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Turbine Flow Meters: 5 Critical Design Features

In the second of the two-part turbine series,
Titan Enterprises shares the five critical design features for Pelton wheel turbine flowmeters.
The design challenge for turbine flowmeters based on the working principles of this type of radial turbine is primarily straightforward: simple electronics versus complex precision engineering.
In developing a cost-efficient and reliable Pelton wheel turbine flowmeter, Titan Enterprises considers five critical design elements:

1. Excellent linearity and repeatability
2. Long operational life
3. In-line meter connections
4. Good chemical resistance of materials
5. Ease of manufacture

1. Linearity and repeatability

Good linearity and excellent repeatability
are essential in any turbine flowmeter, and one of the more subtle critical design areas is that of the radial clearance of the turbine in the housing. If the radial clearance is too small there is a constant drag with the chamber wall that causes problems with linearity

and changes in fluid properties. Too large a clearance and the chamber volume becomes unacceptable and the entrainment of gasses becomes problematic. The same is true with the side clearances. There are a series of solutions to turbine drag as the chamber velocities start to become laminar.

Titan use a hexagonal chamber that permits the formation of vortices which reduce the drag and assists the linearity into the laminar flow region. Other turbine designs use square chambers or square chambers with posts in the four corners, effectively generating the space for eight vortices.

With known fluid properties and careful calibration techniques, variations affecting linearity and repeatability can be 'calibrated out'. Designing-out some of these issues to give good flowmeter performance ensures the resulting solution doesn't become overly expensive.

2. Long operational life

The linearity and repeatability

are also linked to the design of the bearings. Here, special care must be taken in both bearing design and choice of materials to ensure long, reliable operational life. The most common fluids used in these devices are water-based and many bearing materials would not be suitable for long term use due to the poor lubricating qualities of water, increasing wear. Add to that the requirement of aggressive chemicals and the bearing material options are further reduced.

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With low flow rates and the energy available from the fluid minimal, the bearings must also be of low friction and able to maintain the original level of friction for the operational life of the meter. For a domestic coffee machine for example, this may only be four hundred hours of use so a simple metal spindle in plastic housing would be sufficient. Whereas the operational life of flowmeters used in medical equipment is more likely to be 4 years plus, so a more durable bearing material like sapphire or ruby would be more suitable.

The loads on the bearings can be quite high so there is a trade-off to consider between bearing life, low friction and the meter's lifespan. A ball and cup bearing would give low friction and excellent low-end performance when new, but the wear on the extremely small contact area would soon result in turbine precession affecting linearity and repeatability.

Titan utilise a sapphire spindle and bearing arrangement, and together with their recommended installation, this ensures the flow devices continue to operate within specification for years.

3. In-line meter connections

With a rotating turbine,

the lower density gasses tend move towards the spindle and can stay there under certain conditions effecting the meter linearity and life of the bearings. One solution is to extract the fluid axially on the centre line of the turbine's rotation, leaving the inlet and outlet connections at 90° to each other. This 90-degree inlet to outlet orientation is not

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always acceptable and can cause problems for installation. However, this can be solved with a complicated housing but this will result in a retained fluid volume increase, as well as compromising the bearing arrangement.

Some flowmeter manufacturers run the incoming stream at an angle so that it wraps its way around a wider than normal blade and exits at a corresponding angle to the inlet jet, one whole revolution later. Two hundred and seventy degrees of wrap-around is also quite common but this tends to leave the inlet and outlet on the same ‘face’ of the device or requires the incorporation of a manifold system.

Titan chose the in-line radial design, i.e. the inlet and outlet are opposite each other, for 3 key reasons:

- Ease of installation for the customer
- Lower manufacturing costs which result in a cost-effective meter
- To minimise the pressure drop within the customer’s piping system

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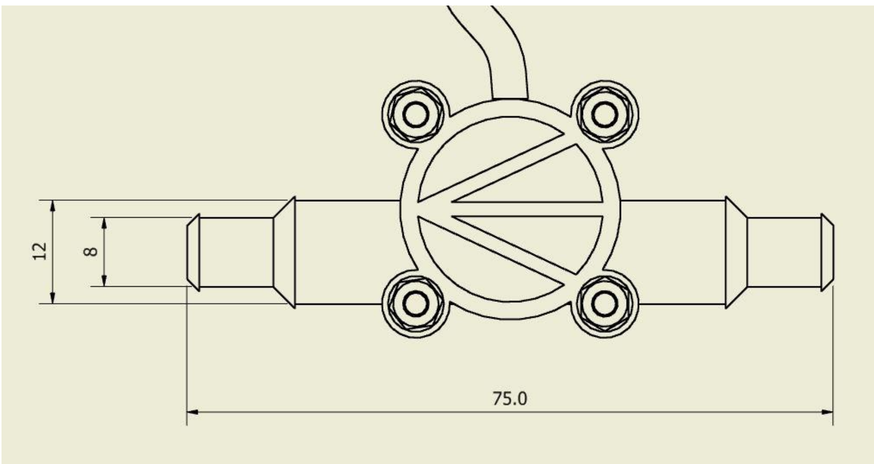
In-line Radial Turbine Design



4. Good chemical resistance of materials

The turbine itself seems like a simple element but it must also be carefully considered. Low mass is important, so a polymer is often used in turbine manufacture, and occasionally the turbine's density is matched to the fluid to fractionally reduce bearing load at start-up. A potential issue here is that the turbine's rotation must be detected somehow. Optical detection allows for no extra mass increase to the turbine, but liquid measurement is restricted to optically clear fluids and any build-up of deposits on the optical path can stop detection.

Some manufacturers use curved or tapered blades on the turbine. If magnetic or inductive detection is required, a suitable magnetic material insert is necessary, and this should be over-moulded to protect it from aggressive chemicals.

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Titan produce the majority of their turbine devices in NSF-approved PVDF (suitable for food and medical applications), and overmould the magnets to ensure long-life in the most corrosive chemical environments.

5. Ease of manufacture

To ensure ease of manufacture, the design should integrate the latest innovations in moulding and machining technologies, accommodating various flow ranges and simplifying production. From the outset, components should be designed for easy interchangeability and made from high-grade materials to enhance durability and streamline assembly. This approach not only optimises manufacturing efficiency but also ensures consistent quality and performance.

To conclude, a Pelton wheel turbine is not just the simple paddle in a chamber. It is the perfect device for cost effective low-flow measurement and the choice available is extremely wide from the $1 meter for your coffee machine, through to a device costing tens of thousands for demanding industrial use.
As with all flowmeters, it is essential to ensure you are choosing the correct sensor for your application. When specifying a flowmeter, Titan Enterprises recommends the following considerations:

- Is the flow range, pressure, temperature and chemical resistance acceptable for your application?
- Is the flowmeter cost-effective over the lifetime of the installation?

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- Does it have the performance required for the application and will it maintain that performance over the operational window?
- Are the suppliers/manufacturers knowledgeable in their technical capabilities and honest in their specifications?

Visit Titan Enterprises' website for full technical information on Titan's turbine flowmeters. To discuss your specific OEM application, please contact Titan Enterprises on +44 (0)1935 812790 or email sales@flowmeters.co.uk.

November 2024 **titanpr143-TurbineFMDesignFeatures**

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Illustrative images (available on request)