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Señora Jefe de la
DIVISION DE NUEVAS CREACIONES
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SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO



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Asunto : Solicitud de Patente para **TRANSDUCTOR DE PRESION
DIFERENCIAL A FIBRA OPTICA**
Solicitante : PETROLEO BRASILEIRO S.A. PETROBRAS
Clase : F15B 005/000
Publicada en : La Gaceta No. 574 Del 30 de marzo de 2007
Fecha de Solicitud : 8 de septiembre de 2005

1. Yo, Emilio FERRERO, identificado como aparece al pie de mi firma, actuando como apoderado en el asunto de la referencia, atentamente, solicito se efectúe el examen de patentabilidad de la solicitud en referencia. Para tal efecto presento junto con este escrito el recibo por valor de \$ 404.000.00, que corresponde a la tasa fijada según lo dispuesto en la resolución No. 36155 de 28 de diciembre de 2006.

2. Ruego atentamente a la Señora Jefe se sirva ordenar que se anexe este recibo para que se efectúe dicho examen y se continúe con el trámite de la solicitud.

Señora Jefe,

EMILIO FERRERO

T.P.A. No. 31.929

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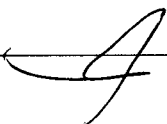
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***** C O N C E P T O *****

CANT.	RENTISTICO	CONCEPTO	TOTAL CONCEPTO
1	50005-01-01	SOLICITUDES	
		85 EXAMEN DE PATENTABILIDAD DE INVEN	404,000.00
		TOTAL :	\$ 404,000.00

SON: CUATROCIENTOS CUATRO MIL PESOS

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DIVISION DE NUEVAS CREACIONES

RADICACIÓN EXPEDIENTE No 05-90935

EL EXTRACTO DE LA PRESENTE SOLICITUD DE **PATENTE DE INVENCION** FUE PUBLICADO EN LA GACETA DE PROPIEDAD INDUSTRIAL

No **575** DE FECHA **30** DE **ABRIL DE 2007** EL TERMINO HABIL

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NOTA: Dentro del plazo de los seis (6) meses siguientes a partir de la fecha de publicación en la gaceta de Propiedad Industrial, deberá solicitar y cancelar el examen de patentabilidad so pena de que la solicitud caiga en abandono, de acuerdo con lo establecido en el Artículo 44 de la Decisión 486/2000.

SE PRESENTARON OPOSICIONES POR PARTE DE TERCEROS.

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NO__ _X_ _____



DP flow sensor using optical fibre Bragg grating

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Abstract

An optical-based differential pressure (DP) flow sensor has been developed for an optically-powered hydraulic valve monitoring and feedback control system. The DP sensor employs two optical fibre single-mode Bragg grating elements, which are mounted on either side of the DP sensing diaphragm. The fluid flow-rate signal is obtained in the form of differential optical wavelength shift, and temperature compensation is provided. The sensor has been tested at fluid flow-rates from 0 to 800 cm³/s with temperature varying from 25 to 75°C. The optically-powered hydraulic valve using the DP flow sensor as a monitoring system has been tested with hydraulic oil with a flow-rate up to 6 cm³/s at a pressure of 700 kPa. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Differential pressure; Flow sensor; Bragg grating

1. Introduction

An optically-powered hydraulic valve has become practicable in real applications, for example, fly-by-light systems in aerospace industries and applications in hazardous environments [1,2]. A monitoring system is required to indicate the valve operation and to provide a measurement signal for feedback control as shown in Fig. 1. A differential pressure (DP) method is used and diaphragm strain is sensed using one of the optical fibre Bragg gratings (FBGs), while the other Bragg grating is used to provide temperature compensation.

This paper will present some preliminary results of the DP flow sensor, which employs the two optical FBGs on a thin diaphragm. The two sides of the diaphragm are connected to sense DP across an orifice plate located in the fluid pipe. The DP flow sensor has been tested with water flow-rate between 0 and 800 cm³/s at a pressure of 200 kPa and temperature range 25–75°C.

The advantages of this sensor configuration include non-electrical operation, no moving parts, no transparent windows required, relatively simple construction, light-wavelength modulation minimising light intensity variation problems, and temperature compensation using a differential wavelength method [3].

2. Basic design

An orifice plate is used to restrict fluid flow and cause a pressure drop across itself. A thin plate diaphragm is strained by applying this DP across it. The radial strain on the diaphragm surface is linearly related to the applied pressure. The strain is transformed into optical information by using one of the optical FBGs mounted at the centre of the diaphragm on the side which is in tension. The second grating is mounted on the diaphragm side which is in compression and responds to temperature but not strain. The reason for this is that the thin Bragg element is not rigid in compression and the thin diaphragm does not exhibit compression strain in its central region. The gratings are placed at right-angles to one another to maintain diaphragm symmetry. The differential wavelength shift between the reflected signals from the two gratings provides a measurement of the fluid flow-rate. Temperature variation causes the variation in the reflected wavelengths to be the same and therefore there is no change in differential wavelength (assuming perfect symmetry). The DP across an orifice plate is given by the equation [4]

$$Q = \frac{C_d A_0 \sqrt{2 \Delta P / \rho}}{\sqrt{1 - (A_0 / A_1)^2}} \quad (1)$$

where Q is the volumetric flow-rate, A_0 the hole area of the orifice plate, A_1 the cross-section area of the pipe, ρ the fluid

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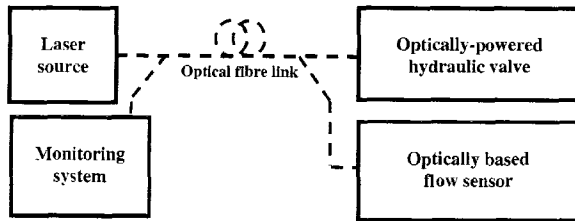


Fig. 1. Optically-powered valve monitoring scheme.

density constant, C_d the discharge coefficient of the orifice plate, and ΔP the DP across the orifice.

The relationship between the DP across the orifice and the strain on a circular thin plate diaphragm is given by the equations [5]

$$\varepsilon_r = \pm \frac{6M_r}{Eh^2} - \nu \frac{6M_\theta}{Eh^2} \quad (2)$$

$$M_r = \frac{\Delta P}{16} [a^2(1 + \nu) - r^2(3 + \nu)] \quad (3)$$

$$M_\theta = \frac{\Delta P}{16} [a^2(1 + \nu) - r^2(1 + 3\nu)] \quad (4)$$

where ε_r is the strain in radial direction on the diaphragm centre, M_r the bending moment in radial direction at the diaphragm centre, M_θ the bending moment in angular direction at the diaphragm centre, E the modulus of elasticity of the diaphragm material, h the diaphragm thickness, ν the Poisson's ratio of the diaphragm material, a the diaphragm

radial, and r the distance of the point of consideration from the centre.

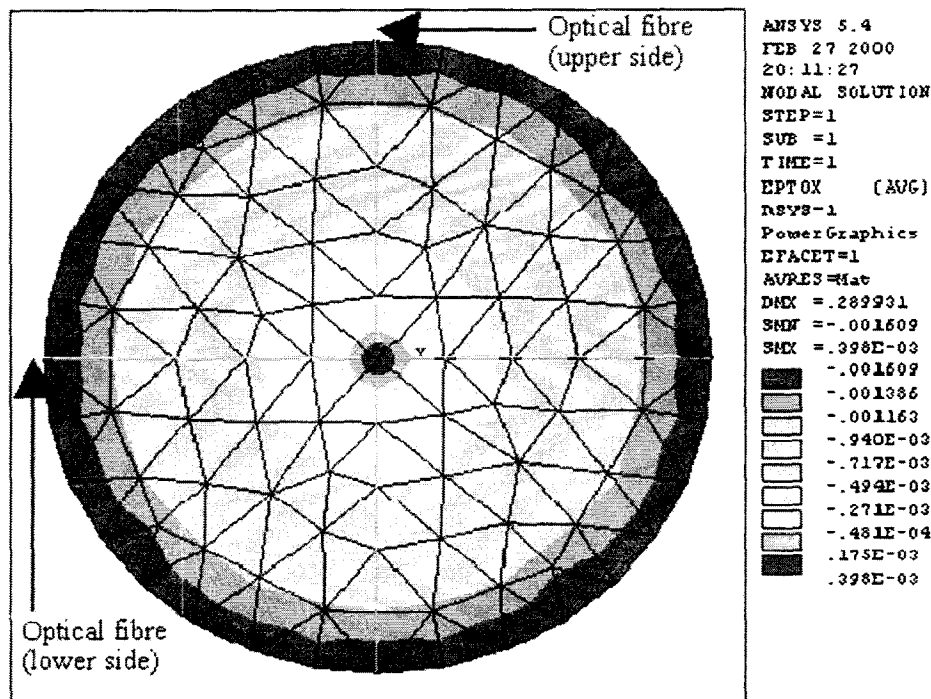
The reflected wavelength from a FBG caused by the strain at the centre of the diaphragm is given by the equation [6,7]

$$\Delta\lambda_B = (1 - p_e)\lambda_B\varepsilon \quad (5)$$

where $\Delta\lambda_B$ is the Bragg grating wavelength shift, ε the applied strain, p_e the effective photoelastic coefficient (≈ 0.22), and λ_B the Bragg grating centre wavelength.

The following assumptions have been made in the above equations: single-phase fluid flow and the Reynolds number (Re) greater than 2000 (for the square-edged orifice), isotropic diaphragm material and constant temperature. However, in the real configuration the optical fibre reinforcement on the diaphragm has to be considered. Therefore, finite element modelling has been used to predict the diaphragm characteristics. The modelling has been performed with a commercial finite element program (Ansys V5.4) and the results are shown in Fig. 2. In the model, isotropic materials are assumed for the diaphragm and the fibre. The analysis mesh chosen provides 22 contacts between the diaphragm and optical fibre material on both sides. A static pressure is applied on one side of the diaphragm model, while the circumference is fixed.

From Eqs. (1)–(5) and the modelling, data can be used to predict the differential wavelength shifts from the sensor and the strain corresponding to the fluid flow-rates (see Fig. 3). It can be seen that the optical fibre reinforcement has reduced the strain of the diaphragm and the sensor sensitivity by ca.

Fig. 2. Diaphragm with optical fibre reinforcement finite element modelling(maximum strain at centre 398 $\mu\epsilon$, symmetrical pattern).

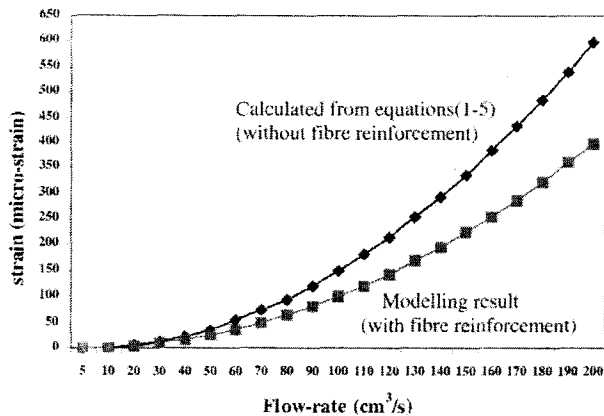


Fig. 3. Flow-rate and strain relationship.

one-third. However, it is possible to increase the sensor sensitivity by changing the diaphragm material and dimensions.

3. Construction

The experimental arrangement used for the tests is shown in Fig. 4. The optical source in the experiment is an SLD 5 mW, L3302-01 from Hamamatsu emitting at 848 nm peak wavelength and its spectrum bandwidth is about ± 20 nm (see Fig. 5). The optical power is launched into a 50:50 single mode optical fibre coupler. The two output ends of the coupler are connected to optical FBGs which are used on the diaphragm. The other end (at the input side) of the optical fibre coupler is connected to an optical spectrum analyser (Anritsu MS99A, resolution about 0.03 nm).

The Bragg gratings were fabricated on step-index single mode silica optical fibre, 5.1/125 μm diameter size by using the phase-mask technique at a wavelength of 840 nm (peak reflectivity 70%). A piece of FBG is glued to each side of the diaphragm surface at the centre position by using cyanoacrylate adhesive and coated with a thin layer of silicone rubber. Both gratings are pre-strained (at ca. 200 $\mu\epsilon$) when they are stuck on the diaphragm surface [7,8]. The free ends

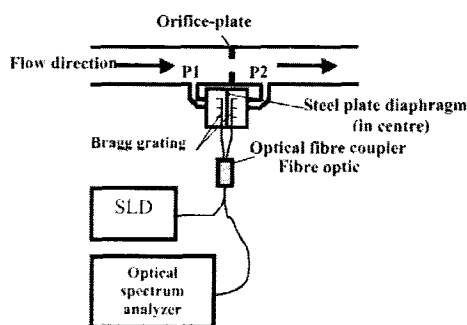


Fig. 4. DP flow sensor construction.

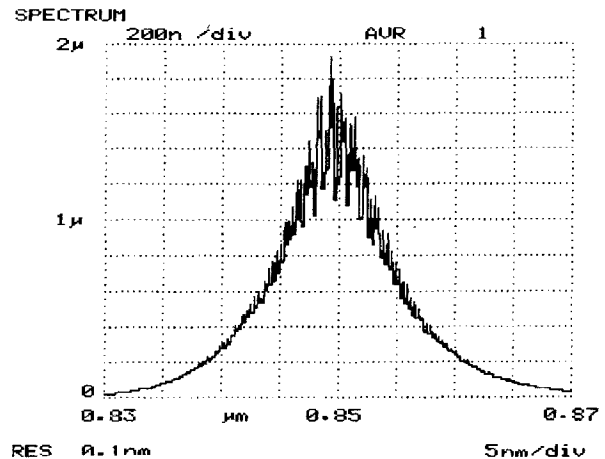


Fig. 5. The SLD light source wavelength spectrum.

of each FBG sensor are put in index matching gel in order to reduce reflecting light. The DP sensing diaphragm is made of stainless steel of 0.1 mm thickness and 25 mm diameter circular shape. The diaphragm clamp is also made of the same material to reduce strain which might be caused with temperature change.

The DP sensor is connected to the DP across the orifice plate in the flow test rig (Fig. 6). This test rig employs a centrifugal pump to circulate water from a water tank passing the test section. This section comprises a turbine flow meter and the 50% restrictive orifice plate ($C_d = 0.85$) which is clamped by a pair of flanges. DP at 80 kPa is produced by the maximum flow-rate of 800 cm^3/s . The water flow-rate is controlled by a by-pass flow control valve and main flow control valve, which maintain constant pump speed and system pressure. The flow-rate and DP relationship is monitored by a DP pressure meter. The measured value is used to provide comparison with the result of the FBG-DP flow sensor. Temperature effects have been investigated by varying the water temperature between 25 and 75 $^{\circ}\text{C}$.

4. Test results on sensor

Preliminary experiments have been performed using various water flow-rates at room temperature (25 $^{\circ}\text{C}$). The flow-rate through the orifice plate was increased from zero to 800 cm^3/s . The DP was indicated by the digital pressure meter and varied between zero and 80 kPa. The optical wavelength of the two FBG sensors was measured by the optical spectrum analyser. At a temperature of 25 $^{\circ}\text{C}$ the first FBG provided a reflecting wavelength at 838.96 nm and the second FBG wavelength was 839.3 nm. Therefore, the difference between the two FBG reflecting wavelengths was 0.3 nm at the zero flow condition (see Fig. 7).

The experiment setup was tested and the differential FBG wavelength increased in 0.1 nm resolution steps as the flow-rate was increased 380 cm^3/s . The full-scale wavelength

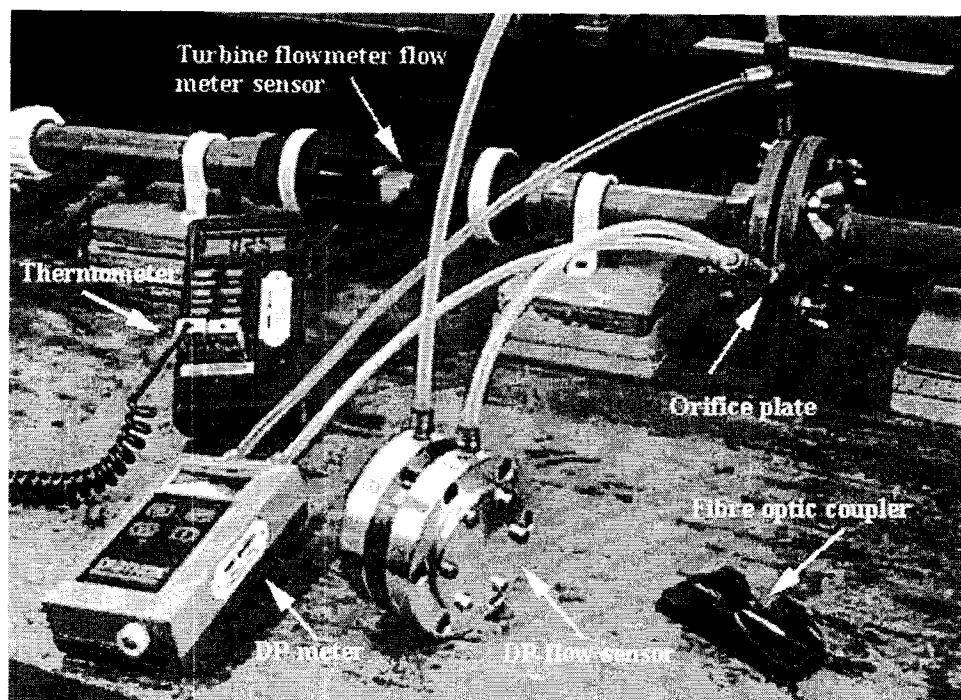


Fig. 6. The experimental setup.

change of 0.76 nm occurred at the maximum flow-rate, 800 cm³/s (see Fig. 7). The nonlinear relationship between flow-rate and differential FBG wavelength shift is in agreement with the predicted result from finite element

modelling but the sensors' sensitivity is lower than the predicted value by ca. one-fifth (see Fig. 8).

The temperature effect was investigated by increasing water temperature in the tank. The differential wavelength

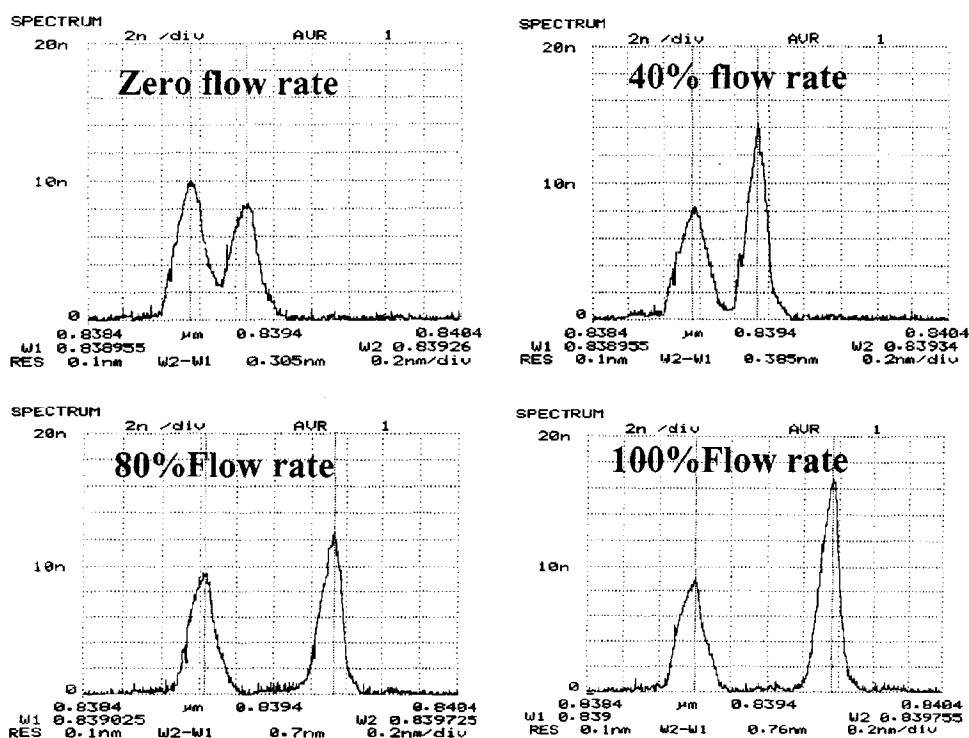


Fig. 7. The wavelength spectra of the two FBGs at various flow-rate, room temperature.

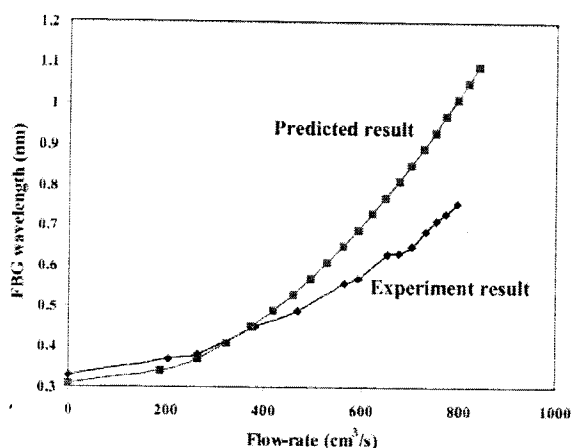


Fig. 8. Experimental results at room temperature.

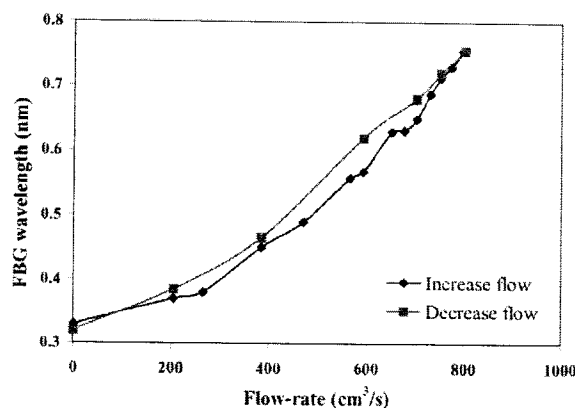


Fig. 10. The hysteresis loop of the sensor at room temperature.

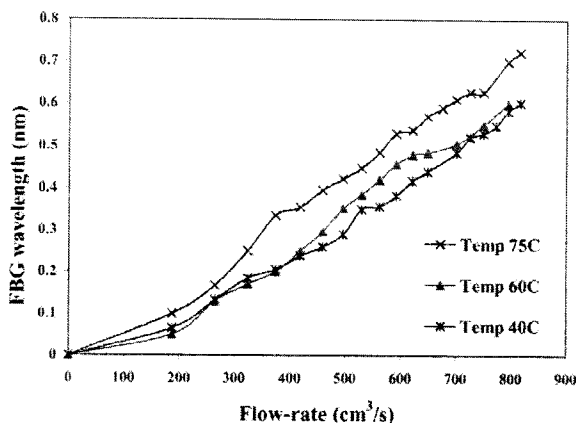


Fig. 9. Flow-rate and FBGs differential wavelength relationship at various temperatures.

shift for changing in temperature was ca. 0.1 nm in every 15°C. The relationship between the differential wavelength and water flow-rate was effected by temperature (see Fig. 9). The sensor repeatability has been tested at room temperature by increasing the flow-rate from zero to the maximum value and decreases the flow-rate back to zero. A hysteresis loop was found, as shown in Fig. 10.

5. Power-by-light hydraulic valve using DP flow sensor

The DP flow sensor has been applied as a monitoring system for an optically-power hydraulic valve. Both FBG elements in the DP flow sensor were remounted on a thinner diaphragm (0.08 mm) in order to increase the sensor sensitivity. The valve employs a PZT Bimorph and a nozzle flapper mechanism as a valving element [1,2]. The valve inlet port is connected to a 0.8 mm orifice plate which provides DP for the DP flow sensor (see Fig. 11). The

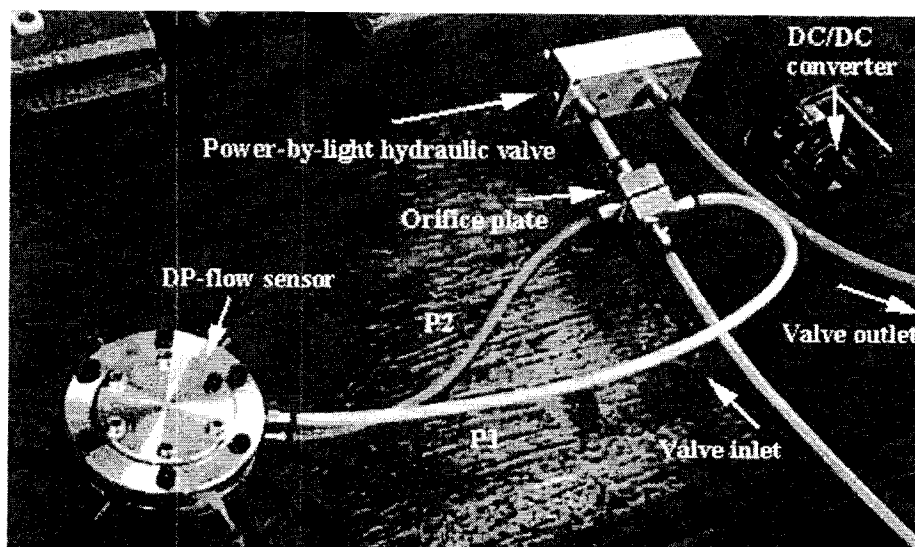


Fig. 11. The DP flow sensor tested with the power-by-light hydraulic valve.

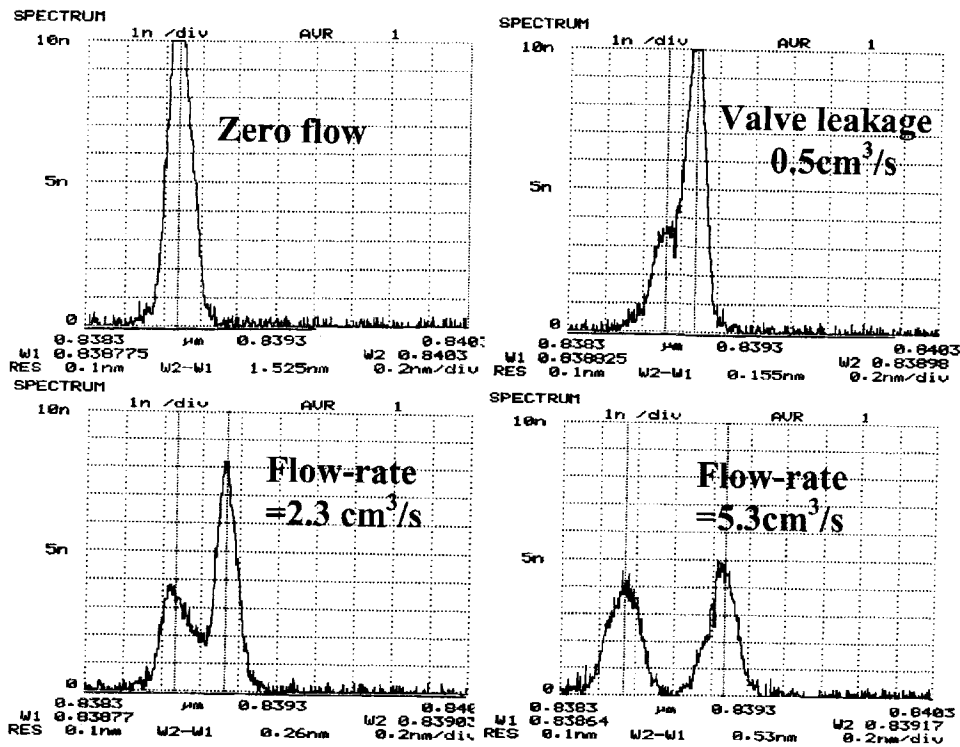


Fig. 12. The wavelengths spectra at the flow sensor output for various valve flow-rates.

experiment has been tested by using type Somator31 hydraulic fluid at a pressure up to 700 kPa. The valve is operated by 80 V dc which is converted from optical power by a photovoltaic cells and a high efficiency dc/dc converter; 46 mW of optical drive power (at the valve end) is transmitted from a laser diode (peak wavelength 808 nm) via 100/125 μm multimode optical fibre. The valve can provide hydraulic flow-rate up to 6 cm^3/s . The outlet port of the valve is connected to a flow control valve which is used to vary the flow-rate during the test. The wavelengths spectra at the flow sensor output for various flow-rates are shown in Fig. 12. Valve leaking detection has been simulated. The

minimum valve leakage that can be monitored by the flow sensor is ca. 10% of the maximum valve flow-rate. The relationship between the hydraulic flow-rate and differential light wavelength shift has been obtained at room temperature (see Fig. 13).

6. Discussions

The difference between the experimental results and the predicted values may be caused by the FBGs which could not be mounted at the dead centre of the diaphragm at the highest strain point. Because the area on the diaphragm of highest strain is quite small and the position of the FBGs in the optical fibre cannot be seen, the FBGs transfer lower strain than that predicted. The temperature compensated values at 75°C are larger than these at 40°C and 60°C. This is probably caused by the thermal expansion effect of the diaphragm and the limited operating temperature of the cyanoacrylate adhesive (limited to 80°C). The hysteresis error of the sensor is probably caused by the limited resolution of the spectrum analyser and the inaccuracy of the turbine flow meter. The creep in the adhesive bonding between the FBGs and steel diaphragm could also cause hysteresis.

The sensor operated satisfactorily with the power-by-light hydraulic valve. As only single value measurements were taken, uncertainties in measured values leads to a spread in the points.

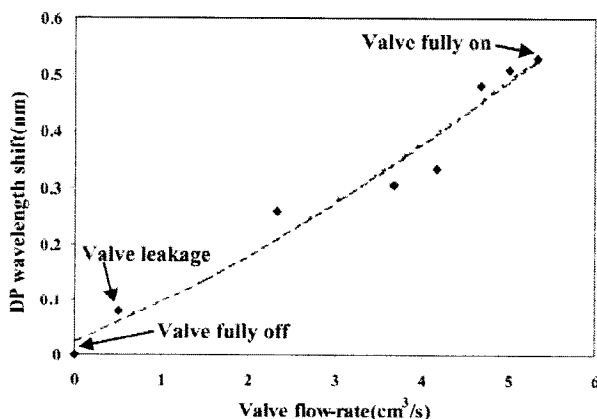


Fig. 13. The wavelength shift at various valve flow-rates (single value measurements).

7. Conclusions

It is clearly important to mount the FBGs in the right positions so as to avoid non-uniform strain effects [9]. The difference between the experimental and theoretical results is due to limitations in the model, in particular no consideration has been taken of the anisotropic steel diaphragm or the adhesive reinforcement effect. Due to the limitation in measuring resolution of the optical spectrum analyser flow was not detectable below 200 cm³/s. The compensated temperature coefficient has a value of 0.5% per °C. The error from the hysteresis of the sensor is ca. 5%, at room temperature. The DP sensor can be used to monitor the power-by-light valve operation. Valve leakage at ca. 10% of the maximum flow-rate is detectable.

It is possible to increase sensor sensitivity by changing the diaphragm material and dimensions. In order to achieve higher resolution, better accuracy, and minimum pressure loss, a Fabry-Perot tuneable filter would need to be used.

For the practical valve application, it is necessary to utilise a single multimode optical fibre for both optical powering and optical sensing. Therefore, multimode FBGs will need to be used in the final system [10–13]. The use of multimode FBGs and suitable diaphragm arrangements are being investigated.

Acknowledgements

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Biographies

J. Lim received his BE and ME degrees in 1991 and 1996, respectively, in production engineering with a major in Industrial Automation System from King Mongkut's Institute of Technology, North Bangkok, Thailand. During the period 1992–1998, he worked in the automation industries and then joined his university as a lecturer. He is now undertaking PhD research in the field of power-by-light and control-by-light of hydraulic valve systems in the Department of Systems Engineering, Brunel University, UK.

Q.P. Yang received the diploma in instrumentation and measurement from Chengdu Aeronautical Polytechnic, Chengdu, PR China in 1983. He was then an assistant engineer, deputy head of Department of Measurement and Testing in the Aircraft Structural Strength Research Institute (Ministry of Aerospace), Shaanxi Province, PR China. He was awarded a scholarship to study at Brunel University in 1988 and finished his PhD in 1992. He currently lectures on manufacturing measurement, quality engineering and information technology. His current research interests include advanced sensors and transducers, dimensional metrology, quality engineering, virtual instrumentation and measurement science. He has published more than 35 papers in these areas.

B.E. Jones has been professor of manufacturing metrology at Brunel University and director of the Brunel Centre for Manufacturing Metrology (BCMM) since 1986. He is a previous honorary editor of *Journal of Physics E: Scientific Instruments* (now *Measurement Science and Technology*) and a past member of the UK Council for National Academic Awards. He was formally a member of the academic staff at the University of Manchester and then UMIST. His research interests encompass sensors, transducers and actuators, optical and mechanical metrology, automatic inspection, intelligent and distributed instrumentation. He is author and editor of five books and has published over 250 papers and articles. The research work has been undertaken in collaboration with industry and involved many international links particularly in Europe. Professor Jones was awarded the DSc from the University of Manchester in 1985 and holds fellowships of five professional bodies. He received a 1995 Metrology for World Class Manufacturing Award as Champions of Metrology (sponsored and supported by Industry and Government).

P.R. Jackson is a senior project engineer at Flight Refuelling Ltd., Wimborne, UK, working in the field of power-by-light and control-by-light technology for the aerospace industry. His BE was obtained at Edinburgh University and he subsequently obtained MSc and PhD degrees in industrial measurement and control systems from Brunel University in 1993 and 1996, respectively.

Strain and Temperature Sensors Using Multimode Optical Fiber Bragg Gratings and Correlation Signal Processing

Jirapong Lim, Qingping Yang, Barry E. Jones, and Phillip R. Jackson

Abstract—Multimode fiber optic Bragg grating sensors for strain and temperature measurements using correlation signal processing methods have been developed. Two multimode Bragg grating sensors were fabricated in 62/125 μm graded-index silica multimode fiber; the first sensor was produced by the holographic method and the second sensor by the phase mask technique. The sensors have signal reflectivity of approximately 35% at peak wavelengths of 835 nm and 859 nm, respectively.

Strain testing of both sensors has been done from 0 to 1000 $\mu\epsilon$ and the temperature testing from -40 to 80°C . Strain and temperature sensitivity values are $0.55 \text{ pm}/\mu\epsilon$ and $6 \text{ pm}/^\circ\text{C}$, respectively. The sensors are being applied in a power-by-light hydraulic valve monitoring system.

Index Terms—Bragg grating, correlation, hydraulic valve, multimode, optical fiber, optically-powered, strain, temperature.

I. INTRODUCTION

DURING the past decade, single-mode optical fiber Bragg gratings (SM-FBGs) have been used for strain and temperature sensing in many applications such as structural monitoring, down-hole and hazardous environments. Recent research work has been reported on a differential-pressure (DP) flow sensor using SM-FBGs for hydraulic valve monitoring applications [1]. However, using SM-FBGs in the application of an optically-powered hydraulic valve monitoring system is not really appropriate [2], [3]. This is because the system must utilize only one optical fiber for both optical power transmission and for sensing. The optical fiber transmits power from a laser source into the optically powered hydraulic valve at the remote end of the fiber. It is also used for feeding the valve operation information back to the valve monitoring system via the same fiber, as shown in Fig. 1; the optical fiber link might be 4 km in length. The other reason is that it is difficult to launch high optical power into the single-mode optical fiber due to its small core diameter. Therefore, a multimode optical fiber Bragg grating (MM-FBG) is more suitable due to its larger core diameter. **A particular advantage of this configuration is that no optical fiber coupler is required at the valve end and this makes the system less complex and minimizes optical power loss.**

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P. R. Jackson is with Flight Refuelling Ltd., Wimborne, Dorset, U.K.

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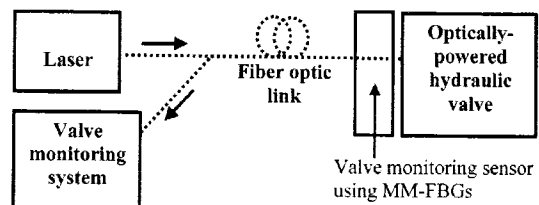


Fig. 1. Optically powered hydraulic valve system.

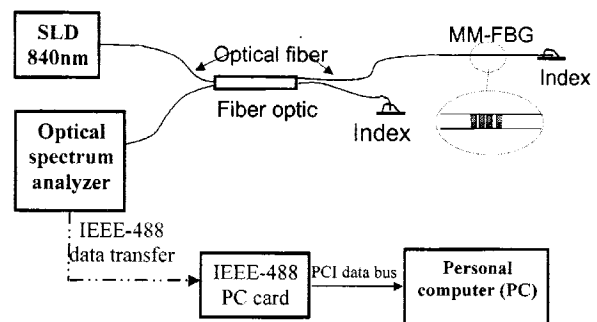


Fig. 2. Experimental setup.

The early use of MM-FBGs was reported by Wanser *et al.* [4], [5]. Microbending was used to disturb the mode population in an optical fiber through mode coupling before passing the light to the MM-FBG. A similar approach using the bending effect on a transmission spectrum of the MM-FBG for displacement sensing was introduced by Mizunami *et al.* [6], [7]. However, these sensing techniques require mechanical parts and are therefore more complicated than conventional SM-FBGs. The use of MM-FBGs for both strain and temperature sensing by using the same method as used with a Bragg grating in a single-mode fiber is also possible [8], [11].

Changes in optical signals obtained from a multimode optical fiber can be caused by changes in both strain and temperature. Significant variation in these signals can be noticed from the amplitude-wavelength signature by number of peaks, peak values and signal distortions, but it is difficult to pinpoint the amount of wavelength shift that is proportional to strain or temperature changes.

In this paper, a method of using correlation signal processing to quantify variation of wavelength shift caused by altering strain or temperature is reported. Advantages of using this method include minimizing the effect of variation in signal amplitude and shape of the MM-FBG amplitude wavelength spectrum, and reducing the effect of noise. Tests have been

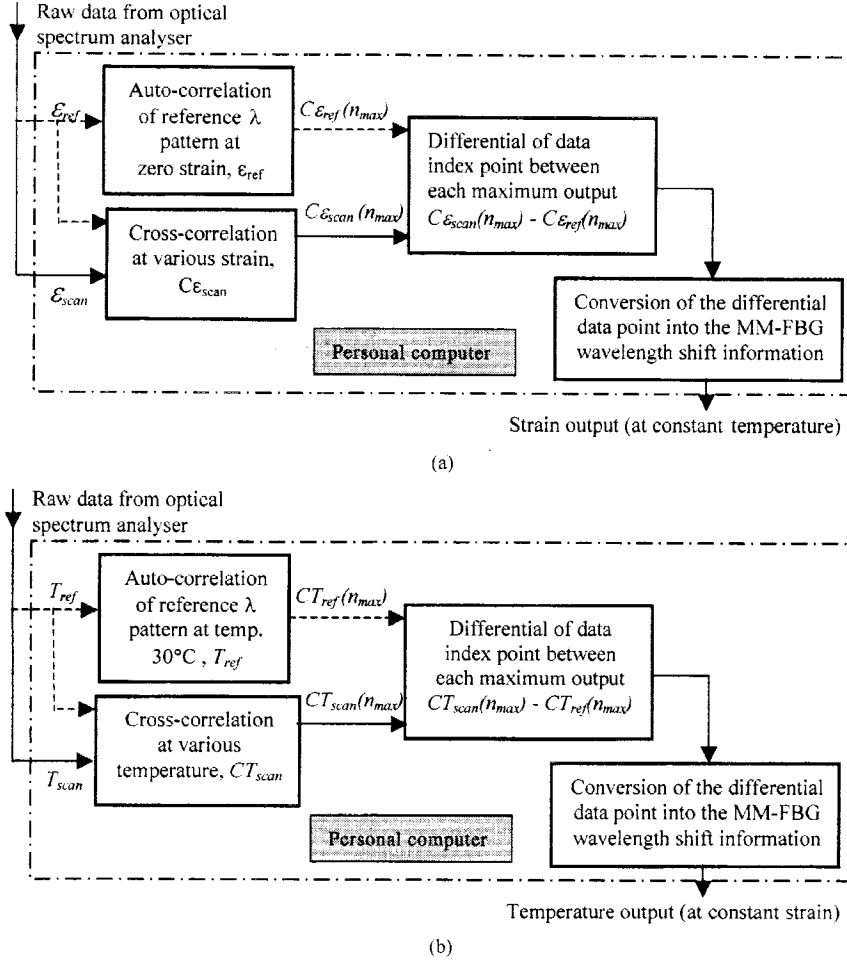


Fig. 3. Signal processing scheme for (a) strain test and (b) temperature test.

performed to compare the characteristics of the two MM-FBG sensors for axial strain measurement and for the temperature measurement. The effect of temperature on strain sensing has also been investigated.

II. BASIC SCHEME

Two MM-FBGs fabricated in $62.5/125 \mu\text{m}$ graded-index silica multimode fiber have been tested using the same experimental setup (Fig. 2). The first MM-FBG was fabricated by the holographic technique without buffer coating, while the second MM-FBG sensor was fabricated by the phase mask technique with acrylate buffer recoating. The reflectivity of the first and second MM-FBGs is approximately 35% at peak wavelength of 835 and 859 nm, respectively. In the experimental setup, one end of the MM-FBG was connected to one of the output fibers of a 50:50, 2×2 multimode optical fiber coupler. The other end of the MM-FBG and the output end of the coupler were placed in index matching gel. At the input end of the coupler, one optical fiber was connected to a light source and the other optical fiber fed a sensing signal to an optical spectrum analyzer (Anritsu MS99A). The spectrum of the reflected signal from a Bragg grating in a multimode optical fiber is very different for different light sources [7]. For example, using a halogen

lamp high multimode excitation occurs, and this results in more multiple peaks and a wider spectrum of reflected signal than occurs for the lower order mode excitation light sources such as laser diode, LED, and super-luminescent diode (SLD). For graded-index MM-FBGs, the propagation constant for the N th principal mode can be approximated by the equation [7]

$$\beta = \frac{2\pi}{\lambda} \cdot n_1 \sqrt{1 - 4\Delta \frac{N+1}{V}} \quad (1)$$

where β is the propagation constant at the phase-matching condition $\beta = \pi/\Lambda$, Λ the grating period, λ the Bragg wavelength, n_1 refractive index of the core, V normalized frequency ($V = 2\pi a \cdot NA/\lambda$), a the fiber core radius, NA the fiber numerical aperture, and Δ the maximum relative index difference between core and cladding of the fiber. To achieve a low complexity of MM-FBG signal, the SLD with a single-mode optical fiber pigtail, providing 0.5 mW of light power at wavelength 849 nm, was selected for the experiments.

To investigate the strain characteristic, axial strain was applied to the fiber using a fiber fixture/drawer. The axial strain was varied from 0 to $1000 \mu\epsilon$ by adjusting an accurate micrometer. The strain characteristic for the first-order mode of the MM-FBG is similar to that in a conventional SM-FBG strain

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SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO
DIVISIÓN DE NUEVAS CREACIONES

2020
Bogotá, D.C.,

Abogado
EMILIO FERRERO

ASUNTO	Radicación	05-90935
	Trámite	002
	Evento	001
	Actuación	430
	Oficio	1556
	Folios	004

Patente de Invención	☒	Patente de Modelo de Utilidad	☐
Vía Nacional	☒		
Vía PCT (fase nacional)	☐	Cap. I	☐
		Cap. II	☐

Como resultado del examen de fondo, realizado con fundamento en el artículo 45 de la Decisión 486 de la Comisión de la Comunidad Andina, se le comunica:

1. Documentos estudiados

- 1.1. Descripción: Folios: 7 a 28 como se radicó inicialmente
- 1.2. Reivindicaciones: Folios: 29 a 35 como se radicó inicialmente
- 1.3. Dibujos: Folios: 37 a 55 como se radicó inicialmente
- 1.4. Prioridad: Folios: 64 a 124.
(9 sept. 2004, BR, N° PI0403786-3).

2. Análisis de la Prioridad

Comparando el documento de prioridad N° BR PI0403786-3, con la presente solicitud, se encuentra que ambas corresponden a la misma materia, por lo cual se acepta la fecha de prioridad.

3. Objeto de la invención

La presente solicitud se titula "TRANSDUCTOR DE PRESION DIFERENCIAL A FIBRA OPTICA", Folio N° 1.

El objeto de la presente solicitud de patente consiste en un transductor de presión diferencial a fibra óptica para utilización en un medidor de caudal de producción o inyección de fluidos en el interior de pozos de petróleo.

De otra parte, el pliego reclama un transductor de presión diferencial a fibra óptica para medir a presión diferencial generada por un dispositivo tipo Venturi en pozos de petróleo.

El objeto de la solicitud definido anteriormente se clasificó en la IPC H04R 1/00.

4. Claridad de la solicitud

4.1. Reivindicaciones (artículo 30 D 486)

Algunos términos utilizados en el pliego reivindicatorio no son usuales en la técnica y pueden prestarse para confusiones, por ejemplo el termino Vedar (vedación) utilizado en la mayoría de las reivindicaciones, no es apropiado ya que hay términos más precisos para expresar las mismas acciones (sellar, aislar, etc.)

El término O-Ring es un extranjerismo que no debe ser utilizado, ya que el término correcto en español sería empaque de sellamiento o sinónimos de este.

Las reivindicaciones 15 y 16, no especifican ninguna característica contenida en la reivindicación 5, tan solo repiten la materia ya dicha, por favor aclarar estas reivindicaciones

Por los motivos anteriores, el pliego reivindicatorio calificado NO cumple con los requisitos de claridad exigidos en el Art. 15 de la decisión.

5. Determinación del Estado de la Técnica

Considerando la fecha de presentación de la solicitud que reivindica prioridad a la fecha del 9 de septiembre del 2004, se buscaron documentos del estado de la técnica relacionados, con fecha de publicación anterior a esta. Se realizo búsqueda de documentos relevantes dentro del estado de la técnica, entendiendo como estado de la técnica la definición provista en el Art. 16 D 486, y las excepciones fijadas en el Art. 17 de la misma.

Consultadas las fuentes de información con que cuenta esta oficina, se hallaron los siguientes documentos que hacen parte del estado de la técnica más cercano al objeto de la presente solicitud:

Nº	Título	Fecha de publicación
D1	DP FLOW SENSOR USING OPTICAL FIBRE BRAGG GRATING. Sensors and Actuators A 92 (2001) pp. 102-108	2001-08-01
D2	STRAIN AND TEMPERATURE SENSORS USING MULTIMODE OPTICAL FIBER BRAGG GRATINGS AND CORRELATION SIGNAL PROCESSING, IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, VOL. 51, NO. 4, AUGUST 2002.	2002-08-01

*se anexa copia de cada documento citado

6. Análisis de patentabilidad

6.1. Nivel inventivo (artículo 18 D486)

La presente invención está contenida en un capítulo reivindicatorio que incluye conformado por 35 reivindicaciones. De acuerdo al estado de la técnica establecido en el numeral 5, los documentos más cercanos a la solicitud son los denominados documentos D1 y D2.

Las reivindicaciones 1 a 31, que presentan tres modalidades de transductor de presión diferencial, en las que se utilizan dos sensores de redes de Bragg, ubicados cada uno a un lado de un diafragma, se ven afectadas de la siguiente manera:

El documento **D1** se relaciona con un sensor de presión diferencial basado en fibra óptica, desarrollado para monitorear y retroalimentar el sistema de control de una válvula hidráulica (resumen). El sensor emplea dos sensores de redes de Bragg, los cuales se montan a cada lado de un diafragma (fig. 4). El sensor desarrollado en este documento cuenta con un cuerpo principal sellado (fig. 6), un diafragma (fig. 4), tomas de presión (fig. 6), e instrumentos de monitoreo (figs. 1, 4 y 6).

En esta anterioridad, los dos sensores ópticos de redes de Bragg, están en fibras diferentes, por lo cual es necesario integrar las dos fibras a través de un acoplador de fibra óptica (fig. 4), lo cual es diferente a la materia de la presente solicitud. Sin embargo la anterioridad **D2**, la cual se refiere a sensores multimodo de redes de Bragg (MM- FBG) utilizados para realizar mediciones de fuerza y temperatura, presenta un método para usar la correlación en el procesamiento de señales y así cuantificar la variación en la longitud de onda causadas por la alteración de fuerza o temperatura medidas (introducción), las ventajas de esto es que se minimizan los efectos en la variación de la señal y se reducen los efectos del ruido.

Basándose en el método de correlación con MM-FBG, D2 presenta una configuración de prueba que presenta la ventaja particular de **NO requerir un acoplador de fibra óptica en la válvula**, lo cual hace al sistema menos complejo y minimiza las pérdidas de potencia óptica (Introducción).

De esta manera, el problema técnico planteado en esta solicitud: un transductor de presión diferencial a fibra óptica, para registrar la variación de presión producida cuando el fluido corre a través de un dispositivo tipo Venturi, utilizando una sola fibra óptica, se puede resolver combinando las características de los documentos citados dentro del estado de la técnica.

7. Conclusión:

Los requisitos de patentabilidad de la presente solicitud se encuentran afectados así:

N°	Reivindicaciones afectadas	Requisito que afecta
D1	1 a 31	Nivel Inventivo
D2	1 a 31	Nivel Inventivo

Se recomienda, que tenga en cuenta que el replanteamiento de esos apartes NO podrá implicar una ampliación de la protección que correspondería a la divulgación contenida en la solicitud inicial, de acuerdo a lo que establece el artículo 34 de la Decisión 486.

En cumplimiento del artículo 45 de la Decisión 486 de la Comisión de la Comunidad Andina, se le indica que debe dar respuesta dentro del término de sesenta días contados a partir de la fecha de notificación de la presente comunicación. En caso de no dar respuesta al presente requerimiento, o si a pesar de la respuesta subsistieran los impedimentos para la concesión, se denegará la patente.

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Notifíquese el presente oficio conforme a lo dispuesto en el numeral 5.2 Literal e) del capítulo quinto del título primero de la Circular Única No. 10 de 2001.


ALIX CARMENZA CÉSPEDES DE VERGEL
Jefe de División de Nuevas Creaciones

El anterior requerimiento fue notificado por fijación en lista, de fecha

CONCEPTO TECNICO No. 272	EXAMINADOR TÉCNICO Código No. 202082
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