titan flowdown

...an informative bulletin from Titan Enterprises - the *low flow experts*

Welcome to the **Autumn 2019** issue of fLowdown - a quarterly Newsletter from Titan Enterprises Ltd. written to keep you informed about the latest technological developments, applications advances and breaking news in the field of flow measurement.

If a particular feature interests you do not hesitate to contact us or follow the link for further information. We welcome your feedback.

Trevor Forster *(Managing Director)*

Trevor's Technical Tip

Trevor Forster is our Managing Director, his experience in fluid handling dates back to the mid 1960's when he started working on rotating seals and flowmeter design for third party clients. Trevor draws upon over 40 years of using innovative design and production techniques to produce elegant flow metering solutions for organisations around the globe. In this issue - Trevor offers you useful technical tips on:

A Guide to Choosing a Partner for Your Flowmeter OEM Product Development.

Choosing an OEM partner for flowmeter applications is a two-way thing.

From the flowmeter supply company perspective, we are frequently asked for a flowmeter to function in a new or previously unmetered process. Unfortunately, a large proportion of the enquiries centre around early stage interest from entrepreneurs seeking a flow metering solution to a tantalising application not soluble by off-the-shelf products. Having said that, some of these ventures do indeed take-off but the majority will fall by the wayside. As a flowmeter developer / supplier we always aim to be responsive to enquiries but remain realistic and inform the entrepreneur of the likely pitfalls. Mindful of the 'cash limited' status of many fledgling businesses we will, if necessary, suggest that they research the application opportunity further before committing too much investment.

From experience, we find a greater proportion of OEM flowmeter enquiries that go right through the development process and reach market are from established companies who undertake market research on their target application and acknowledge a realistic timescale to bring the product to market But not always. Around twenty years ago we were approached by a company looking for a flowmeter for what sounded like a miracle chemical technology that was developed in Russia. This product was a liquid that was highly effective in killing bacteria, viruses and fungi but was harmless to humans and could be poured down the sink after use. Our potential customer wanted a flowmeter to measure the liquid for the sterilisation of medical equipment. The mystery liquid, with the amazing properties, turned out to be an hypochlorous acid solution from a Sterilox generator. To date we have secured several OEM customers using our flowmeters on this wonderful liquid for the sterilisation of endoscopes and dental equipment.

For companies seeking an OEM flowmeter to solve their application challenge the viewpoint can be quite different. Typically the major considerations are reliability, is the product fit for purpose, and is it available at the right price? Customers, unsurprisingly want the best possible specification for the lowest possible price. To this desire we suggest a pragmatic approach. There is no point in paying for a sophisticated, five piece sapphire bearing set and high grade polymers for the device body if in reality the flowmeter only has to last for 500 hours of use or just meter dispensing of 2000 cups of coffee! The accuracy and linearity may not be as good with a product made and supplied on a tight budget, but will the recipient mind if their coffee has +/- 2% more or less water in a cupful? At the other end of the spectrum if a piece of laboratory equipment has to deliver a pure chemical, uncontaminated in any way, to within an exacting specification then flowmeter performance and chemical resistance become essential. Further, the life of the device and the

product line itself become critical. The short life cycle of coffee machines means they are redesigned each year and spares will be no longer available after three. By comparison, an inert chemical laboratory dispenser might have a product life of 5 years but, as it is likely to be a relatively high capital value piece of equipment, the spares will have to be available for another 10 years after the device has been superseded. Consequently, our OEM customer in this instance has to be sure that we will still be happy to produce that particular flowmeter for 15 or 20 years.

Key considerations companies seeking an OEM flowmeter:

1. Do I really need a flowmeter?
2. What are the actual requirements for the flowmeter?
3. What is the maximum price our product will stand for supply of the flowmeter component?
4. How good is good enough: there is little point in over-specifying?
5. How long will my product remain in production?
6. How long do we require spares to be available?
7. What level of customisation is economic?
8. Where is the cross-over point between up-front costs and production run per change from a standard product?
9. Is the time window for the OEM flowmeter development achievable?

Key considerations for flowmeter developer / supplier:

a. What quantities are required?
b. Does this look like a viable product?
c. Does the OEM customer have the necessary resources in place available to successfully bring the product to market?
d. Does the OEM truly understand the required flow meter specification?
e. Can we meet the required specification?
f. Do we have the required production capability?
g. Is the OEM customers timescale realistic and achievable?
h. If modifications to a standard device are required where does the responsibility for the design and acceptance rest? Who signs the product off for production?
i. If we are developing a new device do we have the resources to complete the project on-time and on budget?

To discuss an OEM flowmeter product development please **click here**.

Flow Technology Spotlight

Benefits and Trade-offs in Flowmeter Miniaturisation

Throughout its history, Titan Enterprises has striven to make smaller and better flowmeters, ranging from miniature turbines and gear meters through to more recently ultrasonic devices.

A: Turbine Flowmeters. Making a very low flow, high performance turbine meter is always going to be a challenge. There are a whole range of physical issues preventing you from producing small devices. Generally radial flow turbines are better for low flow applications than axial flow turbines. In no particular order, the main problems include:

i. **Friction**. Stiction, which can be defined as the friction on two surfaces which prevent the parts being in motion is the first problem. This effect on any bearing will determine the point at which a turbine starts rotating. With a large turbine it is generally not a problem as you are likely to have a large driving torque relative to the stiction. On a miniature device the available driving torque compared to the stiction is greatly reduced. Just getting the bearing spinning freely can be a challenge. This is often overcome with sapphire bearings but again the contact area of these highly polished surfaces can still be relatively high. A point contact offers the lowest friction and is possible with ball or cone bearings. The problem then becomes bearing load. A single point contact equates to an infinitely high bearing load which reduces bearing life. Stiction itself will also depend on the mass of the turbine.

ii. **Weight**. The mass of the turbine in the fluid not only effects the stiction it also has a consequence on the response time. The greater the mass the slower the response time. A turbine with minimal mass could be of a similar density to the fluid that is being metered so that it possesses neutral buoyancy. There is also a trade-off here between turbine diameter, blade width / thickness, materials of construction and detection method. The larger the moment on the turbine from offset of the incoming jet, the stronger the driving force. But if the mass and rotational resistance is higher

then so is the drag on the other non-driven blades. Very fine blades can be hard to detect optically and the blade width is restricted to the diameter of the incoming jet plus some incoming jet “spreading” distance within the fluid. Too narrow, and much of the fluid will spill around the side, but too wide and unnecessary drag will occur.

iii. **Detection system**. A no-drag system is essential and optical is ideal providing you have a fluid which transmits the light effectively. It can be reflective or more often some type of beam cutting arrangement. Adding magnetic material to the turbine for a zero drag inductive, magnetic or Hall Effect detector increases the mass but enables the flowmeter to handle opaque fluids such as emulsions. For such applications there is a trade-off between magnetic elements, their size and mass.

iv. **Fluidics**. As flow rates become lower, the more liquids look and behave like treacle. Turbines become viscosity sensitive as they are primarily Reynolds number devices which are happier with turbulent flow. We try to negate some of these effects with fluidic tricks such as the induced secondary vortices which behave like “roller” bearing which reduce viscous drag and extend the linear flow range.

v. **General mechanics**. This is a catch-all section and hard to quantify. There is a relationship between turbine diameter, jet offset and size as well as turbine and chamber thickness and clearances. It is a delicate compromise between these elements.

B: Gear flowmeters. At Titan Enterprises we opted to incorporate the oval gear design into our gear meter products, as there is a much greater driving torque for a given differential pressure which is derived from fluidic asymmetry of the gears. There are fewer subtleties in the design options on oval gear flowmeters, in comparison to radial turbines, because of their basic operating principles. Oval gear flowmeters operate on the principle of positive displacement, by taking a parcel of fluid and transferring it from the inlet side to the outlet side without any leakage. This sounds very easy but there is a trade-off between gear clearance, leakage, friction and fluid viscosity.

i. **Clearance and Leakage**. Make the clearances small and you can meter low viscosity fluids very accurately over a large flow range. Make them too large and the flowmeter will not work well until the liquid is highly viscous. As an oval gear flowmeter is made smaller, the leak path becomes proportionately larger. If we take one of our smaller oval gear flowmeters and straighten out the leak path it can be defined as a strip some 60mm long by the clearance between the gear and the chamber. We would normally run that clearance at 0.03mm which gives a potential leak area of $1.8mm^2$ This is equivalent to a round hole nearly 1.5mm diameter. If you halved the size of the gears in all directions the leak path would become essentially half so still nearly a 1mm hole for a square-law reduction in gear size and efficiency. Bigger oval gears are easier to manufacture as they are more efficient at, relatively speaking, lower flows.

ii. **Friction**. If there is stiction an oval gear flowmeter will not start. If there is running friction the linearity will not be good. Like mini-turbines, friction must be kept to a minimum. However, there are fewer options with oval gear flowmeters as the bearings loads can be quite high. This is because the load induced by the meter’s pressure drop (which is necessary to work the meter) becomes problematic at higher flows.

iii. **Fluid Viscosity**. The fluid viscosity is fundamental to the performance of oval gear flowmeters. Most are not very happy with non-lubricating low viscosity fluids such as water. However, we can minimise problems through selection of high-quality materials and precision manufacture. For example, hot water has a viscosity around 0.6 Centipoise which is very happy slipping through that theoretical clearance equivalent of a 1.5mm diameter hole without rotating the gears unless the mass of the gear is low, the friction minimal, and the clearances as tight as possible. A very small increase in viscosity (and usually lubrication) makes a vast difference to the efficiency of an oval gear flowmeters performance.

C: Ultrasonic Flowmeters. We are targeting this area of technology as providing the best solution for our many of low flow developments. For the two technologies outlined above the pure mechanics of these systems is the limiting factor. Some energy needs to be injected into the system to achieve lower flow rates. There are also some problems to solve when producing low flow ultrasonic devices due to the sheer physics of the technology.

i. **Basic physics**. Time of flight ultrasonic meters work because sound speeds up when it travels with the flow and is retarded when it travels against it. Effectively the phase shift between these two signal transit times is twice the velocity of the fluid in the pipe. The lower the flow rate the lower this phase shift or time of flight in each direction becomes.

ii. **Reduced bore sizes**. Decreasing pipe diameter accelerates the velocity so increasing the phase shift between the upstream and downstream signals. Getting the ultrasonic signal into these smaller pipes is itself a problem. On our lowest flow Atrato ultrasonic flowmeter we inject and receive the ultrasound signal into a 6mm diameter bore but then reduce the pipe to a 1mm bore in the central section between the crystals to accelerate the liquid and increase the velocity. This comfortably permits us to meter flows down to 2ml/min.

iii. **Future developments**. We are working on even lower flow devices by utilising one of the unique features of our patented technology. We can send ultrasound around corners. We have successfully prototyped a device which effectively is a 300mm long 1mm diameter tube but produced in a 30mm diameter coil. The basic physics of this unique design increases the pathlength which significantly increases the difference between the up and down signals. However, there are also trade-offs with this design. The signals are seriously attenuated in such a long tight bore so signal to background noise ratio increases accordingly. This effectively dictates our flow range and low end flow

capability. There is currently a point at which we start to lose efficiency with greater increased length and do not see any decrease in low flow measurement. Currently 0.25ml/min is the lowest flow we have successfully measured in the laboratory but improved electronics, algorithms and ultrasound coupling is likely to lower this threshold further.

D: Thermal Technology Flowmeters. These inherently mass flow devices are also becoming smaller with faster response times. By definition (unlike the flowmeter technologies outlined above) they can only handle specific fluids as the thermal transfer characteristics of each fluid changes the calibration of the device. Thus, a flowmeter set-up for one liquid would not accurately meter a second without a change in calibration factor. Currently for equivalent devices they do not perform with the same accuracy as our ultrasonic technology, but they do meter much lower flows.

To discuss development of a micro flow measurement device for your application please **click here**.

How do I measure?

In this issue of fLowdown we discuss:

Non-Invasive Metering of Biological Fluids in Medical Applications

The first question is – what is your definition of non-invasive? If you ask an industrial instrument engineer - they would list a whole raft of flowmeter technologies including Ultrasonic, Coriolis, electromagnetic and possibly thermal. All of these devices are capable of accurately measuring the flow in a pipe without impeding the channel in any way. In most cases however there would be a requirement to break into the pipe and insert a full bore flow element. Ask a medical instrument engineer the same question and they would view the problem in a different way. Apart from ultrasonic or laser, currently there is not much else available for truly non-invasive clamp-on technologies to meter biological fluids through a tube wall. There are other options though. Disposable flow elements or fully sterilisable products. Both are extensively used in the medical flow measurement. Obviously both of these options have a financial overhead and most engineers would like to avoid this scenario if possible.

Titan Enterprises has licensed one major medical company to use our technology for a disposable ultrasonic flow element. Each unit contains the crystal assemblies, flow tube and a chip to hold each elements calibration data. When the cartridge is inserted the battery powered transmitter attached to a patients arm reads this calibration data and the device is set-up ready for use. After use, which could be up to four days, the flowmeter cartridge is discarded.

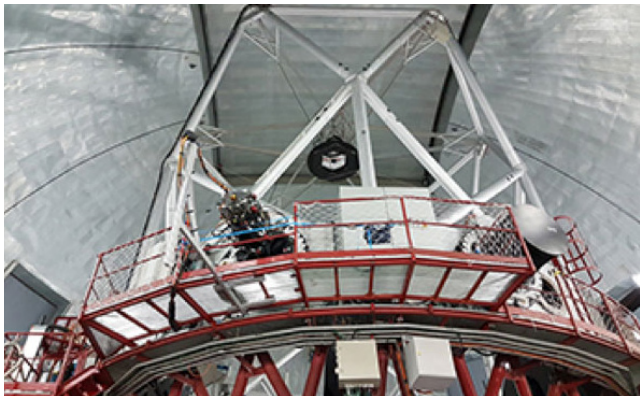
We have also produced a very basic clamp-on device for use with 1/16-inch diameter tube and this development is looking positive although more R&D is required before it will become a viable commercial product. However, we have proved the basic principles and know that, should an OEM ask the question, we could produce a viable clamp-on ultrasonic meter with far superior performance to existing ultrasonic devices.

To discuss how our proprietary ultrasonic flow technology can help meter liquid flow in your medical application please **click here**.

Problem Solved

Cooling the World's Most Sensitive Astronomical Camera: How old flow technology has solved a high-tech problem.

The world's largest optical telescope, the 10.4m Gran Telescopio Canarias (GTC) on the Canary Island of La Palma, is equipped with a powerful new astronomical camera built by the University of Sheffield, UK. This camera, called HiPERCAM, was commissioned on the telescope in 2018 and can take over 1000 pictures every second simultaneously in five optical colours. The person behind HiPERCAM, Professor Vik Dhillon of the University of Sheffield, states that "HiPERCAM is the most sensitive astronomical camera in the world, and has been used to study black holes, neutron stars, white dwarfs, exoplanets, active galactic nuclei and the outer regions of our Solar System".



he 10.4m Gran Telescopio Canarias (GTC) on La Palma – the world's largest optical telescope.

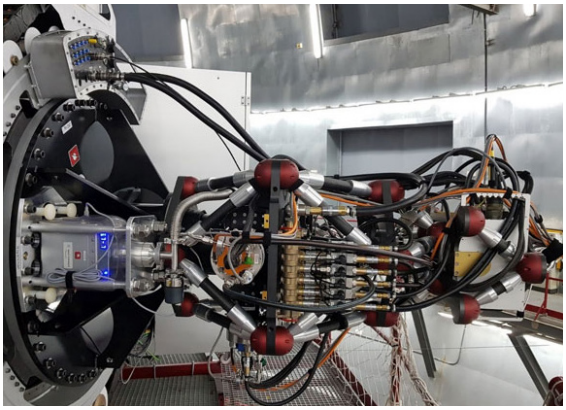
The five light sensors used in HiPERCAM are ultra-sensitive

First light with HiPERCAM – the spiral galaxy NGC 4800, which lies at a distance of 80 million light years.

charge-coupled devices (CCDs), which require cooling to 183K (-90degC) to minimise noise in the images. This cooling is achieved using very high performance thermo-electric (peltier) coolers, which in turn require a liquid coolant (a water-glycol mixture at +5degC) to remove the heat they extract. If the flow of coolant fails, the heat input from the peltier power supplies would destroy the CCDs, which would cost over £500,000 and take years to replace. With so much at stake, the Sheffield team have developed a fail-safe system, where any disruption to the flow of coolant past the detector causes the power supply to the peltiers to switch off automatically, thereby protecting their expensive equipment. Clearly, the most important element in this fail-safe system is an accurate and reliable flow sensor for the coolant.

This is where Titan Enterprises enter the story. Our 1000-series mini-turbine flow sensors were initially selected for HiPERCAM. Six such flow sensors were required, one for each of the 5 detectors and a sixth for the control electronics (which are also cooled). These six flow sensors were attached to the 6-way input manifold mounted on HiPERCAM that is used to feed the 6 parallel cooling circuits, as shown in the photo below. The Titan 1000-series flow sensors were first tested in the lab in the UK and then commissioned on the camera on La Palma in 2018.

All seemed to work well at first, with each sensor typically reporting a flow rate of 1.5 litres/minute. However, over time (days-weeks), the sensors started to report zero flow rate, which caused the peltier power supplies to switch off and the detectors to warm up, making HiPERCAM inoperable. Given that each night on the telescope costs 50,000 euros, this was a serious problem.



HiPERCAM mounted on the GTC. The 6 Titan 1000-series flow sensors mounted on the 6-way brass manifold can be seen in the centre.

On inspecting the faulty sensors, it was discovered that the magnets in the Hall-effect propellers had accumulated a slimy, metallic substance over time, which had eventually prevented them from spinning on their sapphire bearings, thereby reporting zero flow rate. Clearly, despite filtering, the coolant supply provided by the observatory was not clean enough to use this type of flow sensor.

The HiPERCAM team therefore recontacted Titan Enterprises for advice. We recommended a change to ultrasonic sensors, as these are impervious to the metallic sludge present in the coolant. We provided custom housings for our Process Atrato ultrasonic sensors and a special calibration to emulate the 1000-series sensors, so they were “plug and play” replacements. Once again, the flow sensors were tested extensively in the lab at Sheffield prior to shipping to La Palma for commissioning on HiPERCAM at the start of 2019.

Titan Enterprises optical flow sensor.

Unfortunately, once the flow sensors were installed in HiPERCAM on La Palma, they behaved erratically, exhibiting zero or highly variable flow rates, something that had not been evident in the lab during testing in Sheffield, UK. This problem was traced to the presence of tiny bubbles in the coolant supply of the telescope, which attenuated the ultrasonic signal and made the flow sensors unreliable. Since the telescope’s coolant supply is provided by an observatory-wide chiller system housed in a separate building, something which the HiPERCAM team have no access to and no control over, there was no way of removing either these micro bubbles or the metallic sludge.

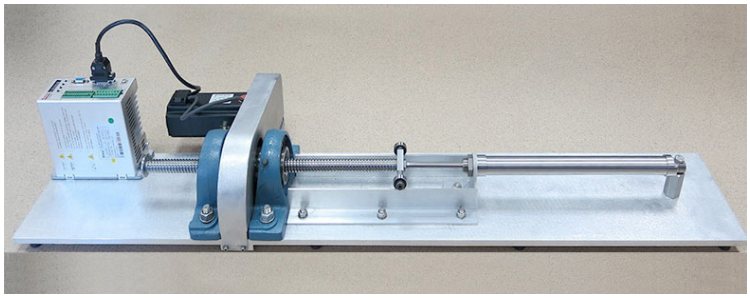
As a result the HiPERCAM team turned again to Titan Enterprises for further advice. Is there another type of sensor that could be used that is impervious to the undesirable (but unavoidable) characteristics of the telescope’s cooling fluid? The answer was yes – the Titan FT2 optical flow sensor that uses an LED and photo-diode to measure flow. When the rotor spins the photo-diode can detect the LED with a frequency proportional to the flow rate. When the rotor is static, the photodiode cannot see the LED, indicating no flow.

While this is an old and infrequently requested technology, fortunately for the HiPERCAM team, they are still available, and six were delivered in October 2019. The optical flow sensors have just been successfully tested in the lab at Sheffield and are now on their way to La Palma for final commissioning on HiPERCAM. Everyone involved is now hopeful that this will be a successful end to the story, and Titan Enterprises will have enabled HiPERCAM to finally achieve its full scientific potential.

For further information on the HiPERCAM camera being used on the world’s largest optical telescope, the 10.4m Gran Telescopio Canarias (GTC) on the Canary Island of La Palma – please **click here**.

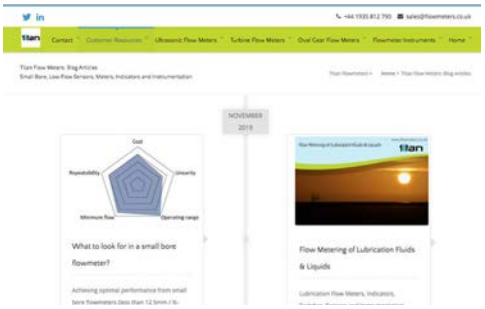
News Update:

New Micro Calibration Rig



Due to our requirement to calibrate large quantities of our Model 803 flowmeters we have designed and built a dedicated flow rig for these devices. It is a fully automatic system and, although currently only calibrating one flowmeter at a time, has the capability of doing two together at a later date. It has the capacity to produce a fully traceable calibrated flowmeter every 40 seconds.

The calibration rig comprises a miniature piston prover driven by a digitally controlled servo motor. Calibration of the volumetric displacement is done with our certified scales using distilled water and has returned an uncertainty of ±0.06% over the flow range of 0.05 to 0.5 litres per minute. For further information please **click here**.



Titan's web blog – a great information source

For over six years we have regularly updated our web blog with a host of interesting and informative posts to bring you the latest Titan Enterprises technological innovations, applications advances, breaking news, interviews, published articles and more. Updated with new blog posts several times per month we highly recommend that you bookmark the web page - **www.flowmeters.co.uk/flowmeters-blog/** as a valuable information source worthy of regular revisits.

Product Focus:

Stamp of Approval for Titan Turbine Flowmeters

Increasingly food and beverage manufacturers wishing to meter production flow are requiring the assurance of NSF certification that the flow measurement devices they choose are completely compatible with their products. Our 800 Series turbine flowmeters and beverage meters have been certified under NSF/ANSI 169 as equipment suitable for food production.

The 800 series turbine flowmeter gives high performance over six flow ranges from 0.05 to 15 L/min, while the beverage flowmeter is designed specifically for the drink dispensing industries, including beer wines and spirits, with a flow range up to 10 litres per minute. These products' totally non-metallic wetted components make them highly suitable for metering food and beverage materials, as appropriate. To learn more about NSF accredited flowmeters for food and beverage applications please **click here.**

Humour

A little bit of light heartedness to brighten your day.

The Optimist, the Pessimist, and the Engineer

The optimist says: "The glass is half full."
The pessimist says: "The glass is half empty."
The engineer says: "The glass is twice as big as it needs to be."

This writing will turn blue if you run away fast enough!

Douglas Adams HHG to TG:

A common mistake that people make when trying to design something completely foolproof is to underestimate the ingenuity of complete fools.

Or

It is a well known fact that those people who most want to rule people are, ipso facto, those least suited to do it. To summarize the summary: anyone who is capable of getting themselves made President should on no account be allowed to do the job.

TITAN ENTERPRISES LTD.

Coldharbour Business Park, Sherborne, Dorset DT9 4JW. UK

Phone: +44 (0)1935 812790

Email: sales@flowmeters.co.uk

www.flowmeters.co.uk