Applications in Liquid Measurement Using Clamp-On Ultrasonic Technology
Class # 2460

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Introduction

Ultrasonic Technology is often referred to as new technology. While it is true, API only started recognizing custody transfer measurement by Ultrasonic Meters with the publication of Chapter 5.8 in 2002 the fact remains that ultrasonic technology has been around for many years. Working for Mid-Valley Pipeline in 1982 I can remember my first encounter with an Ultrasonic meter or in this case a densitometer. Yes the densitometer did work and did what it was supposed to do. The one problem however was the densitometer was an insert ultrasonic instrument and Mid-Valley was a crude oil pipeline. Simply put, in the winter time when the paraffin really began forming on the pipe wall and scrappers were being run every week on the north end, it was noticed that the densitometers, the insert ultrasonic ones, started having problems. After waiting 2 or 3 days to see if the problem would correct itself, we often found ourselves scheduling maintenance time to pull the densitometer and clean the sensing element. Granted it has been a few years but I remember thinking this was not bad technology, it just was not applied as well as it should have been. This introduction was started however talking about this new technology called ultrasonic and yet my first experience with it was in 1982, almost 30 years ago. Well, as one might suspect it gets one to thinking about ultrasonic technology and when it might have first been proposed for the measurement of flow in pipes. Some may not believe it but the first patent issued I know of was in the late 1800's in Germany. While it is safe to assume no meters were made at that time using this new principle it can not be denied the principle existed then. The fact is, in the 70's, one might have been able to count the number of clamp-on manufactures on one hand. However today, 2011, there are over 50 manufactures of clamp-on ultrasonic meters. While the majority of these manufactures align there products with specific industries, several manufactures still service several industries with their meters.

Principle

It is not the intent of this paper to derive the formulas for the calculation and measurement by ultrasonic principle. However, it is believed that having an understanding of the principle will enable you to better understand how this technology might best fit your application needs. Like the old saying, "there is more then one way to skin a cat", the same can be said about the ultrasonic measurement techniques.

It is generally accepted that ultrasonic measurements are typically made using one of two principle measurement methods. These are methods are simply known as Doppler and Transit Time. Starting in about 2005 a third version of ultrasonic measurement appeared on the scene that is a variation of the normal Transit Time measurement.

Doppler measurement is based on frequency shift. That simply means the transmitted frequency is fixed and the received frequency is shifted. The shift in the frequency is proportional to the flow velocity of the particle in the stream that the transmitted signal is reflected off. While this method will provide flow readings it tends not to be as accurate as Transit Time ultrasonic measurement in general and is often dismissed without any consideration for the important role it plays in flow measurement in the petroleum industry.

Transit Time ultrasonic measurement can rightfully be considered the backbone of ultrasonic measurement at the time of this writing. The principle of operation is as the name implies measurement of time. Just measuring time does not provide flow measurement however and to determine flow measurement one must measure time in both directions. Additionally, it is necessary to know the geometry of the pipe as well as the length of the path the signal takes. The flow rate is proportional to the difference in time it takes the signal to travel in the upstream and downstream direction. In addition to the difference in time, the average time the signal takes to travel the distance is computed to provide the speed of sound of the flowing product. Other parameters that may be provided by this method are: signal strength, signal gain, aeration.

The newest version uses pattern recognition algorithms to follow the flow pattern as it moves down the pipe. By knowing distance travelled and the time it takes to travel that distance the flow velocity and therefore flow rate can be computed. The signal source is typically ultrasonic transducers.

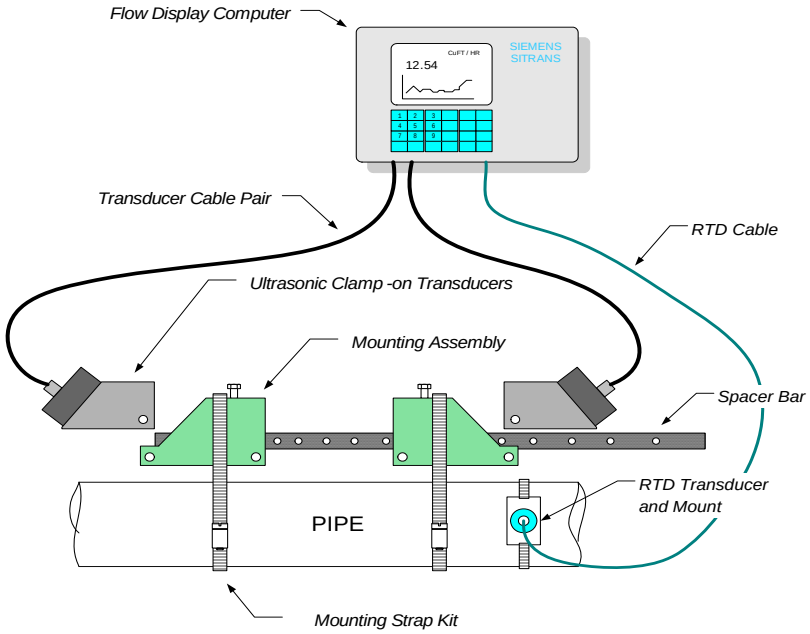
Sum of the Parts

Clamp-on meters are easily understood when you break them down into the distinct parts that makeup the clamp-on meter. Because the heart of the ultrasonic meter is it microprocessor the electronics naturally must be considered as a major part of the meter. It is this part of the meter that is responsible for creating the electrical signals, measuring the signals, processing the signals, calculating the flow velocity and other parameters, displaying the information and outputting the information to the end user's Scada or DCS.

Next are the mouth and ears of the system. Yes the transducers are the part that converts the electrical signals to Ultrasonic sound and Ultrasonic sound to electrical signals.

The third and very important part is the mounting system for the transducers. This part of the meter might not seem all that important but when you consider the meter may not function if the mounting system is damaged then you start to understand its importance better.

Last are the connecting cables used to pass the signals back and forth between the transducers and the electronics.



Concerns

Why would anyone consider clamp-on ultrasonic meters? Could it be simply that using clamp-on meters eliminate many of the installation cost associated with other technology? Or is it that some clamp-on meters can perform the task of several pieces of equipment. For certain the thought of clamp-on implies easy of installation but maybe it is too easy and therefore the reverse may also true. These are questions the user must ask.

Manufactures of these meters spend a large part of their time concerned with the mounting systems. The goal being easy of installation yet roughed enough to handle the routine physical abuse instrumentation might be subjected to on pipelines, facilities and refineries. While each manufacturer takes their on approach their goal is the same, a rugged mounting system that is easy to install.

Applications

Ultrasonic meters are typically used to measure flow and clamp-on ultrasonic meters are no exception. One will find these meters installed in most aspects of the petroleum industry. For example, in the production field you will find ultrasonic meters being used to measure the production from the wells. But if you look closer, clamp-on ultrasonic meters can be found in water flood applications where they monitor the injected water into the formation. However their use even starts before that when you realize they are sometimes used on the drilling rigs that drill the wells.

These versatile meters can often be found on separators. Not only measuring the flow into the separator but also measuring the flow out, the water, the oil and even the gas.

Offshore one even finds these clamp-on meters performing a multitude of task. Whether simply measuring flow rates on the processes on the platform or measuring the flow onto and off the platform. These adaptable little meters are even found on FPSO and sometimes a mono buoy where they are used as leak detection meters and check meters.

Gathering systems often utilize these meters because they enable the measurement coordinator to easily monitor the over and shorts. On multi-product pipelines these meters not only provide flow information for line balance and check metering purposes but may also provide interface information. The fact these meters are non-intrusive makes them an excellent choice when considering an interface detector when you compare them to other systems that require special licensing or tapping the pipeline.

Some companies have mounted meters in their vehicles to track production from each well in their system. The ability to interface with a pc enables the user to load the sites he will visit that into the memory of the meter and thereby minimizing the setup time to just minutes.

The applications for the use of these meters in the petroleum arena has continued to grow and includes highly aerated liquids, high viscosity liquids (4000 cp), hydraulic lines and additives in addition to crude oils and refined products. Because of their portability and easy of installation they are easily used in line displacements and re-filling. There is a lot of truth to the say if you can flow it in a pipe, it can be measured with an ultrasonic meter.

Considerations

While it is true you can mount these meters anywhere there is enough room on the pipe to fit the transducers. Truth is these meters have even been mounted on elbows. While it is not recommended such a place to mount, it

does attest to the versatility of these meters. As a user, you must be aware of what is happening inside the pipe when you look for places to mount these meters. To attain the best performance requires picking a location where the flow profile is repeatable. This means on a multi-product line the location that has 50 diameters of straight pipe proceeded by two 45 degree elbows should be avoided since the flow profile will flip at some point it time. A more suitable location might be 6 diameters downstream of double elbows in plane. Another great place is downstream of a concentric reducer. Places like these make sense especially when you use a meter with a pipe configuration table that allows you to describe to the meter the upstream piping. It is always good to know what is happening inside the pipe. Is there any build up on the pipe wall? A little buildup will not hurt the measurement much but when you start a meter up and measure double the flow rate and all the parameters are correct, you have to ask the question could it be a little more then just a little build up on the inside pipe wall.

Conclusion

With each year the use of clamp-on ultrasonic meters has continued to grow in the petroleum industry. Additionally, the performance of these meters, when properly installed, has been proven to extremely good. Some customers have reported maintainable line balances of better then 0.25%. The future looks even better as the manufactures continue to improve the systems by incorporating advancements in signal processing and electronics. Some of the meters manufactured today incorporate dynamic tables that allow the user to select gross or corrected flow rates and volumes based on each product the meter sees. These meters typically can perform several task, flow measurement, density measurement, viscosity measurement and pig detection making them ideal for replacing to replace several instruments on the pipeline system.