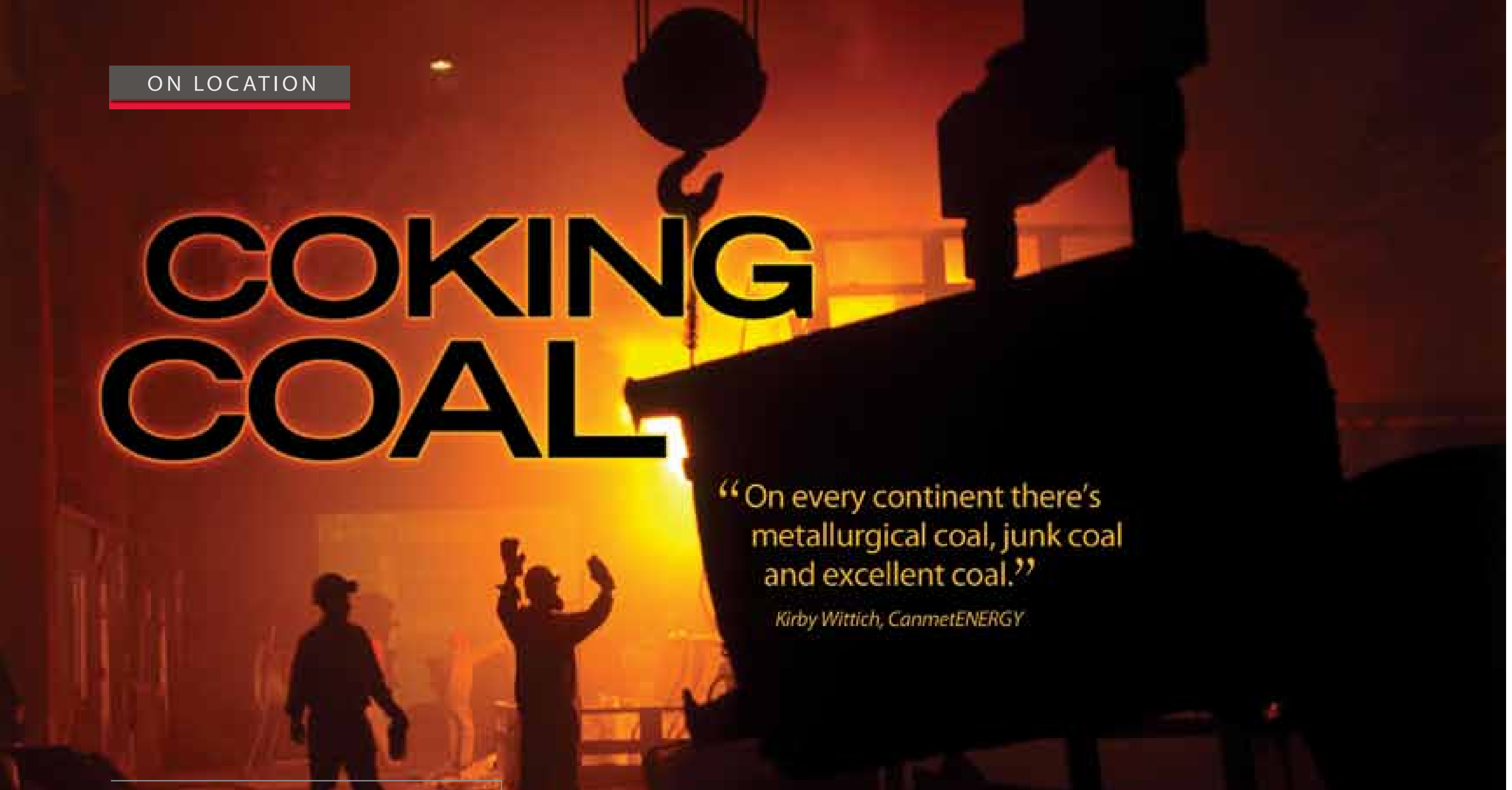

COKING COAL

> "On every continent there's metallurgical coal, junk coal and excellent coal."
>
> *Kirby Wittich, CanmetENERGY*

Brilliant solution:

Jeff Wallace of GTR Scales Ltd., in Arnprior, Ontario, supplied CanmetENERGY with a 920i® interfaced to a high resolution Sartorius base for their coke research lab in Ottawa. "They wanted to place a given amount of coke into a furnace and know when they had burnt off 200 grams. Our sister company, DCH, did it by manufacturing an equal arm balance. One end has the sample of coke in the furnace and the other end rests on the Sartorius. As the coke reacts, the weight is transferred to the scale platform, thus showing us what is happening in the furnace."

GLOBAL STEEL PRODUCTION IS DEPENDENT ON COAL. Steel is an alloy based primarily on iron. As iron occurs only as iron oxides in the earth's crust, the ores must be converted, or reduced, using carbon. The primary source of this carbon is coking coal. Nearly all of the coke produced in the world is fed into blast furnaces to make steel. World crude steel production was 1.2 billion tons in 2009. Around 761 million tons of coking coal was used in its production.

Canada annually exports about 30 million tons of coking coal and uses an additional 6 million tons domestically. On behalf of Canadian coal, steel, and metal producers, CanmetENERGY conducts research and development on metallurgical coal and coke technologies including energy recovery from coke production, metallurgical coke, bio-coke, and research into Canadian coal. CanmetENERGY's coal evaluation, preparation and carbonization facilities are available to industry on a fee-for-service basis to assist with mine planning, marketing and economic investigations; to ensure low risk to expensive facilities during coking; and to evaluate the quality of coke, coal and other alternate fuels including biofuels for metallurgical purposes.

Kirby Wittich, CanmetENERGY research engineer, explains, "On every continent there is metallurgical coal, junk coal and excellent coal. It depends on the particular seam. We are looking for very particular bituminous coals. A very quick bench-top test can be done. We grind the coal up and heat 1 gram of it to about 800° C in a small crucible. After two minutes we take the lid off. If it is coking coal, we'll see a little muffin. If it is not coking coal, it may look exactly as it did before—just powder.

"Some coal may coke at a certain temperature, and another at a different range. When we mix those together we have a mixture that cokes at a wider temperature range. The price difference between coking coal and coal that would be used in a combustion furnace can be five to ten times. If a mine shows that they have coking coal, then often a huge investment is made to mine that coal."

There are two kinds of coke producers: integrated and merchant. Integrated coke producers are affiliated or owned by a steel manufacturer; merchant producers are those who produce coke to be sold on the open market.

Kirby tells us half of CanmetENERGY's tests are done for steelmakers and half are for Canadian coal mines that sell coking coal to steelmakers. "We test the coal they send us in the proportions they suggest. But instead of a 4 or 6 meter high furnace, we test it in a furnace a little over 1 meter high by adjusting conditions. Among other things, we are testing to find the force of the wall pressure on the coke oven, because most of the coke ovens in the world are old. If there is too much pressure on the oven wall, it will crack and leak, and they take many millions to fix."

Possibly the single biggest concern for all coke producers is their ability to meet the requirements of the Clean Air Act Amendments of 1990 (CAAA '90). A cracked oven wall produces emissions, and emissions bring huge fines. Coke is produced in a coke battery that is composed of many coke ovens stacked in rows into which coal is loaded. The generally accepted guideline is that a battery of coke ovens has a 20- to 30-year life span. This premise does not hold up when the merchant coke producer segment is analyzed. The average age of U.S. merchant batteries is 40 years. The reason for this is partly the merchant mentality. An integrated producer views their coke plant as a disposable asset, producing raw material. In the end, for an integrated producer, coke is a "make-or-buy" decision.

The merchant producer knows that his battery is his livelihood and will take extraordinary steps to maintain his facility. For example, the oldest merchant battery operating today was built in 1902 and still has a future due to continuing facility renovation and oven rebuilds. The CAAA '90 has also resulted in the delaying of the deterioration cycle of coke ovens. The mechanisms that result in leakage are the same that cause failure of ovens, so when leakage is systematically eliminated, the result is longer battery life.

Coke producers convert metallurgical or coking coal to coke by driving off small hydro-carbon molecular units to leave almost pure carbon. The physical properties of coking coal cause the coal to soften, liquefy, then resolidify into hard porous lumps when heated in the absence of air. Coking coal must also have low sulphur and phosphorous contents.

The coking process takes place over long periods of time—between 12-36 hours in coke ovens. The heat is transferred from the heated brick walls into the coal charge. From about 375°C to 475°C, the coal decomposes to form plastic layers near each wall. At about 475°C to 600°C, there is a marked evolution of tar and aromatic hydrocarbon compounds, followed by resolidification of the plastic mass into semi-coke. At 600°C to 1100°C, the coke stabilization phase begins. This is characterized by contraction of coke mass, structural development of coke, and final hydrogen evolution. During the plastic stage, the plastic layers move from each wall toward the center of the oven, trapping the liberated gas and creating gas pressure build-up, which is transferred to the heating wall. Once the plastic layers have met at the center of the oven, the entire mass has been carbonized. The incandescent coke mass is pushed from the oven and is then quenched with water or nitrogen to cool it before storage, or it is transferred directly to the blast furnace for use in iron making.

> "The greatest thing about dealing with Rice Lake is they really do customer service. Other scale manufacturers may have a five-year warranty as well, but if someone other than their service rep touches it, the warranty is nullified—and they want a purchase order number before they'll show up!"
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> Jeff Wallace, GTR Scales Ltd.

Optimal operation of the blast furnace demands the highest quality of raw materials. The carbon content of coke therefore plays a crucial role in terms of its effect in the furnace and on the hot metal quality. A blast furnace fed with high quality coke requires less coke input and results in higher quality hot metal and better productivity. Overall costs may be lower, as fewer impurities in the coke means smaller amounts of flux must be used. Coke producers use widely differing coals and employ many procedures to enhance the quality of the coke and to enhance the coke oven productivity and battery life.

GTR Scales' unique 920i® and Sartorius application for CanmetENERGY is helping create the cleanest, most efficient coke for the steel-making industry, ensuring blue skies in the future. ■

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