Title on Invention: **Pipeline Gas Leakage Detection System**

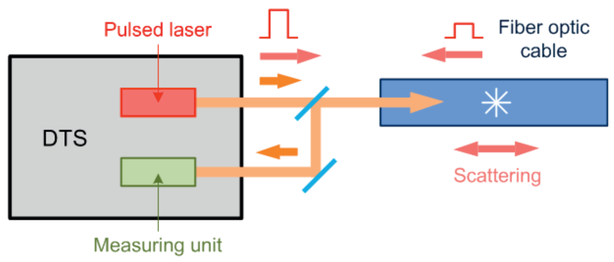
It is the adiabatic effect which can be used for detecting leakage of gases from low-pressure, middle-pressure and high-pressure pipelines. It is typical for this phenomenon that there is no thermal exchange (energy exchange) between the gas within the pipeline and its surroundings. Concerning the pipeline, gas leakage is supposed to evoke the rapid change, and during this change we may neglect the interaction between surrounding air and the gas within the pipeline. The interaction will be neglected if there are no chemical reactions between surroundings and escaped gas. The first law of thermodynamics which describes properties of the gas in the pipeline says that due to zero thermal exchange with surroundings the leaking gas performs work by its expansion to the free space. This expansion work is done at the expense of internal energy of gas. Decreasing the internal energy means that the leaking gas is quenched, and temperature decrease is transferred to the metallic pipeline.

In the case of monitoring the pipeline along its full length, the task is to measure the temperature along the pipeline with distributed gas. If the pipeline fails and the gas leaks, the temperature change is measured, and the suitable method for temperature decrease and its localization must be searched. The most suitable method is distributed temperature measurement with the help of optical fibers.

Several impulses can be used for the design and implementation of distributed temperature optical fiber sensors. The origin of the detected signal depends on whether the detected light is coming from the front or back end of optical fibers, if the light is reflected or transmitted through fiber or if scattering mechanisms are applied. The principal division of distributed sensors according to used impulsess is as follows:

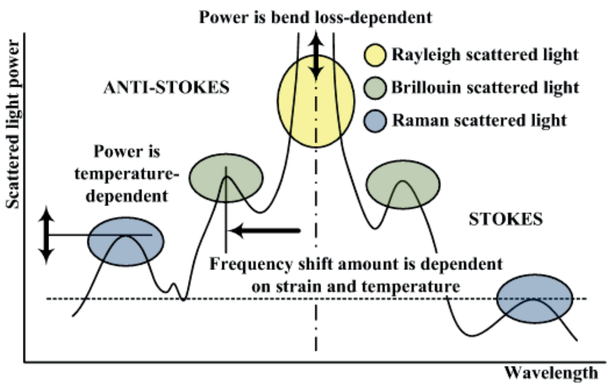
- Rayleigh scattering
- Inelastic spontaneous scattering
- Fluorescence
- Stimulated Raman or Brillouin Scattering
- Light conversion into a different guiding channel
- Reflection by a distributed artifact

Rayleigh scattering is linear, which means that the light wavelength is invariable, and this phenomenon may be used for position measurement. Brillouin scattering is suitable for strain and temperature monitoring with the usage of single-mode fiber, Raman scattering can be applied for temperature monitoring only, but it uses multimode fiber. In both devices not only temperature but position of temperature changes is specified. According to construction of Raman DTS (Distributed Temperature Sensor) the temperature resolution can reach one hundred degrees, and spatial resolution is about 1 m.



Fundamental function of DTS.

There is principal relation between linear and nonlinear effects and their light intensities. Temperature can be measured and evaluated from the knowledge of light intensities of Stokes and Anti-Stokes components where the last one is temperature-dependent. The same attenuation relation holds true for both the components because of their close wavelengths, and the position of temperature changes is evaluated the similar way as in OTDR. Lasers in the Raman DTS source usually use the wavelength of 1064 nm. Peaks of Raman spectrum are in this case shifted ± 40 nm, i.e. 1104 nm and 1024 nm.



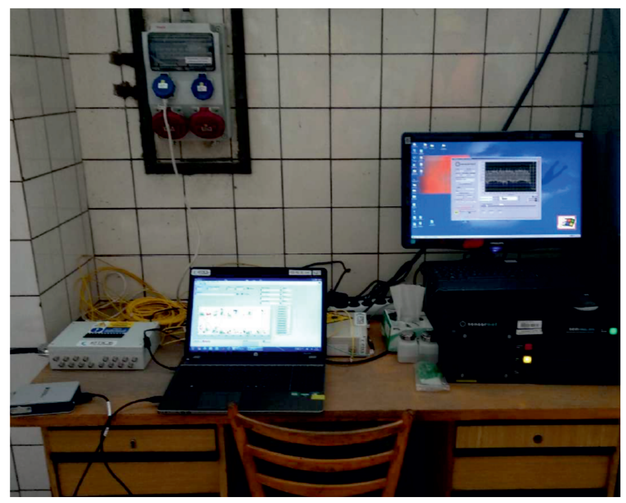
Spectrum of the backscattered light in optical fiber

As a result, three frequencies are observed. The first one is the frequency of passing light waves, the second is the Stokes component of Raman scattering, and the third is the anti-Stokes component of Raman scattering. The situation is similar to mixing two frequencies. The similar relation is valild also for Brillouin scattering. If the results are plotted graphically, all scattering phenomena can be seen.

Typical properties of the monitoring system:

- The possibililty to monitor gas leakagess under any weather conditions
- The system was successful during the blind test in 100%
- The system has registered a patent application
- The solution is suitable for many branches (energetics, chemical industry, media transport)
- The system uses the conventional (low cost) optical fiber/cable
- The monitoring system is safe, there is optical power of several mW in the optical fibre
- The monitored length is about 8 km depending on the method of fiber layout on the pipeline.
- It is fully dielectric measurement with excluding conductive parts. The place of measurement can be removed from the place of evaluation from several tens of metres to several kilometers.
- This type of measurement is suitable for metallic pipelines.
- After fiber/cable installation, no maintenance is needed.
- Optical fiber/cable may be protected with the paint destined for pipelines.

Obr. 1: Real measuring location



Obr. 2: Measuring site

Inventors: Prof. RNDr. Vladimír Vašinek, CSc., Ing. Václav Jakeš, PhD., MBA, Ing. Radek Olszar, PhD., Ing. Jiří Vojník
Contact: ENVIFORM a.s., Závodní 814, Staré Město, 739 61 Třinec, Czech Republic, e-mail: enviform@enviform.cz
Patent application: CZ 2020-715