**Multiphase Flow Meter for Heavy Oil exploration based on Neutron Analysis**

**Problem statement**

Monitoring of the process of oil production is essential for oil production control and optimization. About 70% of oil resource in a world is heavy oil (< 22.3 API). Largest of oil reserves located in Venezuela, Canada, Russia, Kuwait, Saudi, Mexico, China, Indonesia, Iran, Iraq, USA consist from heavy oil, extra heavy oil and bitumen.

It is still a challenge to find adequate and fair technology for heavy oil metering and control. The large number of multiphase flowmeters is defined for use in oil wells with viscosity much lower than 500cP, while metering the Heavy Oil, Extra Heavy Oil, or bitumen in Hot Production brings lots of problems that conventional methods couldn’t resolve.

Heavy Oil has API gravity between 22.3° and 10° (920 kilograms per cubic meter to 1,000 kilograms per cubic meter); extra heavy oil with API gravity less than 10° (more than 1,000 kilograms per cubic meter) and with viscosity lower than 10,000cP; bitumen has API lower than 10 and viscosity higher than 10,000cP.

High viscosity and low reservoir pressure are main problems for heavy oil exploration. Only rarely natural flow occurs. Usually enhanced oil recovery techniques need to be applied. These methods include cold techniques (oil production with sand, water flooding, vapour assisted extraction etc.) and thermal production techniques (like steam assisted stimulation).

Why conventional technologies for multiphase flow metering don’t work for heavy oil?

* There is very small or not at all gravity contrast between oil and water and any system based on phase separation doesn’t work in this environment
* Due to thermal and cold techniques that applied for heavy oil extraction multiphase meter must be able to cope with wide range of produced fluid properties :
  + Emulsification of fluid
  + Foaming
  + High temperature
  + Entrapped gas/sand/water
  + High water-cut

Therefore well-known multiphase flow metering techniques such as separators, turbine meters, ultrasonic meters, coriolis meters, positive displacement meters either not applicable or give big error for heavy oil measurement.

Ideal measurement technology for heavy oil production control must works at wide range of temperature (50-200°C), in low pressure environment (<20 bara), ensure accurate metering fluids of high viscosity, with high water-cuts, be resistant to erosion, plugging, unaffected by entrained gas or solid particles, has low sensitivity to changes in emulsion characteristics (conductivity, permittivity) and velocity profile changes. Especially valued if such multiphase measurement can be made inline, right on site provides measurement in a real time.

**Neutron activation analysis for critical conditions of heavy oil multiphase metering**

Methods of neutron activation analysis (NAA) have been known for quite a long time, since 1936. However, active development of this method and its technological applications has been started recently together with development of various components, critical for this method dissemination (small and safe sources of neutrons, new materials for precise and fast detectors, high speed electronics, and increased processing ability of computers). As a result wide variety of neutron analysis devices have been employed for reliable and precise control in cement industry, borehole logging, security monitoring, nondestructive quality control. In short this method can be described as follows. Examined object is irradiated with neutrons that penetrate deeply into the sample and stimulate nuclear reactions. Characteristics gamma rays born as a result of such reactions give precise picture of the sample elemental composition.

The elemental analysis of the sample together with unique property of neutron beam penetration ability give that technique unbeatable qualities:

* NAA analyses substances at the nuclear level and identifies the composition of the whole examined volume. As a result, there is no procedure (and corresponding error) of the sample selection.
* NАА identifies the composition of substances disregarding of their phase or any other physical properties.
* The penetrating ability of neutrons and resulting gamma rays allows analyzing the substance with the same sensitivity in any part of the investigated volume. As a result, with the help of neutron analysis it is possible to analyze flows of the substance without changing of production process routine, for example, the tubing system.
* NAA gives result very fast within a seconds. Thus online information from NAA systems in a real time mode allows to react faster and more flexible to changes in the production process.

Together with the recent advances in electronics and neutron sources, development of the multiphase flow meter based on the neutron activation analysis will be the best solution for heavy oil production control.

Specific solution can be only developed with the industrial client collaboration as elemental composition of particular well is unique due to variety of techniques and added chemicals applied for enhancement of reserve exploration.

For example with careful adaptation of various neutron activation analysis techniques, measurement of the ratio of sulfur and chlorine in flow can gives precise information about water-cut level, further measurement of unique signature of curtain elements can give not only oil/water/gas content but other added component or substances composition crucial for well production process.

Neutron Activation Analysis multiphase meter can be installed inline, providing online real-time information, safely and easy integrated in industry environment.

**Our proposal**

Our company Rateclab (www.rateclab.com) is an R&D division of Scientific and Technological Center Ratec (http://www.ratec-spb.ru/about.html) that for decades successfully develops Neutron Activation Analysis Systems for industry and security application. Currently we are developing industrial system based on Neutron Activation Analysis for cement industry with finance and support of Russian Innovation Fond Skolkovo (<http://community.sk.ru/news/>) and largest cement producer in Russia.

Our goal is a development and production of the precise and safe instruments for industrial nondestructive testing to meet high expectations of our clients.

We propose the development of Multiphase Flow Meter for Heavy Oil metering with precise adaptation for client needs and requirements.

Having in our team professionals with many years of experience we expect that proposed system development can be estimate within two years of work on engineering and adaptation.

We open to variety of collaboration schema, and ready to start negotiations and technical evaluation of method applicability.

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**Scientific Technological Center Ratec**

RATEC company (<http://www.ratec-spb.ru/>) was established in 1991 for development and commercialization of scientific engineering potential of the USSR in the area of nuclear physics for civil applications.

It was then when the company began working on its solutions in the area of neutron analysis as the most promising direction in research of composition and structural analysis of substances. Neutrons as a source of scanning radiation play a special role due to their high penetration ability and, consequently, wide opportunities for obtaining data for further analysis. That is why first applications of neutron analysis methods have been used for security problems and up till now there have not been any other methods with a similar reliability level and a relatively small number of false alarms (“Detection of Dangerous Materials and Illicit Objects in Cargoes and Baggage: Current Tools, Existing Problems and Possible Solutions”, Olshansky Yu., Journal of Homeland Security and Emergency Management).

RATEC developed a system for detecting explosives based on the combination of high definition gamma spectroscopy and tagged neutrons technology with a possibility to visualize spatial concentration distribution, which demonstrated unique results of detecting explosives even masked in a high-density environment (concrete walls). It is planned to transfer the results and developments achieved during the work on this system not only to solutions in the area of security, but other high-demand industrial applications as well.