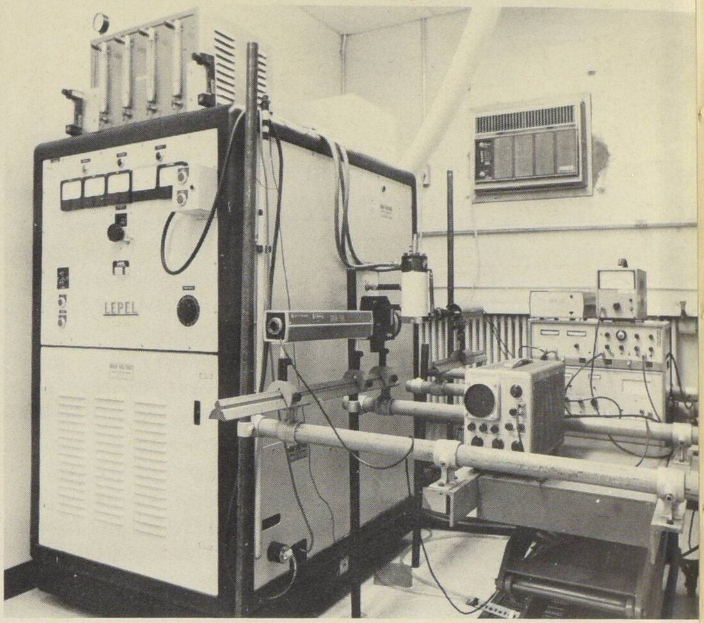
Harnessing plasmas for molybdenum extractio



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Laser doppler anemometer, first of its kind in Canada, for measuring velocity and turbulence of the plasma. • L'anémomètre à effet Doppler et à laser, unique au Canada, pour mesurer la vitesse et la turbulence du plasma.

When allied intelligence agents in the First World War overheard that the Germans were using molybdenum steels in the gun barrels of their "Big Bertha" howitzers, they felt they had stumbled on a goldmine. Acting on their reports, the United States moved quickly to develop sources of molybdenum and to find out what it did to iron and steel. It turned out that the intelligence reports had no basis in fact but this false information nevertheless served a very useful purpose. It provided the impetus for increased research on molybdenum. And it brought to light how useful this metal could be.

At present, molybdenum is principally used in the production of alloy steels. Molybdenum imparts considerable strength to steel, increases its resistance to corrosion and improves its strength at high temperatures. Steels with low concentrations of molybdenum are used for heat-treated machine parts and for tool steel. Higher concentrations of molybdenum are used for corrosion resistant stainless steels (four per cent) and for high-speed tool steel (up to 8.5 per cent). Molybdenum steel finds widespread use in the transportation and chemical processing industries.

Yet despite its usefulness not one pound of molybdenum metal is produced in Canada. For a variety of economic reasons, revolving mainly around market and tariff considerations, some 30 million pounds of molybdenum-bearing materials (along with much of Canada's wealth of mineral concentrates) were exported in 1970 alone to be processed by the importing country either to pure metal or to a stage suitable for steel making, such as molybdic oxide or ferro-molybdenum.

There is every indication, however, that Canada is becoming increasingly concerned about the continuing export of its mineral concentrates and that considerable efforts are being made to develop the expertise and the facilities necessary to up-grade the value of the metals potentially available from its abundant natural resources. To secure new markets, the necessary competitive edge can be obtained only if the best available technology of production is used or, even better, if a new and more efficient technology is developed in Canada. In the case of molybdenum, such a new technology has recently been proposed. Aided by a NRC Special Project grant, a team of researchers in the Chemical Engineering Department at McGill University is actively engaged in research that could lead to a new method for the direct production of molybdenum and several other high-cost metals from their concentrates.

The team is headed by Dr. W.H. Gauvin, Senior Research Associate in the Department of Chemical Engineering, and also Director of Research and Development, Noranda Mines Limited. In collaboration with the Noranda Research Centre, the McGill researchers have harnessed thermal plasmas (ordinary gases at extremely high temperatures, surpassing the surface temperature of the sun) to separate the metal from its ore in small, high-temperature reactors. This metal-producing process has several potentially attractive features: it is versatile; it could be time-saving and possibly more economical and it is non-polluting.

Molybdenum via the plasma route is obtained from molybdenite (MoS_2), a mineral so soft and "greasy" that it has long been confused with graphite (they have nearly identical physical properties). Small particles of molybdenite, in a concentrate obtained by flotation of the ore, are injected into the experimental reactor, a two-foot high glass cylinder, six inches in diameter. The upper portion, the "torch", contains the plasma fireball housed in a two-inch diameter gold-plated quartz tube. In the plasma reactor the particles become so hot in contact with the plasma flame (circa 5,000 to 8,000 degrees Centigrade) that the molybdenite decomposes into metallic molybdenum and gaseous sulphur. The gaseous species then pass through a filter in the lower part of the reactor while the solids, including molybdenum metal remain on this filter and are thus recovered (the boiling point of sulphur is 445 degrees Centigrade and the melting point of molybdenum is 2600 degrees Centigrade). The sulphur vapor is subsequently cooled and condensed to give solid elemental sulphur.

Although of great promise for producing high-cost metals, thermal plasmas do not represent as attractive an alternative to conventional methods where base metals are involved. For example, the electrical energy needed to produce iron powder by the plasma method would alone cost about 1.5 cents per pound whereas the powder itself currently sells for around four cents per pound. Hence, for iron, profits would be negligible. But when a metal sells at over $2.00 per pound, as does molybdenum, the plasma procedure becomes much more attractive.

Molybdenum's high cost is largely due to its small concentration in the ore and to the complexity of the conventional process of producing it. With present methods, the molybdenum sulphide concentrate is first roasted in huge multiple-hearth roasters from which sulphur dioxide is emitted in large quantities. The resultant impure oxide is treated with ammonia and converted to ammonium molybdate which is roasted once more to produce pure molybdenum oxide. A two-stage reduction with hydrogen is then needed to obtain the molybdenum metal.

In 1962, Dr. Gauvin became interested in the possibility of effecting the separation of desired metal products from their natural mineral compounds by passing small solid particles of these minerals through the intense heat of a plasma flame. But this method was beset with difficulties. One stumbling block was that only a few milliseconds of contact time with the hot gases are available to heat up the particle to the reaction temperature and to bring about its conversion into the desired product. Another was that plasma devices and