A New Platinum Metals Refinery

SOLVENT EXTRACTION PLANT UTILISES TECHNOLOGY DEVELOPED BY MATTHEY RUSTENBURG REFINERS

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Following extensive testing and evaluation in a pilot plant, a large commercial pre-production noble metals refinery utilising a recently developed solvent extraction process has been constructed and is currently undergoing commissioning trials. Built with due regard to the needs of the users of the platinum metals, to the health and safety of the operators and to the protection of the environment, the capacity of the new refinery indicates confidence in the long term demand for the platinum metals.

Perhaps the most remarkable fact about the new platinum metals refinery, currently completing its commissioning trials at Royston, Hertfordshire, is not the substantial technological changes its design incorporates, but that it should have been built at all. The decision to proceed with the project was taken by the Board of Matthey Rustenburg Refiners in February 1981, at a time when world trade was generally depressed and the prospects for an improvement were not auspicious. It demonstrated the faith Matthey Rustenburg Refiners and its parent organisations, Rustenburg Platinum Mines (Pty.) Limited and Johnson Matthey, have in the future demand for platinum group metals. It indicated also the determination of Matthey Rustenburg Refiners to consolidate its technical advances, to provide a sound basis for further development of the new process and to maintain its position at the forefront of refining technology.

The New Refining Process

Since the early years of this century, the six metals of the platinum group have been refined to individual metals at very high purity by chemical techniques (1, 2). The separation processes are complex, the stage efficiencies are not ideal, and the necessary recycling resulted in materials being retained in the processing system for a significant length of time. Specific metals are precipitated from multi-element solutions, but such methods are incomplete. Recent advances in the intermediate processing of the ore obtained from the Rustenburg mines have produced a concentrate completely soluble in acid chloride media and this encouraged investigation of new techniques capable of high separation efficiencies. These include distillation, ion exchange and solvent extraction.

Solvent extraction is a well established technique in which an aqueous solution is contacted with an immiscible organic liquid containing an extractant specific for an element in the aqueous phase. This element is subsequently recovered from the organic phase, either directly or by re-contacting with a new aqueous phase under different conditions.

Commercial solvent extraction processes are operated in the hydrometallurgical industry for the recovery of copper, gold and uranium. Matthey Rustenburg Refiners have operated solvent extraction based processes for the recovery of copper at Brimsdown and at Rustenburg. Now their new base metal refinery at Rustenburg incorporates the separation and recovery of nickel and cobalt.

Specific extractants for individual platinum

Fig. 1 The new refinery has been built to the north of the existing facilities. The Solvex Building, shown here, houses both process facilities and support units. The process plant is divided into sections, one houses the solvent extraction equipment, another the feed preparation and interstage treatment plant; the metal refining stages are also carried out here

metals and groups of metals were examined and a separation sequence was devised and tested (3). The refining sequence was not based exclusively on solvent extraction, the separation of both ruthenium and osmium by the distillation of their volatile tetroxides still being retained from the established chemical refining route. An ion-exchange system was selected for the separation of rhodium. Following further bench and small pilot plant work at the Research Laboratories, a complete intermediate scale pilot plant was constructed in Matthey Rustenburg Refiners' Development Department at Royston, and this was operated for three years to obtain design data and to generate confidence in the new process (4, 5, 6).

Fig. 2 In the feed preparation area the platinum group metals concentrate is dissolved in acid by reaction with chlorine gas. After any insoluble residue has been filtered off the solution is pumped to the solvent extraction area

The new Royston refinery which is shown in Figure 1 has four major process areas, all of which are fully integrated. They are feed preparation, solvent extraction, metal refining and values recovery plant.

Feed Preparation

The platinum group metals concentrate is dissolved in acid by reaction with chlorine gas, the dissolving equipment being illustrated in Figure 2. Any insoluble residue is separated by filtration and, after any necessary adjustments, the solution is then pumped to the solvent extraction area, shown in Figure 3.

Solvent Extraction

Methylisobutylketone is used to extract gold, iron and tellurium from the feed liquor in a stirred column. The extracted metals are recovered directly from the organic phase by cementation and a gold-rich solid residue is separated by filtration. The organic phase is then recovered by distillation, and recycled.

The raffinate, that is the aqueous product resulting from the solvent extraction process, passes through an intermediate treatment stage to the second solvent extraction step. Then, using counter-current mixer-settler boxes, palladium is extracted into an organic phase containing an oxime from which it is recovered by extraction into an aqueous phase.

The aqueous raffinate moves through another interstage treatment to the section where ruthenium and osmium are distilled off.

After further treatment the aqueous mainstream passes on to the platinum separation section where an amine is used to extract platinum in a train of counter-current mixer-settler boxes. The platinum is then removed from the organic phase by an aqueous solution.

Following concentration, the mainstream liquor is subjected to another interstage treatment as it passes to the iridium section where it is contacted with an organic phase containing an amine. Stirred columns and mixer-settler boxes are used to extract the iridium and then to transfer it back into an aqueous phase.

This aqueous raffinate is again treated prior to entering the rhodium section, where rhodium is extracted by ion exchange. The rhodium is backwashed from the resin by another aqueous stream and the mainstream raffinate passes to the values recovery plant.

Metal Refining

All the products of the solvent extraction area are released in a form which is compatible with the existing platinum metals refinery, where they are converted to the pure metals.

Values Recovery Plant

All residual liquors from the new plant pass to the values recovery plant, where any noble metal is recovered by a cementation process.

Plant Design

In 1979 the Matthey Rustenburg Refiners' Project Design Group was set up to study the design of a plant or plants based on the new technology. The group studied various options and costs before deciding on the general design of the most suitable plant to be built at Royston.

This Design Group also evaluated a number of international contractors to provide design detailing, project and construction management services for the construction of the new plant. On 1st September 1980, Davy McKee (Minerals and Metals) Limited was appointed the main contractor.

With a plant of this complexity, it was advantageous to make extensive use of modelling. In the early stages of design, a conceptual model at a scale of 1 : 33 was made and subsequently a detailed model of one section of the plant was built at a 1 : 10 scale. Finally, fully detailed 1 : 15 scale models were prepared of the solvent extraction building, the values recovery plant and the tank farm, to assist in the detailed design, particularly in the layout of the piping.

Construction work on the site started in August 1981 and was substantially complete by 23rd June 1983 when the plant was opened by the then chairman of Johnson Matthey, Lord Robens of Woldingham. Pre-commissioning

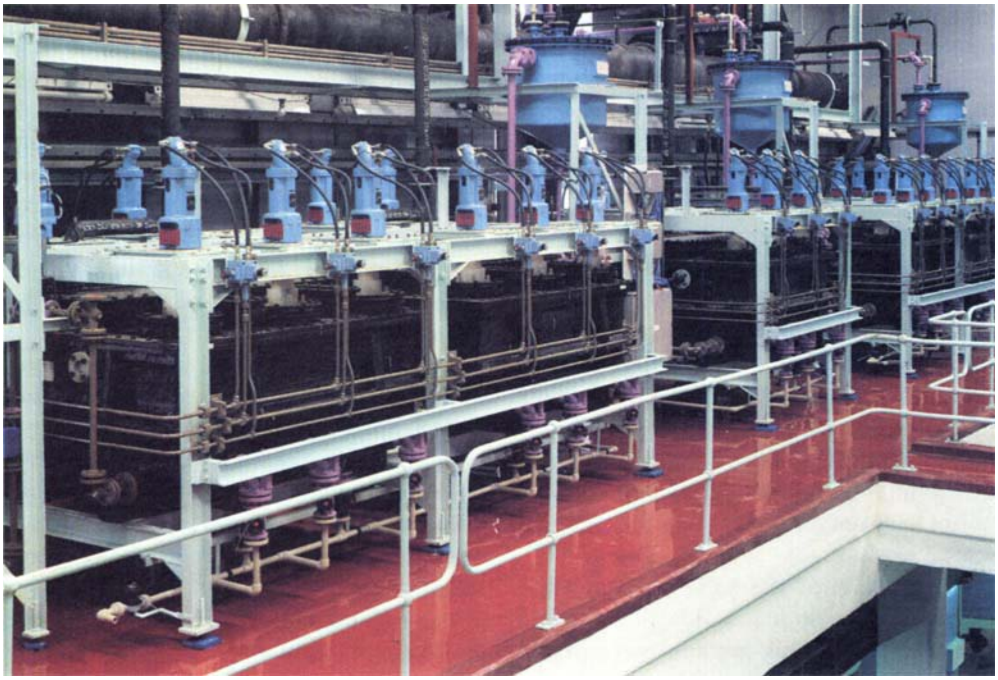

Fig. 3 After the extraction of gold, iron and tellurium, the platinum group metals are extracted. The separation of platinum, palladium and iridium relies upon a particular metal being selectively extracted from the aqueous phase by an immiscible organic solvent in counter-current mixer-settler boxes

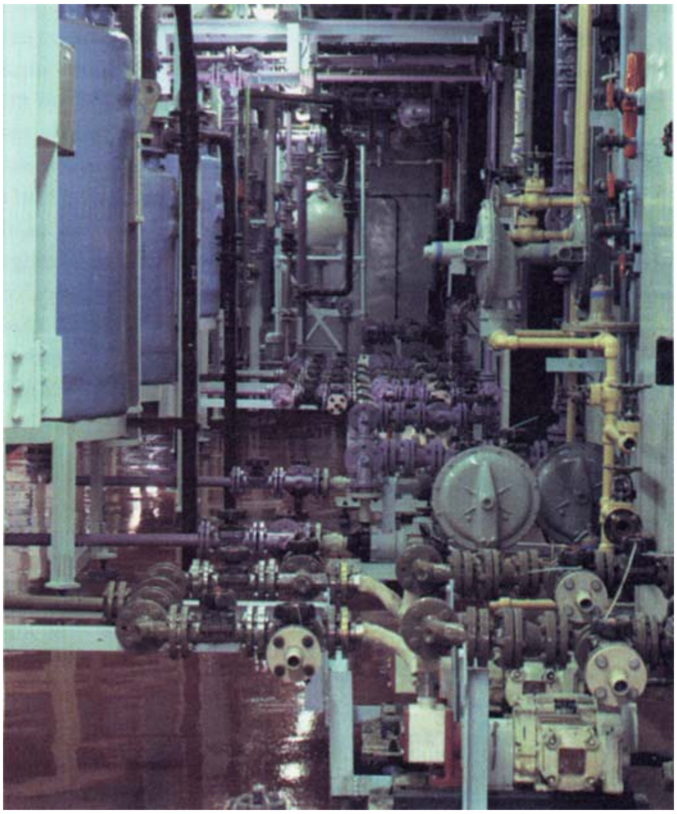

Fig. 4 One hundred and eighty pumps are used to transfer the liquors through the various stages of the extraction process. The use of closed containers minimises the contact of personnel with process materials

work commenced immediately and the first noble metal concentrate was fed into the plant in August 1983, since when commissioning trials have continued satisfactorily and are nearing completion.

The New Royston Plant

The refinery has been built to the north of the existing facilities of Matthey Rustenburg Refiners. It consists of two main buildings, one large area of unenclosed plant and three subsidiary external plants.

The three storey Solvex Building mainly houses process equipment. Also located here are production control offices, instrument and programme logic control rooms, the chemical control laboratory, electrical switch rooms, and a chemical store.

To the south of the Solvex Building, but directly attached to it is a smaller two storey Amenities Block. This contains the materials reception and despatch area, maintenance shops, and electrical equipment, in addition to the necessary offices and personnel facilities. On the roof are located the draught air inlet fans, filters and preheaters, and the extract draught fans.

The Values Recovery Building incorporates an electrical/instrument control room, and process equipment on two levels. The Tank Farm is an open structure of two parallel lines of treatment and storage tanks for cementation liquors.

The refinery contains well over 700 items of equipment. More than 200 of these items are vessels ranging in size from 50 to 70,000 litres in capacity. Over 150 agitators are used to stir these vessels, and heat transfer is effected by 60 heat exchangers constructed of carbon, glass or titanium.

Liquid transfer through some 15 miles of pipe and 3,700 valves is effected by 180 centrifugal and diaphragm pumps, a number being shown in Figure 4. Approximately 40 per cent of the piping is carbon steels, a variety of plastic or plastic lined carbon steel being used for the remainder.

For the solvent extraction duties, stirred columns of glass and titanium are used, together with mixer/settler boxes of glass reinforced plastic. An area of the solvent extraction plant is shown in Figure 3.

On the electrical side, a main transformer supplies power from the 11 kV grid to the plant through five motor control centres. There are 300 independent electrical drives, with a direct coupled emergency generator to maintain essential services in the event of a major power failure.

A very comprehensive and sophisticated control system, based on programmed logic control, has been designed for the plant. Thirty-eight independent panels are linked through the system and control 250 liquid flow loops, 180 temperature systems, 100 pressure systems, together with over 400 liquid level control loops and 100 alarm systems.

The building finishes have been installed to the highest standard so that hygienic conditions can be maintained. The space ventilation provides a positive input of filtered heated air, balanced by extraction. In addition, a policy of maximum enclosure of plant items has been followed, to minimise the contact of personnel with process materials.

Matthey Rustenburg Refiners take special pride that the new process was researched and developed in the United Kingdom. It is confidently anticipated that the output of the plant will enable Johnson Matthey to increase still further its capability to supply users with the platinum group metals of the highest purity and in whatever form they are required.

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