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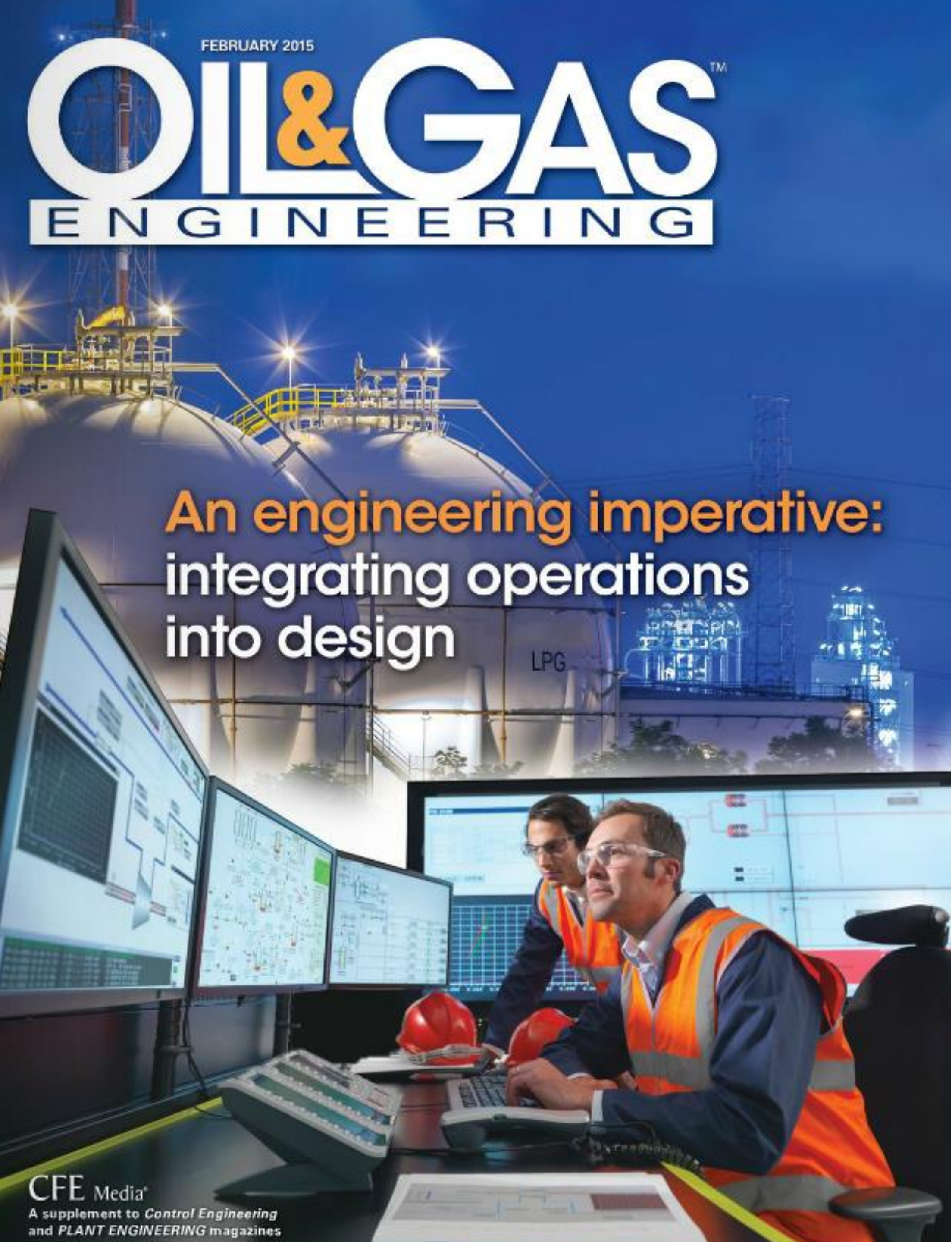

An engineering imperative: integrating operations into design

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Benefits of heating heavy oil with medium-voltage mineral insulated cables

Thermal enhanced oil recovery (EOR), which has been around for more than 50 years, is a relatively old technology. But over the past 20 years thermal EOR has evolved to feature all kinds of tricks, including: steam heating, water flooding, solvent dissolving, in-situ combustion, direct ohmic heating of the reservoir, microwave heating, and steam-assisted gravity drainage (SAGD). Thermal EOR is a technology that keeps on learning new tricks despite its age.

By Chet Sandberg, PE

Many technologies have been proposed to reduce viscosity of heavy oil to allow its extraction from reservoirs. Steam heating, water flooding, solvent dissolving, in-situ combustion, direct ohmic heating of the reservoir, microwave heating, as well as resistive heating elements are some of the techniques. Heavy oils, rated less than 22.3 API gravity, do not flow easily. Extra-heavy oil and bitumen is rated less than 10 API gravity and is heavier than water. The oil's viscosity is temperature dependent, and even an 80 C increase will lower the viscosity for easier extraction; see the real-world viscosity chart. Steam, used in a SAGD operation, is currently a solution, but the use of a significant amount of water is required and is extracted along with the oil. Between two and seven barrels of water are produced with each barrel of oil. This produced water may be considered hazardous waste because of high salinity, mud, and traces of drilling chemicals. While many technologies are possible, an electrical heater may be an optimum solution both technically and economically.

Table 1: Heating Chart

Cable Voltage	600 V	4,160 V
Power per foot	144 w/ft	140 w/ft
Operating Temperature	400 C	400 C
Length of heated section	250 ft	2000 ft
Outside design diameter of MI cable	1.00 in.	0.75 in.
Diameter of heater wire in MI	0.25 in.	0.155 in.
Diameter of Overburden wire in MI	0.25 in.	0.155 in.
Overburden Loss as % of Total	51.9%	11.8%
Estimated weight of 3 cables/foot	5.3 lbs/ft	3.0 lbs/ft
Overburden length	2,000 ft	2,000 ft

Table 1: This chart provides a comparison between 600 and 4160 V heating cables. Courtesy: Chet Sandberg

The reliable heater

Electrical heaters have been thought of as solution for more than 50 years. However, the technical capabilities of low voltage (fewer than 600 V) have limited the use because of parasitic energy loss in the overburden and short lengths of heaters in horizontal wells. These two detractors have made low-voltage heaters uneconomic for commercial applications, while numerous short-length pilots (up to 250 ft) have proven this technique of viscosity reduction to be technically feasible but not economic.

A major oil company has provided research in the past five years that has enabled the development of a medium-voltage (4,160 V) heater system. This heater technology is now available for commercial applications. An example is a heater that can produce 1,000 w/m and have a length of 1,000 m. This is a 1-MW heater that matches the horizontal-well drilling technology. The following chart compares the 600 V system with the 4,160 V system. Note the limited length of the 600 V heater and the increased weight necessary for transmission of the power to the heated section of the heater. Even with the increased diameter of the 600 V heater, the overburden energy loss is 51.9% compared with only 11.8% for the 4,160 V heater.

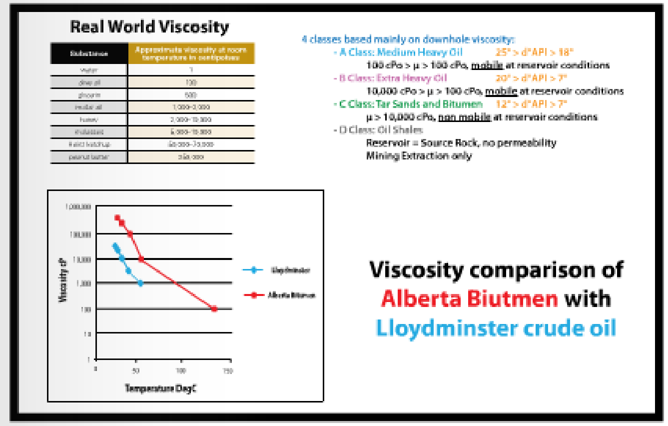

Figure 1: This chart lists four types of heavy oil viscosities and provides a comparison to household items as well as a comparison between Alberta Bitumen and Lloydminster crude, which are found in Canada. Courtesy: Chet Sandberg

Long length EOR extraction

The heater shown looks a lot like a standard mineral insulated (MI) cable heater. There are two important differences:

1) The increased ability for the magnesium oxide (MgO) to withstand the higher voltage without electrical breakdown, thus permitting operation at 4,160 V.
2) The ability to manufacture the cable in long lengths, up to 2,000 m without splices, is beneficial as splices have been a problem in other designs, which increased the diameter at the splice by about a factor of three times. This has caused considerable deployment issues, sometimes necessitating a larger well diameter.

While viscosity reduction is one application, preheating a SAGD operation also may be a major opportunity. In this example, a well with an initial temperature of 10 C would be heated electrically to a little more than 120 C and then be steam injected to produce the "drive" to move the oil to the producing well, located under the heater well. This might produce a 50% reduction in water injection, as well as much less heat loss in the overburden.

These new technical capabilities could enable use of medium-voltage electrical heaters in many applications for downhole heating, including viscosity reduction and flow assurance. This technology is ready to become mainstream as product reliability and deployment technologies are now proven. OG

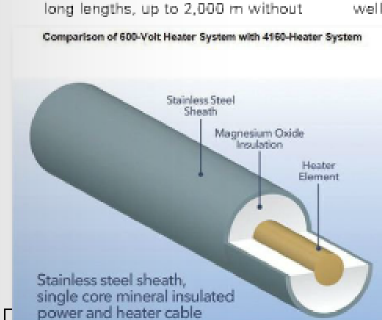

Figure 2: Magnesium oxide insulated cable. Courtesy: MCAAA Ltd., United Kingdom

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