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OPTICAL PROBES DEVELOPMENT FOR FLOW MEASUREMENT

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Abstract. This work describes the fiber optics sensors development for homogeneous or heterogeneous flows measurement. Optical sensors are distinguished from conventional sensors because they are coupled in optical fiber. The great advantage is immune to electromagnetic interference; Are made inert material (glass), little reactive and conducive to environments subject to explosions; Can potentially be read from a distance because of the low attenuation of the optical fiber; Are compact and durable. For all this the optical sensors have been applied in the industry in inhospitable environments or where another type of sensor can not be used. The optical sensors used are based on Bragg gratings in Fiber Bragg Gratings (FBG) and also in heterogeneous structures SMS and SMSMS formed by the splice between optical fibers of different technologies. The acronym SMS and SMSMS literally represent the order of the different fiber technologies in the formation of the hetero structure, with "S" being the designation for single mode fiber and "M" the designation for multimode fiber optics. This article presents a procedure for the design and application of new optical fiber sensors flow measurement. An innovative methodology is presented to design fiber optic sensor, and its application to speeds and flows measurement.

Keywords: counters of water tachometric, admeasurement, two-phase flow.

1. INTRODUCTION

Industrial activity routinely involves the consumption of liquids and gases. For example: industry oil transportation in pipelines, fuel transportation of to feed boilers and motors, transport of water in supply systems, liquid waste in

various sectors. This effort is due to a concern with the monitoring of the equipment used in industrial processes as well as their efficiency and products generated, parameters associated with the economic impact that may arise.

Optical sensors are distinguished from conventional sensors because they are coupled in an optical fiber. There are some advantage: is immune to electromagnetic interference; Are made inert material (glass), little reactive and conducive to environments subject to explosions; Can potentially be read from a distance because of the low attenuation of the optical fiber; Are compact and durable. For all this the optical sensors have been applied in the industry in inhospitable environments or where another sensor can not be used (Silveira, et al.,2015). The objective of this work is develop new fiber optic sensors for flow measurement and evaluate the performance in several Reynolds numbers, both in laminar and turbulent flows.

2. EXPERIMENTAL PROCEDURE

The work proposes a application new fiber optic sensors capable of obtaining mass flow measurement parameters. Aiming to develop an innovative methodology in the construction of sensors and its application in the measurement of speeds and flows. In the context, the Optical Physics theory science will be applied in electrical quantities determination and wavelengths, optical fiber sensors operation principle. The Fluid Mechanics concepts will be applied for flow and velocity determination.

The fluid flow in tube could be measured using an optical fiber that is allowed to bend as a fluid movement function. There are two ways of implementing this system. The first is shown in Fig. 1, an optical fiber crossing the tube crossing its center. The second is shown in Fig. 2, where the cleaved fiber is inserted into the tube so that curves are allowed under the drag of the moving fluid. Both forms need to use special devices that alter the transmitted or reflected power as a function of fiber curvature. For example, cavities formed by SMS structures, SMSMS and tapers (Silveira, et al.,2015).
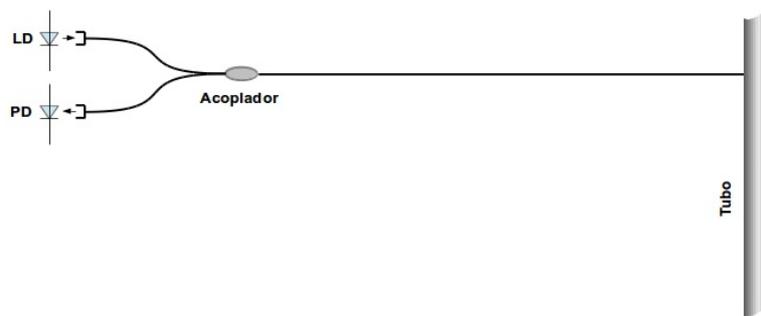

Figure 1. Application of a laser diode (LD) and a photodiode (PD) for the excitation and reading of the power reflected by the end of the fiber inside the channel of the wind tunnel.
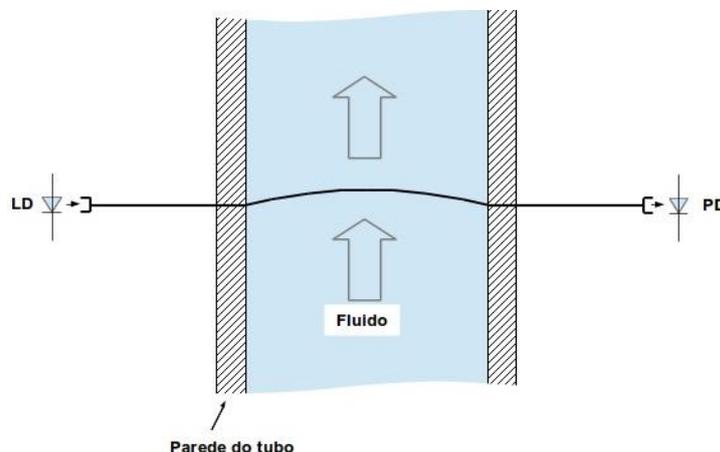

Figure 2. Optical flow meter using bend sensor that would lie exactly in the middle of the optical fiber in the center of the channel to measure water flow rate.

2.1 Fiber Bragg Gratings – FBG

The optical sensors to be used are based on Bragg gratings in Fiber Bragg Gratings (FBG) and also in heterogeneous structures SMS and SMSMS formed by the splice between optical fibers of different technologies, Figure 3. The acronyms SMS and SMSMS literally represent the order of the different fiber technologies in the formation of the heterostructure, being "S" the designation for single-mode fiber and "M" the designation for multimode fiber optic. The SMS, SMSMS and derivatives structures have been investigated in the Laboratory of Applied Electromagnetism - LEA of UFPA as potential sensors of curvature of very low cost (Giraldi, et at., 2014). This project will emphasize the development of mechanical structures for the utilization of these transducers in SMS and SMSMS fiber, for the potential they present for the construction of low cost and high sensitivity flow sensors.
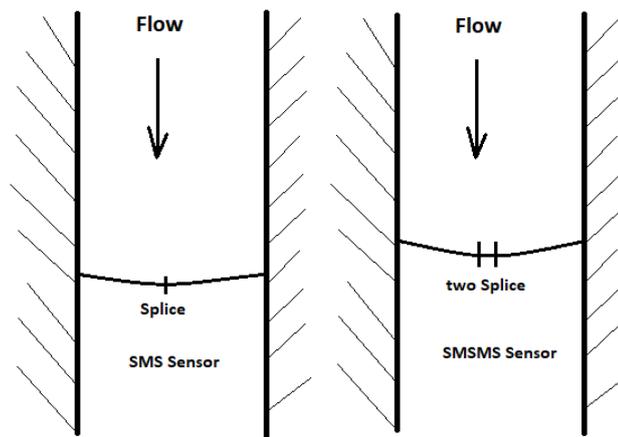

Figure 3. Schematic Fiber Optic Sensors.

3. RESULTS

In the measurements made later it is noticed a change in results and comparison with the first graph. Next, we have the data to calculate the flow as a function of the Reynolds number, without the use of the needle in the optical fiber.
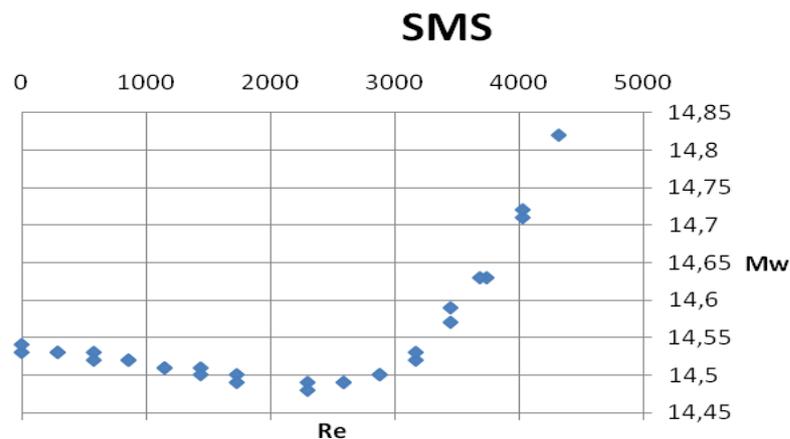

Figure 4. Reynolds Number versus Power (mW) sensor with SMS.

In the graph above we note that with the use of fiber optic with needle the fiber oscillation decreases, with this we can affirm that the use of fiber optic with needle is the most indicated, because the results obtained with it are more satisfactory.
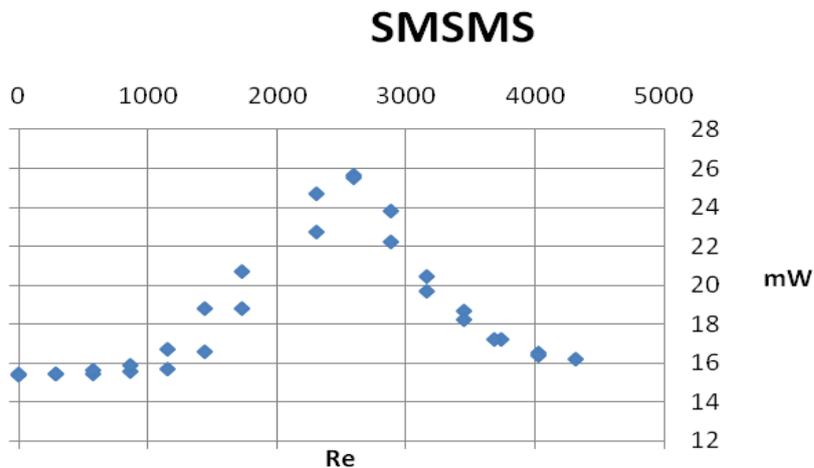
Figure 5. Reynolds Number versus Power (mW) sensor without SMSMS.

In figure 4 we see the graph of the flow x power, we realize that the values for each flow number and its corresponding power number have a great variation, much larger than those presented in the use of the fiber with needle. It is important to note that the values showed a good behavior for Reynolds above 2400, which characterizes the turbulent flow. In view of this, said sensor exhibited good repeatability for this flow. As in most industrial applications the type of flow found is turbulent, said sensor has good prospects for use in the industry.
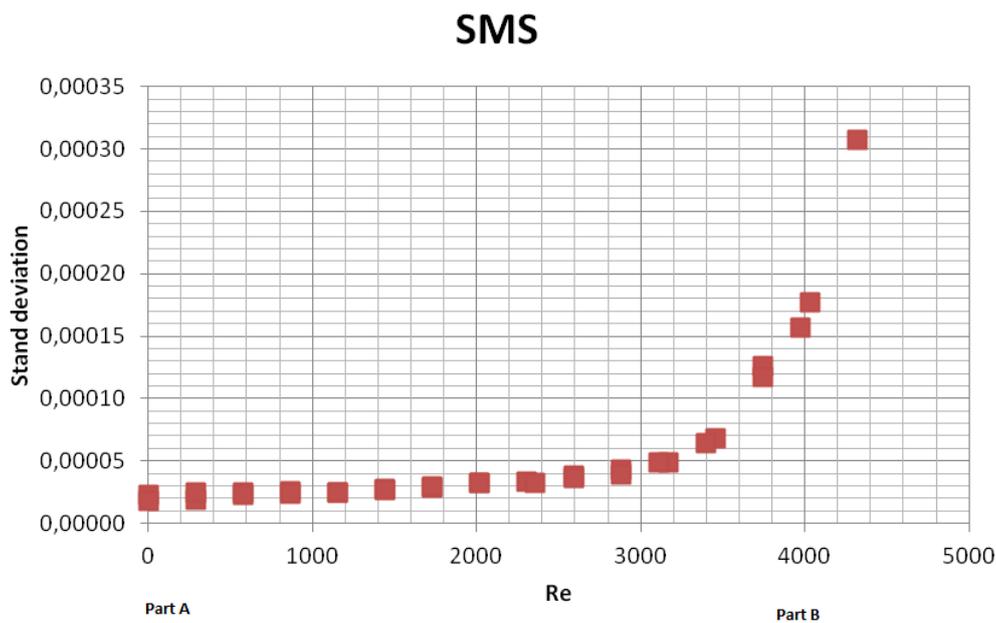

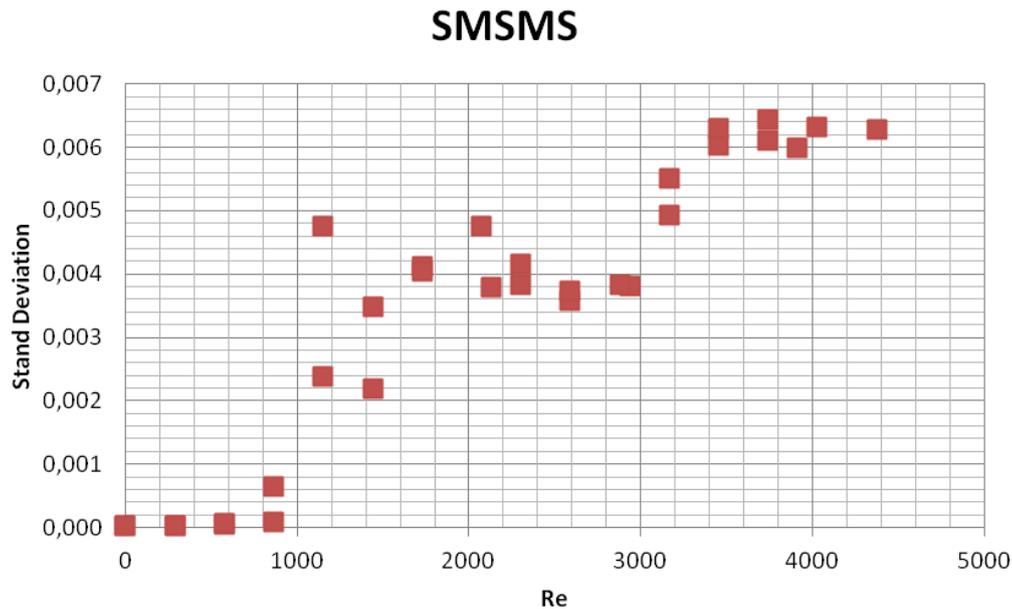Figure 6. Standard Deviation with SMS sensor.

SMSMS

Figure 7. Standard Deviation with SMSMS sensor.

At Figure 6 shows the standard deviation of the results obtained as a function of the Reynolds Number. We noticed that in the "part A" graph there was a greater dispersion of the results in the sensor considered resin (without needle), possibly due to the vibration caused by the flow turbulence. The sensor having the needle as the carrier, graph b, caused the turbulence effect to decrease, causing a better stability in the standard deviation graph. The results obtained are statically treated from a 10000 sample sample for each point, where the 95% uncertainty analysis was evaluated, and they were determined on the order of 10-7.

4. CONCLUSIONS

The results show that the optic sensors with needles presented a more suitable behavior for measurements one in flows. This is confirmed by the graphs of the standard deviations shown, which showed few fluctuations in the measured samplings in SMS sensor. The measurement technique applicability presented is appropriate for Reynold values above 3000, turbulent flow.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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7. RESPONSIBILITY NOTICE

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