THE TITANIUM INDUSTRY IN THE UNITED KINGDOM

T.W. Farthing

IMI Titanium
P.O. Box 216, Witton, Birmingham B6 7BA
England

INTRODUCTION

It is 12 years since the first International Titanium Conference in London and, in view of the Japanese contribution to modern technology, it is wholly appropriate that the present Conference should be held in Japan. We are privileged to be here and, on behalf of all the UK participants, I would like to thank our hosts for their invitation and not least for their organisation of the Conference.

In his preface to the first Conference, Dr Promisel wrote:

"A major international conference ... by its very nature stimulates retrospection and prognostication. Retrospection is generally safe; prognostication, usually imprudent. In retrospect, the titanium story has been unique ... as an engineering metal, as a major industry, as a metal of continuously increasing promise. Exacting, mysterious, frustrating, unusual, expensive, lavish ... . Never has a metal invited and received such attention, not only from the technical viewpoint, but from the political arena and the world of finance as well ..."
These comments related to the 1940's, 1950's and 1960's, and Dr Promisel modestly called them "retrospection". However, with the benefit of hindsight in 1980, they represented a pretty accurate "prognostication"!

For what has changed! We still are concerned with an exacting, frustrating, expensive metal, which still receives much attention from the technical and political viewpoints, and not least from the world of finance!

We ought however to take heart from the past comments of Dr Promisel, and notwithstanding the adjectives which he used about titanium, we can now surely add "significant and important".

COMMERCIAL

In 1976, we reminded ourselves that titanium had "come of age" and that our task was to make the industry a profitable enterprise. We recognised the need to manage, side by side, the two quite different markets in which we sell our products. The aerospace sector which has in the past always been highly cyclical; which is still our most important single market; which demands the very highest quality and reliability of material, mainly in alloys; and which involves a high level of back-up in R & D and quality control, for both process and products. Our other main market is chemical and general engineering, which also require the highest quality and reliability, but usually in the pure metal and without such "in depth" technical support.

These observations are equally true today when we are faced with a resurgence in aerospace demand, but with a much less buoyant position in chemical and general engineering.

We are now experiencing the largest ever demand for titanium, principally from aerospace markets. The shipment of mill products to West European markets in 1979 was of the order of 8000 te and this will be exceeded in 1980.
This increased demand was forecast in general terms at the last Conference, but its magnitude is greater than we anticipated then, and it has occurred rather earlier. In 1976, it appeared that commercial developments in aerospace had been overshadowed by the economic recession at that time, and that sales of such aircraft as the Airbus and Lockheed TriStar had been lower than expected.

The situation in 1980 has changed dramatically. Many industries are still faced with an economic recession, still caused in part by ever increasing oil prices and the effects of inflation. But despite these factors, the demand for air transport is strong. Together with the need to replace old and inefficient aircraft, there is therefore considerable pressure on the airlines to re-equip. At the same time, significant programmes are in hand for military aircraft. All of these have resulted in a demand for titanium of unprecedented magnitude.

The most significant UK civil programme in the next decade, as in the last, will be the Rolls Royce RB211 engine family. The Dash 524 version has recently been selected by Pan Am for long range Lockheed TriStars and by several airlines for Boeing 747's. The latest member of the family, the cropped fan Dash 535, has been chosen as the launch engine for Boeing's new civil airline for 1982, the 757. Each of these engines represents a significant demand for titanium and titanium alloy in the compressors and casings. The Airbus Industrie A 300 and A 310 are also selling well, and over 400 have been ordered or are likely. British Aerospace is responsible for the design and manufacture of the Airbus wing, which contains substantial amounts of high strength titanium alloy. In the recently launched British Aerospace 146 jet feeder-liner, the applications for titanium alloy are similar to those in the Airbus and should provide worthwhile sales through the 1980's.
British Aerospace are also contracted with Romania for "One-Elevens", which use the Rolls-Royce Spey engine, and these will also add to the demand for titanium. New generation engines currently under development include the 19,000 lb thrust RJ 500 in collaboration between Rolls-Royce and a consortium of aero-engine manufacturers in Japan, and the 5,500 lb thrust RB401 for future executive and trainer aircraft.

On the military side, the German-Italian-British Tornado, powered by Rolls-Royce-Turbo Union 199 engines, has now matured and will be the dominant feature of the European military production programme for the next decade. Over 800 aircraft are to be delivered to the three participating countries. The vertical take-off Harrier and its associated Rolls-Royce Pegasus engine continues to absorb worthwhile quantities of titanium. The existing model has prospects for sale in India and elsewhere, and its derivatives such as the US AV8B, the "big wing" Harrier, may extend the programme. The Westland Lynx helicopter with its Rolls-Royce GEM engines represents another continuing programme, and will be supplemented by new developments such as the Sea King replacement. Among other military engines the Rolls-Royce/Turbomeca Adour has proved its versatility, powering Jaguar aircraft for Europe, India and elsewhere, together with the British Aerospace Hawk trainer and the Japanese T2 and F1 aircraft. In addition to these manned aircraft programmes, there is increasing interest in titanium for space and missile components, which will continue to generate a small but steady demand.

To summarise, we have in the UK for the first time for a number of years, an aerospace programme with active projects on all fronts, namely engines and airframe in both the civil and military sectors.

In the short and medium term, today's commercial challenge is to meet this aerospace demand.
The first, and most basic area in which this challenge has presented itself is in the supply of raw metal. A major development in the UK since the last Conference has been the decision to close the only extraction unit in Western Europe. This is likely to take place in the next few years. It will be replaced by a 5000 tonnes per annum unit, capable of expansion up to double this capacity, which will be operational in 1982. In parallel with this, and to match the increasing demand for mill products, there will also be new investment in IMI in melting and fabrication plant. This has already begun.

Expansion in raw metal capacity has also been announced in the US and especially here, inside Japan. In spite of these however, some difficult shortages of metal have developed, and price has risen sharply in recent years. Both of these factors represent serious problems for the industry and are threatening some of our developing markets, especially in chemical and general engineering.

Compared with aerospace, commercial developments in chemical and general engineering have been relatively dull, but in line with the general level of economic activity in these industries. There have been no major breakthroughs such as dimensionally stable anodes for chlor-alkali production, or titanium starter blanks. In the main, the period has been one of consolidating existing products. We have seen, for example, a continued expansion of markets for thin-walled tube, where its use has substantially improved the reliability and cost-effectiveness of condenser and heat exchange systems.

Before the introduction of titanium, the plugging of leaks, and often complete tube-bundle replacement, was no rare occurrence in systems handling sea water or polluted inland waters. Two decades of experience have demonstrated the clear economic viability of titanium, either as a substitute in problem plant or when selected from the outset.
By and large, the most significant volume applications for titanium outside aerospace continue to be in the pure metal, and based mainly on its outstanding corrosion resistance. Its mechanical properties and its low density, except indirectly, are not prime factors in its choice as an engineering material. And yet these are the characteristics which, properly exploited, should have a direct bearing on the most important issue facing all of us today, namely the more efficient use of energy. Strength-to-weight is of course exploited in aerospace; why not more widely in general engineering, in any moving machinery? Such applications to date are very specialised and small in volume.

TECHNICAL

The question of metal extraction has received much publicity in the last couple of years, but for the validated and proven alloys required for aerospace, the industry is still committed to the traditional Kroll/Hunter processes. The most publicised different route is that based on fused salt electrolysis, and a pilot production facility has been reported from the US. We all look to this with interest, from both technical and economic points of view.

The melting of titanium has been one of the most critical parts of the technology since the industry began, and improved techniques have always been a major goal. It will be interesting to see if any new developments are reported at the present Conference. CEVAM melting is still dominant for commercial production, with a general tendency towards increased ingot size. Microstructural controls and standards, and chemical homogeneity however, tend to constrain this trend, at least for alloys. We at IMI have continued to have good experience with NaK cooling, and the safe operation of such furnaces has allowed greater flexibility in their use.
It seems clear that the trend towards more efficient and less noisy aircraft will continue. This is a healthy sign for the titanium industry, whether solutions are to be found in the engine or the airframe. With this, and with rising material prices, there will be a continuing emphasis on savings in materials. The market for titanium castings is growing, for example, albeit from a very small base. There is still no titanium foundry in the UK because, in our view, the industry is still over-populated with suppliers. Because of this, and the small size of the market, the required capital investment cannot be justified.

Among other manufacturing techniques aimed in part at improving material utilisation and, hopefully, reducing costs, work is being carried out on alloy "shot". However, even assuming that quality, integrity and consistency can be achieved, products must be made at the "right" cost.

It is obvious that, in common with other sectors of the metals industry, powder metallurgy has a place in titanium, as evidenced by Session X-B of this Conference. The extent, as always, will depend on the economics of production.

In discussing alloy development, it is a truism to say that the cost of developing a new alloy is high, and getting higher. Following the initial research stage, and after the composition has been chosen, extensive development work is needed to establish the full range of properties; the effect of minor impurities; the influence of production variables on properties, etc; against a background when the customer's demands are getting tighter and more demanding. Even when this work has been done, the costs of introducing the material into full production have to be borne, whilst experience is gained on the new alloy.
All of these steps are vital and inescapable in the development of new materials for aerospace. Investment on this scale can only be justified when significant and worthwhile new markets will follow.

Alloy development in the UK has continued along two main lines. The one is concerned with improved engine alloys for operation at increasingly high temperatures. The most recent material to be introduced is IMI 829, the properties of which are described in another Conference paper. With the increasing cost of fuel and the search for more efficient engines, it is likely that titanium will be required to operate at even higher temperatures. Work has already started in this direction, on the possibilities of conventional alloys or indeed into materials based on intermetallics.

The second main line of alloy development is the search for a better understanding of the metallurgy and characteristics of existing alloys which, in common with the rest of the industry, is part of a continuous programme of improvement. This has enabled us to improve the level and consistency of properties over the years. Process improvements have been introduced to provide "disc quality" material, with the special integrity and quality demanded for these critical applications.

CONCLUSION

This review started with a reference to Dr Promisel and I would like to close with another. In his preface to the first Conference, Dr Promisel stated:

"... to a very significant degree, the merit of the conference was in bringing together hundreds of scientists and engineers from many lands, who gave freely of their thoughts, knowledge and experience, to the mutual enhancement of the conference theme."
This is just as relevant today as it was then. Many interesting papers have been submitted and we all look forward to studying and discussing these in more detail throughout the coming week. Just as important however, will be the opportunity of meeting old friends and making new ones. Personal contacts are an important feature of our industry, and I am confident that "Kyoto" will be no less successful than past Conferences in building and strengthening these traditions.

ACKNOWLEDGEMENTS

The author would like to express thanks to his colleagues for their advice and notes in the preparation of this review.