T.I.C. Activities

The Eighth General Assembly of the T.I.C. was held in Brussels on October 11, 1977. The feature of the meeting was the completion of the plans for the First International Symposium on Tantalum to be held from May 10, 1978 through May 12 at Rothenburg ob der Tauber, West Germany. Details of the programme are provided below.

The guest speaker at the General Assembly was Mr. José Nicolai, Adviser for Domestic Market and Industrial Affairs to the European Economic Communities (EEC). His talk, which covered the relations between the industrialized countries and the developing countries with respect to the production and supply of raw materials, will be published in Issue No. 13 of the T.I.C. Quarterly Bulletin.

THE FIRST INTERNATIONAL SYMposium ON TANTALUM

The chronological schedule for the World Symposium on Tantalum was provided in Issue No. 11 of the T.I.C. Quarterly Bulletin. To recapitulate, participants should plan to arrive at Rothenburg on the evening of Tuesday, May 9. The Symposium will close on the evening of Friday, May 12 in Nürnberg.

The papers which will be presented at the Symposium are as follows:

I. Raw materials, supply and demand situation.
   — "The Situation with Respect to the Supply of Tantalum." Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Germany.
   — "Tantalum Supply and Demand Outlook - Is the Balance Favorable?" T.C. Barron, Emory Ayers Associates, U.S.A.

II. Present situation and future trend of capacitors.

III. Tantalum products and processes.
   — "Specific Problems Related to Tantalum Products." H.J. Heinrich, GFE Gesellschaft für Elektrometallurgie mbH., Düsseldorf, Germany.

IV. Tantalum for chemical equipment.
   — "Engineering Aspects of Tantalum Chemical Equipment." Gerald D. Corey, Fansteel Inc., U.S.A.

T.I.C. Eighth General Assembly

On October 11, 1977, the Eighth General Assembly of the T.I.C. convened in Brussels, Belgium. Thirty-two participants represented twenty-three of the twenty-nine members. A presentation was made by Mr. José Nicolai, Adviser for Domestic Market and Industrial Affairs to the European Economic Communities (EEC) in which he presented a general picture of EEC policy regarding relations between the industrialized and the developing countries as producers and suppliers of raw materials to the Western World.

The Ninth General Assembly will be held concurrent with the Tantalum Symposium, May 10-12, 1978 in Rothenburg ob der Tauber, West Germany.


An outline of the programme and a registration form will be mailed by the T.I.C. Secretariat as soon as possible to all people and institutions who are known to be interested in attending. If others, not so addressed, are interested in attending the First International Symposium on Tantalum, please signify your interest in order to receive the necessary registration form by contacting the Secretary, Tantalum Producers International Study Center, 1 rue aux Laines, 1000 Brussels, Belgium.

All hotel reservations will be arranged by the T.I.C. and confirmed with the final acceptance of the application early in 1978.
Tantalum - Use in Cemented Carbides

The cemented carbide industry (producers of metal cutting tools, mining tools, "hard metal" wear resistant parts, etc.) is the world's second largest consumer of tantalum in the form of tungsten carbide. Although the latter products are primarily supplied by basic tantalum processors who use ores and slags as their material source, cemented carbides are the one use of tantalum for which a high proportion of material source is scrap recycle. Most of the scrap generated by the tungsten carbide industry is used in the production of carbides as well as the cemented carbide scrap recycle. The flow of material in the industry is shown in the accompanying chart.

THE FUNCTION OF TANTALUM IN CEMENTED CARBIDES

Cemented carbides are products in which fine particles of very hard metal carbide alloys are cemented together in a solid mass by a binder metal. Although the composition and properties of individual cemented carbides differ widely, most of these products use tungsten-carbide as a base with various other carbides as alloying constituents, generally bound together with metallic cobalt.

About sixty-five years ago it was found that the superior machining capability of certain steel cutting tools resulted from the inclusion of hard metal carbide particles. From this, it was natural that a method should be sought to make cutting tools of the hard particles themselves. During the early 1920's development was completed of a product consisting of fine tungsten carbide powder compacted into compacts with metallic cobalt particles used for a binder. When the "green compact" produced by newly developed powder metallurgical techniques, was sintered at a temperature around 1500 °C, the cobalt melted and bound the tungsten carbide particles together in a solid, hard matrix. A new industry was born with the introduction to the market by Friedrich Krupp in 1927. The machining demands of the Second World War developed the volume need to the point where the total world production of all types of cemented carbides approaches 17,000 to 18,000 t.m. annually.

The art and science of cemented carbide production and use has progressed rapidly, each tailored to particular end-uses. In the early days of cemented carbide development, it was found that straight WC tools tended to be "cratered" by the pressure of hot steel chips on the rake face of the tool. The WC actually diffuses rapidly into the steel chip, depleting the WC in the cutting tool, producing "craters". This phenomenon weakens the tool and early chipping results in shortening the life of the cutting edge.

The first solution to the cratering problem was to add a small percentage of titanium carbide (TiC), but WC/TiC tools are much more brittle than straight WC tools. Compromise was required that reduced cratering by the addition of small amounts of TiC but allowed some cratering to maintain the toughness of the basic WC. The search for a better solution led to the use of tantalum carbide (TaC). In addition to providing superior cratering resistance, the TaC provides the ability to machine at much higher cutting-edge temperatures and produces shock-resistance, making tools using TaC more suitable for discontinuous cutting. Few straight WC/TaC grades are used today and such are specialty items designed for particular applications. The TaC content of WC/TaC grades will vary from 2.5% to as much as 28%.

Again, because of the high cost of TaC to TiC, compromises have been sought to improve the economics of metal cutting. There are three products offered which accomplish this.

1. WC/TiC/TaC Tools: These tools are used for steel cutting, providing the cratering resistance of both the TiC and TaC with the high temperature shock-resistance characteristics added by the TaC. 50% of all WC-base cutting tools fall into this category, with the TaC running from 2% content to as much as 10%. Statistically, the average content of TaC is about 8.5% over the free world, ranging from a low 7.6% in Western Europe to a high of 9.6% in the United States. This divergence results from the use of NbC to provide part of the tantalum need in Western Europe and Japan.

2. Ta(Nb)C Tools: Since niobium has only one-half the density of tantalum, the same weight provides twice the volume of NbC as TaC. With cost being lower for NbO2 by a factor of about four compared to Ta3O5, a volume of NbC costs about one-eighth of a similar volume of TaC. NbC thus becomes an economically desirable substitute for TaC. Unfortunately, NbC is less effective than TaC and it has been found, as a matter of practice, that complete substitution is useless. Thus the ratio of NbC to TaC is commercially established in the range from 3:7 down to 1:1. In the Japanese and Western European markets use the mixed Ta(Nb)C while the U.S. market does not. The major reason is that metal-cutting in the US requires heavier cuts at slower speeds, a range for which niobium performs less satisfactorily than tantalum. In Europe and Japan, forgings are made to closer tolerances, thus higher tantalum content. There is also an element of habit and taste associated with U.S. companies rarely using mixed carbides, apparently not fully justified by objectively measurable factors. A recent T.I.C. survey estimated the average percentage of mixed carbides as follows:

<table>
<thead>
<tr>
<th>Market Area</th>
<th>TaC (%)</th>
<th>NbC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>89%</td>
<td>1%</td>
</tr>
<tr>
<td>Europe</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>Japan</td>
<td>85%</td>
<td>15%</td>
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</tbody>
</table>

The present trend in Europe seems to be toward 70% to 30% ratio. The current higher tantalum prices may force a change in the habits in the U.S., leading to greater use of the mixed carbide.

3. TiC-Coated Tools: During the last fifteen years, the technological progress made in chemical-vapour-deposition (CVD) has resulted in a new cutting tool consisting of a tough WC or WC/TaC base with a TiC coating which resists cratering. This product has made substantial gains in the

<table>
<thead>
<tr>
<th>TYPE OF CEMENTED CARBIDE TOOL</th>
<th>PRIMARY PURPOSE FOR SINGLE TAICUM CONTENT (MAIN ADDEND)</th>
<th>TITANIUM CARBIDE CONTENT (MAIN ADDEND)</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. &quot;Straight&quot; Tungsten Carbide (WC/Co)</td>
<td>Grain growth inhibitor</td>
<td>0.5% - 1.3%</td>
<td>Metal cutting</td>
</tr>
<tr>
<td>2. Complex Carbides</td>
<td>WC/TiC/Co/Co</td>
<td>Thermal Deterioration</td>
<td>0.2% - 30%</td>
</tr>
<tr>
<td>WC/TiC/Co/TiC</td>
<td>Thermal Deterioration</td>
<td>0% - 10%</td>
<td></td>
</tr>
<tr>
<td>WC/TiC/Co/TiC/Co</td>
<td>Thermal Deterioration</td>
<td>1.0% - 15%</td>
<td></td>
</tr>
<tr>
<td>TiC/Co</td>
<td>TiC</td>
<td>Thermal Deterioration</td>
<td>0%</td>
</tr>
<tr>
<td>TiC/Co</td>
<td>Other (e.g., Cr7C2)</td>
<td>Thermal Deterioration</td>
<td>0%</td>
</tr>
<tr>
<td>3. TiC Base</td>
<td>Base</td>
<td>Thermal Deterioration</td>
<td>0%</td>
</tr>
<tr>
<td>4. Coated Inserts</td>
<td>Substrate</td>
<td>Same as above for straight</td>
<td>0.6% - 6.0%</td>
</tr>
<tr>
<td>Complex Substrate</td>
<td>Substrate</td>
<td>complex grades</td>
<td>0.7% - 4.0%</td>
</tr>
<tr>
<td>Other (e.g., Cr7C2)</td>
<td>Substrate</td>
<td>Same as above for straight and complex grades</td>
<td>0.6% - 6.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and complex grades to</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>prevent tool failure when</td>
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<td>the coating surface is</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>worn through</td>
<td></td>
</tr>
</tbody>
</table>
tal cutting tool market, now accounting for about 21% of the total market with the trend increasing. Initially, the TiC coatings were placed on manufacturers’ regular tool grades to extend the life of those tools. Recently, however, research has shown that especially designed substrates can be used which are essentially WC/TaC but with the TaC reduced to only 6%. Some grades, which started at 10%, are now down to 3%.

The cemented carbide producers also use some tantalum oxide as a WC grain-size refiner. It is added in an amount ranging from 0.6% to 1.6% to inhibit grain growth. The use, however, is decreasing as the tantalum oxide is being replaced by other metallic oxides and the demand for fine grain carbides is not increasing very rapidly.

In summary, the use of tantalum in cemented carbides is shown best by the table at the foot of page 2.

CONSUMPTION RELATED TO PRICE

The price of tantalum carbide has ranged from as low as $28 per kg. in 1970 to $66 in 1974, softening slightly in 1975 and again climbing to the current level of $88. Although there has been a wide variation of usage over this period, such is directly traceable to the demand for cemented carbides, not the price of TaC. Within particular grades of tools, the usage of TaC has been almost constant. Actually the consumption of TaC by the free world cemented carbide industry appears to have increased from about 3.0% of total cemented carbide production in 1971 to 3.5% in 1976. Even with the three to one increase in TaC prices, the actual contribution to cost increase per kg. of cemented carbide product has only been a little over $2. Since tungsten prices have also increased significantly, the impact of the TaC price increase has not been too great.

Historically, however, the cemented carbide industry has been very competitive which has engendered technological development to provide lower cost use of their product. This same motivation is still in force and can be expected to continue the efforts to develop lower cost products. A T.I.C. survey of cemented carbide producers made in 1976 indicated that carbide costs resulting from tantalum at $25 per lb. TaC would have no effect for at least two years, because of the lead-time needed to redesign products to use less TaC.

With continuation of tantalite prices at $25, however, it was the consensus of the industry that consumption of TaC would drop 15% over the span of five years. A more recent survey indicates the market for TaC is still holding up but some producers acknowledge that efforts to reduce the use of TaC are underway.

USE OF SCRAP
AS A SOURCE FOR TaC

The use of TaC by the cemented carbide industry provides a use for some types of tantalum scrap which would otherwise be lost. Most applications of tantalum, if scrap is to be used as a source of supply, require very high purity scrap. Since much of the scrap generated does not qualify for these uses, it would be lost as uneconomic to process. The process of mak-

The Outlook for Tantalum Supply

Concerns of tantalum product manufacturers and tantalum end-product users about the future supply of tantalum source materials can be relieved for the short term into the early 1980’s with a full understanding of the supply situation. The long term supply situation, however, depends on factors related to the political climate in source countries and the availability of capital for exploration and development.

FORECAST REQUIREMENT FOR TaC

A recent T.I.C. study (October 1976) provides a forecast through 1980 of the total world consumption of tantalum carbide. The projection assumes an economic cyclical pattern based on an economic downturn equivalent to the 1970 recession affecting the U.S. and Japan in 1979 and Western Europe in 1980. This forecast is provided in graphic form as follows:

![Graph showing forecast for tantalum consumption](image-url)
SOURCES OF TANTALUM SUPPLY

Tantalum source materials are produced by mines operated specifically to obtain tantalum containing minerals, tin mines from which tantalum source materials are obtained as a by-product. Tin smelters produce slags which contain tin, and old tailing dumps which can often be reworked to recover tantalum wanted at the time they were formed. The following chart shows the sources and movements of the various materials to the processors who extract tantalum from the minerals (see chart at the foot of page 3).

The few large mines producing tantalite and columbite are independent of tin production. There are also a number of small mines which usually produce tantalite in conjunction with other metals and minerals, e.g. beryl. In some areas, individuals hand-pick tantalite and microlite from exposed surface deposits. Although the large miners can sell directly to merchants or through agents, there are many collectors who periodically visit the producing areas to buy the output of the small producers. These collectors, generally associated with merchants, accumulate enough material to make large sales and shipments.

The tin mining community is similarly divided by size. Large mines have their own concentration plants, and during processing separate recoverable tantalite out of the tin ores. Small miners who cannot afford concentration facilities utilize custom processors who collect enough tin ore from many small miners in an area. These concentrators also generate tantalite and columbite from the tin ore.

There is always residual tantalum in tin concentrates, as complete separation by ore dressing methods cannot be effected. In addition, some concentrators are not equipped with the additional facilities needed to recover the tantalum. Thus, upon smelting, the tantalum is separated from the tin and is a residual element in the slag. Depending on the amount of tantalum in the ore and the proportion removed, tin smelter slags will vary in tantalum content from as little as 1% to as much as 30% or more. The high extremes are rare, however, and the great bulk of tantalum bearing slags varies from about 1.8% to 15%.

Most tantalum source material is sold to merchants and agents, as the various producing sources are not set up to market their products directly to the processor. Generally, processors are not prepared to handle the sampling and shipping arrangements which can be routinely handled by the merchants. However, there is a small portion of the material purchased directly by processors, particularly those in Japan.

Raw material sources in 1977 by geographic distribution are shown in the following chart. Tin slags account for 52% of the total. The combination of tin slags, tantalites, and columbites from Southeast Asia and Australia amounts to 53% of the total. The combination supply from Africa is another 20%, leaving only 27% from all other sources.

FORECAST PRODUCTION, 1977-1980

The same research by producer has produced a forecast for the years 1977-1980:

The 1976-1980 production forecast shows an increase from 1,150 m.t. to 1,279 m.t. if market prices remain at current levels. This is based on a simplistic assumption that tin output will rise 1.8% per year through 1980. After 1977, tantalite production shows no significant growth. Since only 25% of the tantalite produced is a co-product of tin concentrates production, the slow growth in the tin market is not the primary cause of stagnation. The main inhibitor of new reserves available to current producers. The total increase in tantalum supply from all current sources from 1973 through 1980 will be at an average annual rate of only 2.1%. In view of a 200% price rise during the past four years, this demonstrates again the tantalum price insensitivity. This is to be expected, because 64% of the tantalum raw materials are co-products or by-products of tin production, which makes it impossible to increase output because of tantalum price alone.