry.
- **Contamination Prevention:** In industries where contamination is a concern, such as pharmaceuticals, biotechnology, and food processing, peristaltic pumps offer a closed-system design. The fluid only contacts the tubing, reducing the risk of cross-contamination.
- **Hygienic and Sterile Applications:** Peristaltic pumps are commonly used in industries with strict hygiene and sterility requirements, such as pharmaceuticals and biotechnology. They can be easily sterilized, and the tubing can be replaced for each batch, ensuring product purity.
- **Handling Abrasive or Corrosive Fluids:** Peristaltic pumps are well-suited for pumping abrasive or corrosive fluids because the fluid contacts only the tubing material, which can be selected to resist chemical attack. This is valuable in chemical processing and wastewater treatment.
- **Solvent and Chemical Metering:** Laboratories and manufacturing facilities often use peristaltic pumps for precise metering of solvents and chemicals in analytical instruments, chromatography, and chemical reactors.
- **Viscous Fluids and Slurries:** Peristaltic pumps can handle high-viscosity fluids and slurries, making them suitable for applications like transferring adhesives, paints, and ceramics in manufacturing processes.
- **Waste Removal:** Peristaltic pumps are used for transferring and dosing various waste streams, including hazardous waste, sewage, and industrial effluents, while minimizing the risk of pump damage or contamination.
- **Remote and Portable Pumping:** Peristaltic pumps are often employed in fieldwork and remote locations due to their portability, ease of use, and the ability to handle a variety of fluids without needing complex infrastructure.
- **Low Maintenance:** Peristaltic pumps are relatively low-maintenance compared to some other pump types. The primary wear component is the tubing, which is easy and cost-effective to replace.
- **Pharmaceutical Continuous Manufacturing:** Peristaltic pumps play a crucial role in continuous manufacturing processes in the pharmaceutical industry, helping to maintain consistent flow rates and reducing batch-to-batch variations.
- **Environmental Monitoring:** Peristaltic pumps are used in environmental monitoring and water quality testing for precise and controlled sample collection and analysis.



3 Problems it Solves

1. **Fluid Compatibility:** Peristaltic pumps are compatible with a wide range of fluids, from aggressive chemicals to sensitive biological samples. Their design, where the fluid only contacts the tubing, allows for easy selection of tubing materials that are resistant to the specific fluid being pumped. This ensures that the fluid is not contaminated or altered during the pumping process.
2. **Hygiene:** Peristaltic pumps are often preferred in industries with strict hygiene requirements, such as pharmaceuticals and food processing. Their closed-system design, ease of sterilization, and disposable tubing options help maintain a hygienic process, reducing the risk of contamination and ensuring product purity.
3. **Precision:** Peristaltic pumps excel at precise and consistent fluid dosing and metering, making them valuable in applications where accuracy is critical. Pharmaceutical manufacturing, chemical synthesis, and laboratory processes often rely on peristaltic pumps to maintain tight control over fluid volumes.
4. **Safety Concerns:** Peristaltic pumps offer several safety advantages. Since the fluid remains sealed within the tubing, there is a reduced risk of leaks or spills, which can be crucial when handling hazardous chemicals. Additionally, the pump's design minimizes exposure of operators to the pumped fluids.
5. **Non-Shear Pumping:** Peristaltic pumps are gentle on shear-sensitive materials, such as biological samples, cells, and proteins. This ensures that the integrity of these materials is preserved during pumping, which is vital in biotechnology and pharmaceutical research.
6. **Reduced Cross-Contamination:** In applications where cross-contamination is a concern, such as in the pharmaceutical industry, peristaltic pumps offer a clear advantage. Each fluid is contained within its dedicated tubing, eliminating the risk of contamination between different fluids being pumped.
7. **Sterile Fluid Handling:** Peristaltic pumps can be integrated into sterile processes, allowing for aseptic transfer of fluids. This is crucial in pharmaceutical manufacturing, biotechnology, and the production of sterile medical products.
8. **Compliance with Regulatory Standards:** Peristaltic pumps are designed to meet industry-specific regulatory requirements, particularly in highly regulated sectors like pharmaceuticals and biotechnology. This ensures that processes adhere to safety and quality standards.

9. Reduction of Product Loss: Peristaltic pumps minimize product loss by efficiently transferring fluids and allowing for the complete evacuation of containers, which is important in industries where products are expensive or limited in quantity.

4 Requirements Analysis:

- Fluid Compatibility:
 - Chemical Compatibility: The pump must be compatible with the chemical properties of the fluid being transferred. It should be resistant to chemical corrosion, which may include exposure to acids, bases, solvents, and other corrosive substances.
- Fluid Handling Capability:
 - Viscosity: The pump should have the ability to handle fluids with a wide range of viscosities. This includes both thin, low-viscosity liquids and highly viscous fluids, such as pastes or gels.
- Material of Construction:
 - Tubing Material: Peristaltic pumps often use tubing or hoses to transport fluids. The material of the tubing should be compatible with the fluid and capable of withstanding the mechanical stress of the peristaltic action. Common materials include silicone, Santoprene, and other elastomers.
- Flow Rate and Pressure Requirements:
 - Flow Rate: The pump should be able to provide the required flow rate to meet the application's demands. Different applications may require varying flow rates, and the pump should be adjustable within a specified range. Pressure Rating: Consider the maximum pressure the pump needs to generate to move the fluid through the system effectively. Some applications, like dosing in high-pressure environments, may have specific pressure requirements.
- Precision and Accuracy:
 - Dosing Accuracy: In applications where precise dosing is critical, the pump should provide accurate and repeatable dosing to ensure product quality and consistency.
- Ease of Maintenance:
 - Maintenance Requirements: Assess the ease of maintenance, including tube replacement and general upkeep. Pumps that are easy to disassemble and service can reduce downtime.
- Environmental Conditions:
 - Temperature and Pressure: Consider the temperature and pressure conditions in the operating environment. The pump should be able to operate within specified temperature and pressure ranges. Environmental Resistance: If the pump is exposed to harsh environments, it should be designed to withstand factors such as humidity, dust, and vibration.
- Control Options:
 - Control Flexibility: Depending on the application, the pump may need to integrate with control systems, and it should offer compatibility with various control options, including analog, digital, or programmable interfaces.

5 General Working of Peristaltic Pump :

Conceptual Framework: A peristaltic pump operates based on positive displacement. This method relies on physically occluding (blocking) a set volume of fluid and then pushing (displacing) it forward. Key Components: Elastomeric Tubing: This flexible tube, often made of materials like silicone, Viton, or other specialized polymers, has inherent viscoelastic properties allowing it to return to its original form after deformation. Rollers/Cam: Attached to a rotor, these elements cyclically compress the tubing

against a hard backing, referred to as the pump's "shoe" or "track." Motor: This component provides the necessary torque to rotate the rotor and, by extension, the rollers. Its speed (often denoted in rpm) dictates the flow rate. Functionality: Occlusion Phase: Initiated by the roller compressing the tubing against the shoe, this phase ensures the formation of a sealed pocket, or bolus, of fluid. Displacement Phase: As the rotor turns, the roller progresses along the tubing. The physical deformation of the tubing propels the bolus forward. This is a consequence of the principle of conservation of volume, where the volume of the displaced liquid equates to the volume of the tubing segment being occluded. Recovery Phase: Behind the moving roller, the tubing's inherent viscoelastic properties enable its restoration to the original shape. This creates a negative pressure (suction) that draws more fluid into the tubing.

5.1 Quantitative Aspects

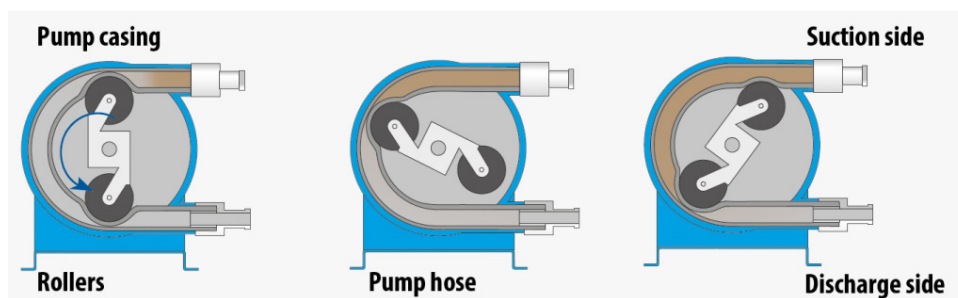
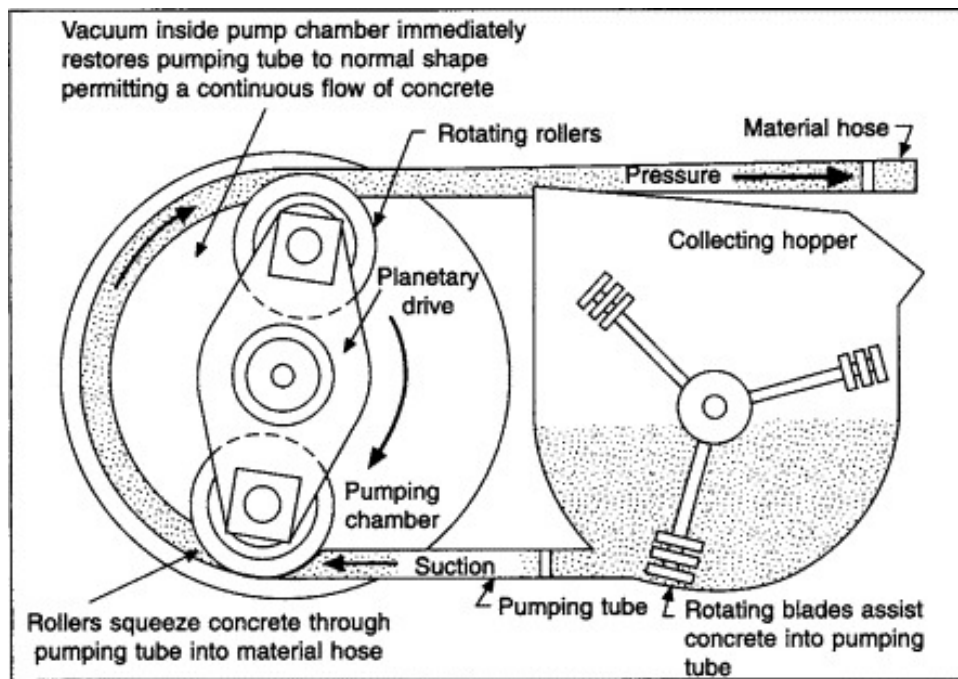
The pump's flow rate Q is a crucial parameter. For a peristaltic pump:

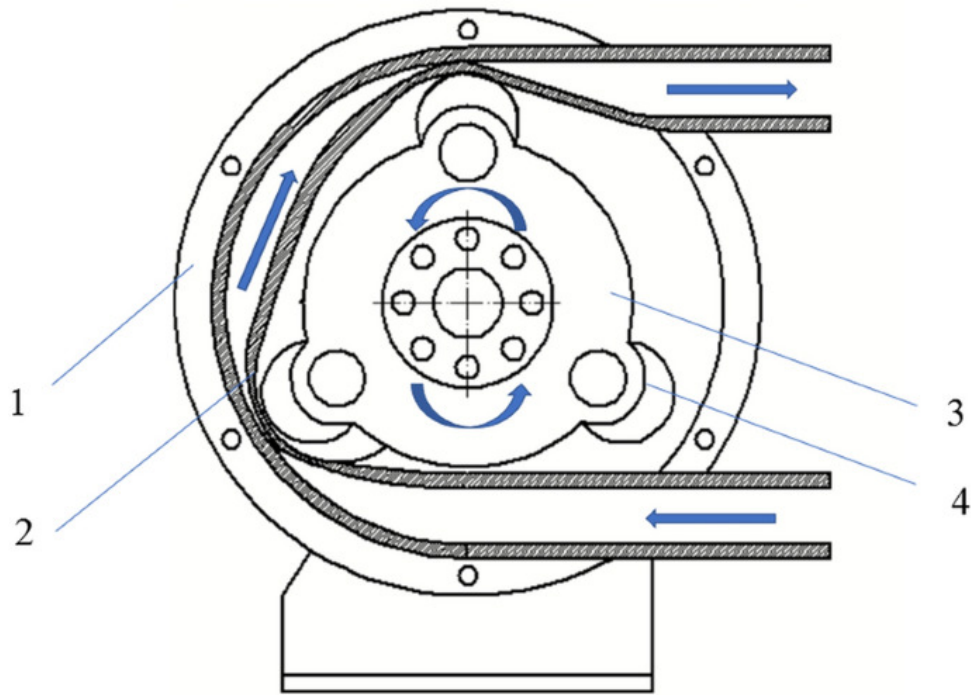
$$Q = N \times V_{bolus} \quad (1)$$

Where:

- N represents the rotor's rotation speed in revolutions per minute (rpm).
- V_{bolus} is the volume of the fluid pocket or bolus between two rollers. This is closely tied to the tubing's internal diameter and the spacing between rollers.

For instance, if a pump with a tubing inner diameter of 2 mm results in a bolus volume of 1 mL and operates at 60 rpm, the flow rate would be 60 mL/minute.





6 Our Case study :

Bredel hose pumps in action at Dong Energy's Studstrup Power Station in Denmark - 30 May, 2017



A Scandinavian heat and power plant switched from coal to biomass and was converted to the benefits of peristaltic pumps.

Manufacturer Dong Energy began work last year on converting its combined heat and power plant in Denmark from coal to biomass. Its goal was for its Studstrup CHP site – one of the largest in the country – to supply sustainable energy to Denmark's second city, Aarhus, and provide green electricity to the national grid.

The switch necessitated construction of a plant facility for firing ash from coal combustion to ensure optimum binding of alkali in the flue gas – which would also

protect boiler walls from scale/slag accumulation, corrosion and reduce poisoning of the deNOx catalyst.

Dong's lead contractor Eurocon had to determine the most appropriate form of pump to employ for the process, which involved handling high density, inhomogeneous mass, abrasive particles and high pressure.

The company had to determine the most appropriate form of pump to employ for the process, which involved handling high density, inhomogeneous mass, abrasive particles and high pressure

Progressive cavity pumps had been considered but successive trials resulted in the selection of peristaltic hose pumps. This was a first use for Eurocon, which turned to Watson-Marlow Fluid Technology Group (WMFTG) for the necessary equipment, in the shape of its range of Bredel hose pumps.

For the plant facility, fly ash is mixed with 35 percent water, fed to the dosing tanks (each with a recirculation line) through a 650m-long pipeline and finally injected to the pellet mills.

Inside, to avoid settlement, four Bredel 80 hose pumps are deployed to circulate the fly ash slurry, which is then dosed from the recirculation line into a Babcock boiler.

The ash slurry is dosed via four wood pellet mills, each mounted with a Bredel 40 pump. In total, the installation involves 21 Bredel pumps of mixed sizes, some of which run continuously.

Before construction it was necessary to determine the viscosity of the ash slurry, as well as measure the pressure drop of the pipes at a given water percentage so that pumps and pipe runs could be dimensioned, explains Edo van der Meulen, training and application manager at Watson-Marlow Bredel BV.

“From this, we calculated that the mixing plant could be sized to 50m³/h, with the supporting dosing system to feed in at a maximum of 280m³ per day. WMFTG participated fully in the dimensioning of the pumps and with the pressure calculations,” he says.

“The effect of abrasiveness on hose life is low; the effect of factors such as dry solid content and pump speed is much higher.” By : Edo van der Meulen, training and application manager, Watson-Marlow

Fly ash is traditionally handled by double-acting hydraulic pumps at £0.5 million apiece, but collaboration between the three companies produced a cheaper alternative.

This focused on maximising natural rubber hose life, adjusting line velocity, and use of pulsation dampeners to reduce system back pressure to 50

“The effect of abrasiveness on hose life is low; the effect of factors such as dry solid content and pump speed is much higher,” says van der Meulen.

“At Studstrup, the dry solids content of the fly ash entering the system is controlled automatically – when it exceeds the limit at which the slurry can be successfully pumped, a Bredel 40 is activated to add water until the B100 [used to transfer the prepared slurry from a buffer tank to the storage tanks] is able to pump again.

“As for pump speed, this has an almost linear effect on hose life: half the speed is double the hose life.”

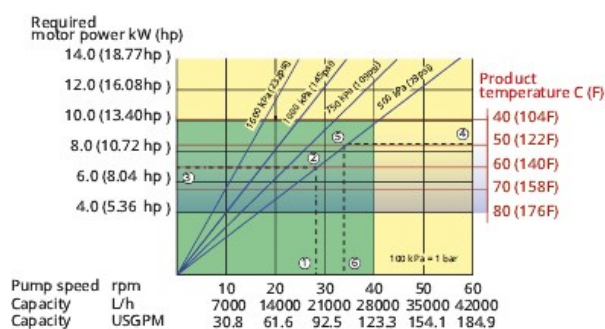
A second installation for Dong Energy is under discussion

Description for Bredel 40

1. Company: Watson-Marlow Fluid Technology Group, Falmouth, United Kingdom
2. Product: Bredel 40 from Bredel Series Hose Pumps
3. Description: The unique direct-couple design of Bredel heavy duty hose pumps combines the small footprint of close-coupled pumps with the reliability and ease of use of long-coupled pumps. The pumps use heavy duty bearings within the pump rotor, eliminating overhung load. The ultra-compact high torque gearing aligns directly to the pump housing and is fully protected by an innovative buffer zone. Key features include:
 - (a) Suction lift capability of up to 9.14m (30 feet)
 - (b) Dry running and self-priming
 - (c) Ideal for high viscosity and shear sensitive product
 - (d) No seals, ball-checks, diaphragms, glands, immersed rotors, stators or pistons to leak, clog, corrode or replace
 - (e) Handles abrasive slurries, corrosive acids, gaseous liquids
 - (f) No slippage, allowing true positive displacement for accurate and repeatable metering
 - (g) No ancillary equipment, check valves, sealing water flush systems or run-dry protection required
 - (h) Fully reversible to blow out suction and drain lines safely DuCoNite® versions for challenging applications

Pump Graph of Bredel-80

Bredel 80



Note: The area of continuous operation diminishes with increased product temperatures. For product temperatures >40°C, the area of continuous operation reduces to the corresponding red temperature line.

1. Flow required indicates pump speed
2. Calculated discharge pressure
3. Net motor power required
4. Product temperature
5. Calculated discharge pressure
6. Maximum recommended pump speed

- Continuous duty
- Intermittent duty

* Maximum 3 hours operation followed by minimum 1 hour stop

7 Real World Examples:

Here are some of the peristaltic pumps in real world with datasheets attached:

1. Flowrox LPP-T Peristaltic Hose Pump
2. Vector Peristaltic Pump- Model 2005

Here is the table for some of the suppliers of the world:

Number of Products	Supplier Name	Headquarters
27	RS Components, Ltd. (Mfg., Dist.)	United Kingdom - Corby, Northants
33	Aalborg Instruments (Mfg.)	NY - Orangeburg
1	Aurora Instruments (Mfg.)	Canada - British Columbia - Vancouver
48	Clark Solutions (Mfg., Dist.)	MA - Hudson
418	Cole-Parmer (Dist.)	IL - Vernon Hills
11	Flowrox Inc. (Mfg., Svc.)	MD - Linthicum
1	Gardner Denver, Inc. (Mfg., Dist.)	IL - Quincy
5	Gardner Denver Thomas (Mfg.)	WI - Sheboygan
3	Greylor Company (Mfg.)	FL - Cape Coral
125	Watson-Marlow Fluid Technology Group (Mfg.)	United Kingdom-Falmouth

- Paint Industry:

- Scenario:

A large-scale paint manufacturer produces various types of paints and coatings. A critical aspect of paint manufacturing is the accurate addition of various additives, color pigments, and solvents to produce consistent batches.

- Use of Peristaltic Pump:
For the precise dosing of color pigments into base paint to achieve the desired shades. A slight variation can alter the shade, so precision is paramount. To introduce specific additives or solvents in regulated amounts, ensuring product consistency across batches. To transfer finished paint products to filling lines without introducing air bubbles, which can affect the paint's application.
- Real-World Inspiration:
Companies like Watson-Marlow have highlighted the use of their peristaltic pumps in the paint and pigments industry for ensuring consistent product quality by delivering accurate and repeatable flow rates.
- Coal to Biomass Conversion in Power Plants:
 - Scenario:
A coal-fired power plant, in its bid to reduce greenhouse gas emissions, decides to transition to biomass. The selected biomass is in the form of wood pellets, but the plant also decides to use liquid by-products from biomass, like bio-oil or pyrolysis oil, as supplementary fuel.
 - Use of Peristaltic Pump:
During the biomass preprocessing stage, certain enzymes or chemicals might be used to break down or treat the biomass. Peristaltic pumps can handle the dosing requirements, ensuring the effective treatment of biomass. For transferring the viscous bio-oil or pyrolysis oil. Given the nature of these oils and the potential for particulates, peristaltic pumps offer an advantage in preventing clogging and ensuring a smooth transfer. To dose additives or catalysts during the combustion of bio-oils. These additives can help in efficient combustion and reduce harmful emissions.
 - Real-World Inspiration:
Drax Power Station in the UK is one of the most prominent real-world examples of a coal-to-biomass transition. While specific pump details would require direct verification, large-scale conversions like this would certainly involve various pumping systems, including peristaltic pumps, to handle different stages of biomass processing and combustion
- Cosmetics Manufacturing:
 - Scenario:
A cosmetics company produces a range of products, from lotions to shampoos. Accurate dosing of active ingredients, fragrances, and colorants is crucial for product consistency and safety.
 - Use of Peristaltic Pump:
For the introduction of specific active ingredients into base formulations, ensuring each batch has the right concentration for efficacy and safety. In the filling lines, to bottle or tube products without introducing air, which might affect product shelf-life or application.
 - Real-World Inspiration:
Watson-Marlow Fluid Technology Group has highlighted the use of their pumps in cosmetics manufacturing, especially where precision, hygiene, and gentle handling of sensitive ingredients are required.
- Pulp and Paper Industry:
 - Scenario:
A pulp and paper mill needs to add various chemicals during the pulping process, bleaching, and wastewater treatment.
 - Use of Peristaltic Pump:
For dosing specific chemicals during the pulping process, which can help break down the wood fibers. To add bleaching agents in a controlled manner to achieve the desired whiteness of the paper. In wastewater treatment, to introduce coagulants, flocculants, or other treatment chemicals.
 - Real-World Inspiration:
Verderflex, known for its peristaltic pumps, has provided solutions for the pulp and paper industry, especially in handling abrasive slurries and dosing chemicals in various stages of paper production.
- Fuel and Lubricants:

- Scenario:
A refinery produces a range of products, from gasoline to lubricants. Accurate dosing of additives is essential to meet specific fuel standards or lubricant specifications.
- Use of Peristaltic Pump:
For introducing specific fuel additives that enhance combustion, reduce emissions, or stabilize the fuel. To dose additives in lubricants that improve viscosity, reduce wear, or enhance heat dissipation.
- Real-World Inspiration:
Refineries worldwide employ various pumping systems, including peristaltic pumps, especially where precise dosing is required. Companies like Watson-Marlow have provided solutions tailored for the oil and gas industry’s needs.

8 Conclusion:

In the sophisticated landscape of modern manufacturing industries, the transition to sustainable and efficient operations is not just a desirable evolution but an essential imperative. The intricate dynamics of today’s industrial demands require tools and technologies that are both innovative and adaptable. Peristaltic pumps, with their origin rooted in the advanced engineering ecosystems of Germany, the Netherlands, the US, and the UK, exemplify such a technology, harmonizing precision with sustainability.

The case study on the industry’s transition from coal to biomass provides an incisive lens into the transformative potential of peristaltic pumps. Coal, once the bedrock of industrial energy, presents significant environmental and efficiency challenges. The move to biomass not only underscores a commitment to greener operations but also the importance of reliable technology that can facilitate such a transition. It’s here that the role of peristaltic pumps becomes paramount. Their capability to handle diverse fluidic properties, ensure accurate dosing, and maintain system integrity makes them an invaluable asset in this transformative journey.

Furthermore, for manufacturing sectors, where quality, consistency, and operational uptime are cornerstones, the adaptability and reliability of peristaltic pumps become even more crucial. Their ability to address specific challenges, whether it’s the corrosive nature of a fluid, the need for sterile conditions, or the sheer demand for volumetric precision, positions them as a linchpin in modern manufacturing setups.

In essence, as industries globally, and particularly in India, pivot towards more sustainable, efficient, and quality-centric operations, technologies like peristaltic pumps will be at the forefront of this evolution. Their adoption is not merely a reflection of a transition in energy sources or materials but signifies a broader paradigm shift in manufacturing – one that embraces innovation, sustainability, and precision. The future of manufacturing will be shaped by such pivotal technologies, and peristaltic pumps, as demonstrated, are poised to be a vital part of this transformative narrative.