Friends,

I am dutifully reminded by our Secretary General Judy Wickens that this will be my last letter in this term of office as the President of the T.I.C. I would like to give special thanks to those whose efforts throughout this year will contribute to what I believe will be a most informative, active and lively General Assembly. It is clear from the large numbers of members who booked places early that they too are looking forward to the mix of technical, social and business discussions that such a detailed and considered programme provides. I also wish to take this opportunity to thank the authors of papers at this year’s conference for having provided presentations of a very high standard that we have come to expect from our fellow members.

This continues to be a challenging environment for our industries and I am so pleased that our membership continues to flourish, with members so willing to contribute to the success of their association with their time, experience and enthusiasm.

I look forward to greeting you at the meeting in the full expectation of another assembly characterised by informative debate, intelligent insight and much enjoyment. The last two years have been a privilege for me to be the President of such an association with strong foundations, a wonderful staff and a promising future.

William Millman
T.I.C. President

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The T.I.C. is an association internationale under Belgian law.

FORTY-SEVENTH GENERAL ASSEMBLY

The General Assembly for 2006 will be held on Monday October 16th 2006 as part of a meeting from October 15th to 17th in Innsbruck, Austria. Technical sessions will take place on the mornings of Monday October 16th and Tuesday October 17th: the abstracts for the papers to be presented are shown below.

TECHNICAL PAPERS, 2006

These papers are expected – the list is not in running order.

A look at the T.I.C. statistics, industry news and developments in the transport project
Ulric Schwela, Technical Promotion Officer, Tantalum-Niobium International Study Center

The statistics collected recently from T.I.C. member companies on production and trading of raw materials and shipments by processors will be reviewed. Notable changes in the industry of tantalum and niobium during the past year will be reported. The project concerning difficulties encountered by companies wishing to transport tantalum raw materials has progressed significantly. The consultants SENES have completed a report based on surveys of the levels of radioactivity of consignments shipped by member companies. The findings of the report will be summarised, and possible next steps and developments discussed.

Conducting polymer dispersions for high capacitance tantalum capacitors
Udo Merker, Wilfried Lövenich, Klaus Wussow, H.C. Starck GmbH, Central Research and Development
To be presented by Udo Merker
Conducting polymers used as cathode materials are the key component in electrolytic capacitors to meet the market needs for low equivalent series resistance (ESR). While conducting polymer electrolytic capacitors have gained substantial market share in recent years, complicated manufacturing processes limit the performance and a faster market penetration.

So far conducting polymers are deposited either by chemical in situ polymerization or by electrochemical polymerization to form a cathode layer. We developed conducting polymer dispersions based on our Baytrontechnology which allow for the direct deposition of the cathode layer by a simple dipping process without any polymerization process. Unlike polymerization processes, polymer dispersions do not cause deterioration of the leakage current and break down voltage of the dielectric.

The use of our polymer dispersion for low capacitance tantalum anodes could be demonstrated. With increasing surface area of the anode, the deposition of conducting polymer dispersions becomes challenging due to the decreasing pore size. We have developed dispersions as well as deposition processes for high surface tantalum anodes. In our presentation we will compare the performance of conducting polymer dispersions and chemical polymerization processes for anodes made of various high capacitance tantalum powders.

Non-destructive testing with a SQUID based system for use in an industrial environment
Friedhelm Scholz, W.C. Heraeus GmbH / WSK Mess- und Datentechnik GmbH

For the development and the application of modern materials it is absolutely necessary to use very highly sensitive and precise nondestructive test methods for the detection of very small inhomogeneities and defects. Also very pure materials must be controlled before and during an expensive manufacturing method to intervene in the production process early enough. Through the co-operation of two companies (W.C. Heraeus GmbH and WSK Mess- und Datentechnik GmbH, both headquartered in Hanau) and the University of Giessen, aided by the BMBF, a SQUID-NDE-System was developed for large planar samples (≤1mx1m) especially for pure niobium sheets (for particle accelerators) and sputter targets. This system was subsequently optimized for routine measurements in an industrial environment. By making many comparative tests with ultrasonic testing, X-ray inspection, and subsequent metallographical microsections, it could be shown that the SQUID system is able to detect even very small material defects (<~50 μm) such as cracks, pores, inclusions, precipitations, laminations, density gradients and others, in quite a number of different materials, for example, metals, ceramics, composites, or coated glass. Due to the high sensitivity and flexibility of the SQUID NDE system, the results obtained give more information about possible defects than most of the other NDE methods established at this time. In a strategic development it should be possible to measure 3-D samples (tubes, wires etc.).

Niobium as mint metal: production, properties, processing
Robert Grill, Plansee SE, and Alfred Gnadenberger, Münze Österreich

For application as coin metal the materials used must be able to meet a wide range of demands. This paper describes the selection criteria for coin metals and gives an overview of the quality and production requirements needed for special coins for collectors. Niobium was selected as core metal for a special 25 euro bi-metallic coin collectors' series issued by the Austrian Mint. As counterpart, silver is used as the surrounding metal.

A special feature of this bi-metallic coin is the use of coloured niobium inserts. The combination of these materials with distinct different material properties, especially the deformation behaviour, and the use of the coloured niobium insert makes an adaptation of production parameters and manufacturing philosophy necessary. Besides a general overview of the properties and applications of niobium, the paper describes the experience of producing the bi-metallic coins.

Application of high purity niobium for European X-Ray Laser Project XFEL
W. Singer, X. Singer, Deutsches Elektronen-Synchrotron DESY

The X-ray free electron laser XFEL will produce high intensity ultra short X-ray flashes with the properties of a laser light, which will make it possible to carry out leading-edge research in Europe. It is planned to start the building of XFEL at DESY in co-operation with European partners at the beginning of 2007. XFEL will include an electron accelerator with 120 cryogenic modules containing about 1000 superconducting resonators and will require about 30t of high purity niobium. Some qualified vendors of high purity niobium are already available, the qualifying of new vendors is under way.

High purity niobium has a tough specification to meet. High thermal conductivity is needed to transfer the dissipated RF power to the liquid helium coolant. Oxygen, nitrogen and carbon act as scattering centres for unpaired electrons. The content of hydrogen should be kept low to prevent hydrogen Q disease, that is, the hydrogen precipitation and degradation of the Q-value under certain cool-down conditions.

Two types of niobium material can be applied. On the one hand, much experience has already been gathered for small grain niobium sheets; as many cavity prototypes have been constructed. On the other hand, another option which may possibly be cost effective is to slice discs of appropriate thickness from ingot with large grain and to produce cavities by deep drawing and electron beam welding. DESY produced several single-cell and 9-cell cavities from large grain niobium from different suppliers. The best reached an accelerating gradient of 41 MV/m with high Q, which is comparable to the best performance of cavities from small grain material.

In addition, the single crystal option (grain boundary free) is promising. It seems that in this case the treatment procedure can be simplified. A fabrication method of single crystal cavity of XFEL shape has been proposed. A grain boundary free cavity even at the welding area can be produced by special preparation and welding. The method developed can be extended to the fabrication of multi-cell cavities.

Solid oxide membrane (SOM) process for environmentally sound production of tantalum metal and alloys from their oxide sources
Uday B. Pal, Professor, Department of Manufacturing Engineering, Boston University

The Solid Oxide Membrane (SOM) process is an emerging technology for the environmentally friendly extraction of high-energy-content metals such as magnesium, tantalum, calcium and titanium directly from their respective oxides. This paper reports on the recent success of the SOM process for tantalum production from tantalum oxide dissolved in a fluoride-based fluid (melt) in the temperature range 1150-1300°C. The SOM process employs an inert oxygen-ion-conducting stabilized zirconia membrane to separate the inert cathode in the flux from the anode. When the applied electrical potential between the electrodes exceeds the dissociation potential of tantalum oxide,
oxygen ions are pumped out of the melt and through the zirconia membrane to the anode where they are oxidized. High purity tantalum metal is deposited at the cathode. The SOM cell has been electrochemically characterized and key concepts that are related to tantalum oxide dissociation and electrolytic production of tantalum are explained. The SOM process has the potential to produce tantalum metal efficiently without the expensive pre-processing of raw materials and generation of harmful by-products.

Niobium in alloys for the oil and gas industry
Rainer Behrens, ThyssenKrupp - VDM GmbH

Metallic components play a vital role in offshore technology and in exploration for and winning of fossil fuels. The spectrum of alloys used ranges from simple carbon-steels up to zirconium or titanium alloys. Alloys with high corrosion resistance, strength, ductility and resistance to abrasion are required to make the winning of oil and gas production more economic and to reach the planned life times of the components and installations. In the oil and gas industry, stainless steels and nickel-base alloys are very often used for this purpose. Niobium is an important alloying element in many alloys for the oil industry. By solid solution strengthening and age hardening (Ni3Nb) niobium contributes to the strength of these alloys. The presentation describes some typical nickel-base alloys and high alloyed stainless steels and their application in the oil and gas industry.

Tantaulum capacitors - how far can they go? Yuri Freeman, Philip Lessner, Kemet Electronics

Tantalum capacitors have been on the market for about half a century. During this period of time, many other electronic components have appeared on the market, reached their crest, declined, and disappeared. There are three major parameters which keep tantalum capacitors on the market and make them attractive for the end-electronic makers. These parameters are high reliability, high volumetric efficiency (CV/cc), and low ESR. After many years of development, CV/cc and ESR of tantalum capacitors are approaching physical limitations for these parameters within traditional technologies of powder and capacitor manufacturing. Going to extremes with the CV/cc and ESR affects the reliability of the capacitor and limits its field of application. The paper discusses the physical nature and progress of these key parameters during the history of tantalum capacitors, the current state-of-the-art in tantalum capacitor manufacturing, and prospects for their future development.

Influence of niobium on mechanical properties and hot crack susceptibility of nickel-base cored-wire weld metal type 70/20 and 70/15
G. Pasch and W. Klaggges, Böhler Schweissstechnik Austria GmbH, R. Vallant and H. Cerjak, Institute for Materials Science, Welding and Forming, Graz University of Technology

In the last few years new types of welding electrodes have been evolving strongly on the market: flux-cored wires (FCW) and metal-cored wires (MCW) are replacing solid wire in the standard gas metal arc welding (GMAW) process. These new types are produced by using various metal and/or mineral powders to fill a tube or a rolled strip before drawing to diameters equivalent to those of solid wires used for GMAW. Using this technique the benefits of the slag systems process and easy variation of alloying concepts known from the shielded metal arc welding (SMAW) process can be applied to the very economical GMAW welding process, with additional advantages in the welding behaviour.

This paper explains briefly the production technology and possibilities of nickel-base cored wires and deals with the influence of different Nb/C-ratios on the hot cracking susceptibility and mechanical properties, especially in nickel-base 70/20 and 70/15 weld metals. Using the PVR-hot-cracking test facility and tensile testing an optimum Nb/C-ratio could be found to minimize the hot-cracking susceptibility at requested mechanical properties.

The results achieved by the use of different nickel-base cored wire weld metals will be set out in relation to weld metals achieved with the SMAW and the solid wire GMAW process.

Future use of tantalum within corrosion engineering and energy production
Dr Bo Gillesberg, Danfoss Tantalum Technologies

Tantalum is recognised as being a superior choice within corrosion engineering. Despite the fact that the metal offers unique corrosion properties, the amount of metal used in the industry is modest. Issues that limit the use of tantalum are related to high price and poor mechanical performance of the material. However in addition other issues become apparent such as difficult supply chain management, and lack of workshop capability. As a result tantalum is today an unattractive solution compared to other special alloy materials such as duplex stainless steel, titanium and nickel based alloys (Hastelloy).

The TANTAULINE concept by Danfoss is an example of a tantalum based corrosion concept that has been developed to compete in the special corrosion alloys markets. TANTAULINE uses tantalum surface technologies as an add-on solution for standard range components in materials such as stainless steel. The result is higher corrosion performance, shorter lead-time and a competitive price compared to titanium- and nickel-based solutions. Danfoss is currently targeting the market with a range of tantalum based products including valves, fasteners, fittings and sensors. Field tests show a very high performance in customer installations.

Longer term approaches include electrode materials to be used in the energy sector. Increasing energy prices may enhance the need for new energy carrier systems, hydrogen or alcohol being processed in fuel cells, for example. Tantalum-containing sandwich layer materials offer superior technical performance compared to current state-of-the-art technologies within production and combustion of these fuels.

Tantalum production using the FFC Cambridge process
Alan C. Bissell, Metalysis Ltd

Discovered at the University of Cambridge in 1998, the FFC Cambridge process is looking set for the commercial extraction of a wide range of metals and the production of both existing alloys systems and 'impossible to melt' new alloys.

This presentation will provide a comprehensive review of the technology and its development at Metalysis relating to its application for tantalum. This will include the company background, technical detail of the FFC Cambridge process and the latest news including the recent acquisition of GinetIQ's FFC operation and the formation of a first overseas subsidiary specifically for tantalum production.

The excitement of discovery: The Blue River Carbonates - The development of a new source of raw materials
Dave Hodge, Jody Dahrouge, Commerce Resources
Wah Chang Seminar

Ati Wah Chang is offering a two-day professional seminar aimed at helping chemical, design, materials and other engineers, fabricators and maintenance personnel to select and work with specific materials for applications in corrosive conditions. The Corrosion Resistant Metals Seminar is one of an occasional series of such conferences organised in Europe and in the U.S.A. Sessions on the first day cover the metallurgy, properties and availability of zirconium, titanium, niobium and tantalum; production and fabrication processes such as forming, machining, welding and heat treatment; corrosion mechanisms, comparison with other corrosion resistant alloys and applications in acidic, alkaline and other difficult media. The second day sessions will include: project management and design of equipment, repair and maintenance; safety; available services in corrosion testing and failure analysis; and web-based tools and resources.

The seminar will be held in a beautiful setting (a chateau in its own wooded grounds) near Paris and Charles De Gaulle Airport, and the fee of 700 euros includes the technical course, one night’s accommodation, breakfast, lunches and dinner. The dates are October 11th and 12th (which may just give you time to attend before moving on to Innsbruck for our own meeting).

For more information or to book a place (places are limited), contact Marphill International: tel. +33 1 42 97 44 74, fax +33 1 42 96 27 18, e-mail marphill.int@wanadoo.fr

Niobium – Plentiful and Reliable

This article was compiled from the following papers given at the Tantalum and Niobium World Symposium in 2005: Niobium – Plentiful and Reliable Technological Solution by José Isildo de Vargas and Tadeu Carneiro, Companhia Brasileira de Metalurgia e Mineração; Niobium in Modern Pipeline Steels, by Klaus Hulka, Niobium Products Company; Modern Steel Sheet for Automobiles, by Shunichi Hashimoto, CBMM Asia

Niobium products are manufactured from two different types of niobium ores. The major source is pyrochlore, but niobium can also be obtained as a by-product of tantalum operations which process columbite-tantalite ores. Pyrochlore production continues to be the single most important source of niobium units, but a substantial increase in the amount of niobium oxide produced as a by-product of tantalum operations was observed in 1998, which had some impact on the higher value added markets such as niobium masteralloys used in manufacturing superalloys, special grade niobium oxides for lenses and ceramic capacitors and niobium metal.

Companhia Brasileira de Metalurgia e Mineração (CBMM) is the largest single source of niobium in the world; its mine and production facilities are located in Araxá, Minas Gerais, Brazil. The Catalão mine of Anglo American Brasil and the Cambior mine in Quebec, Canada, complete the picture. In an investment cycle started in 1998, CBMM increased its ore concentration capacity from 50 000 tpy to 80 000 tpy. A leaching and calcination plant with a new pyrometallurgical process to purify the pyrochlore concentrate was also installed, together with new facilities for crushing, sizing and automated packaging of ferroniobium which increased CBMM’s ferroniobium production capacity to 45 000 tpy.

A further investment cycle to increase ferroniobium capacity was initiated in 2005 with the objective of reaching 70 000 tpy in the next few years. Capacity was due to reach 54 000 tpy by the end of 2005 with the introduction of a new cold-arc furnace for the manufacture of ferroniobium and a new electric-arc furnace for refining niobium concentrate. As well as ferroniobium, CBMM offers niobium oxide, nickel-niobium, vacuum grade ferroniobium, niobium metal, special grade niobium oxide and niobium compounds for chemical applications.

Although it has enormous potential as a refractory metal, niobium is still mostly used as a microalloying element in steel to promote higher strength and improved toughness in those high strength low alloy (HSLA) steels used to build automobiles and high pressure gas transmission pipelines. Niobium is used extensively in both hot and cold rolled sheet/strip for automobiles; these steels are readily available with yield strengths in excess of 550MPa. Niobium has become established as a pre-requisite in the manufacture of tough gas transmission line-pipe steels.

An important secondary role for niobium is to provide creep strength in superalloys operating in the hot section of aircraft gas turbine engines and stationary turbines. Consumption of niobium oxide and niobium masteralloys used in superalloys recovered somehow after the depressing years that followed September 11th 2001, with recovery in the aircraft industry. The superalloys industry has diversified to create new applications for nickel-based alloys containing niobium.

Niobium is also utilised in stainless steel automobile exhaust systems and in the production of superconducting niobium-titanium alloys used for building magnets for Magnetic Resonance Imaging (MRI) for medical diagnostics, an increasing market, and for particle physics research equipment. Other minor applications include electronic ceramics and camera lenses. New niches are being developed for niobium metal applications such as coatings applied by sputtering to architectural glasses, special lenses, flat panel displays and razor blades.

Niobium consumption in the steel industry increased lately driven by a complex set of reasons. The strong demand for pipelines and automobiles, which in turn contained more niobium than was previously the case, was certainly one of them. However, the increase in the steel production in China observed in the recent years associated with the consolidation in the steel industry worldwide is also a factor.

Modern pipeline steels providing designers with higher strength and better toughness allow companies in this industry to comply with increasingly stringent regulations related to safety of pipelines, especially with regard to their fracture arrest characteristics.

In 2004 total shipments of standard grade ferroniobium were close to 45 000 tonnes, representing a distinct increase compared to shipments of the late 1990’s.

Consumption of niobium metal and its alloys decreased in 2004 with the completion of the NbTi manufacturing for superconducting cables to be applied in the Large Hadron Collider, a particle accelerator being built in Switzerland by CERN.
PIPELINE STEELS

Large diameter pipes for the transportation of crude oil and natural gas have been the frontrunner in the development of high strength low alloy (HSLA) steel. For the last three decades the processing route for pipe steel is via the thermomechanical rolling process, for which niobium microalloying is eminently suited. The steel grade X 70 was dominant in this period and it still maintains its position.

Several new demands arose in recent years:
1. The aim for higher transportation capacity promotes the application of steel with higher strength than X 70, such as X 80 to X 100. Even steel grade X 120 has been developed and is considered for new lines.
2. The exploitation of deeper wells brings up sour gas-containing media. Their transportation requires pipelines to be resistant to hydrogen induced cracking.
3. Offshore pipelines need relatively high wall thickness in combination with good toughness, a demand which often cannot be fulfilled by conventional thermomechanically rolled (TM) steel.

For all these new demands clean steel is required, with a low amount of non-metallic inclusions but also low amounts of undesirable elements such as phosphorus, and with a low amount of second phase such as pearlite, which is correlated with the demand in low carbon content.

With a lower carbon content one can make use of higher niobium contents and levels up to 0.10% have been applied successfully. The optimisation of these grades includes an increase in the severity of thermomechanical rolling followed by accelerated cooling regimes including direct quenching. Many of these modern pipe steels are pearlite-free and low carbon bainite has become the dominating microstructure. Niobium, being in solid solution at finish rolling, also adds to this microstructural constituent.

The application of niobium as a microalloy in steel is continuously increasing, and a remarkable growth rate was observed, especially in the last decade, mainly caused by the extension of metallurgical processes originally developed for large diameter pipes to other applications such as welded steel constructions or automobiles. Use of HSLA steels is economical, as they allow reduction of weight in the construction and an even greater reduction in the fabrication costs, without any negative effect on fabrication processes such as cold forming or welding or on the structural integrity. This is achieved by using grain refinement as the major strengthening mechanism: grain refinement is maximised by means of the thermomechanical rolling process, which is characterised by a final deformation of the austenite without recrystallisation.

Large diameter pipelines are the most economical means of transporting natural gas and crude oil over long distances. By increasing the pressure in a gas pipeline, higher transport capacities at lower costs can be achieved (Figure 1).

<table>
<thead>
<tr>
<th>Year</th>
<th>Operating pressure (bar)</th>
<th>Diameter (mm)</th>
<th>Annual capacity (million m³)</th>
<th>Power gas consumption over 6000km (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910</td>
<td>2</td>
<td>400</td>
<td>80</td>
<td>49</td>
</tr>
<tr>
<td>1930</td>
<td>20</td>
<td>500</td>
<td>650</td>
<td>31</td>
</tr>
<tr>
<td>1965</td>
<td>60</td>
<td>900</td>
<td>830</td>
<td>14</td>
</tr>
<tr>
<td>1980</td>
<td>80</td>
<td>1420</td>
<td>26000</td>
<td>11</td>
</tr>
<tr>
<td>2000</td>
<td>120</td>
<td>1620</td>
<td>52000</td>
<td>8</td>
</tr>
</tbody>
</table>

Figure 1: Evolution of transportation conditions in gas pipelines

Higher pressure can be achieved by using either a thicker wall or a higher strength of the pipe steel, or both. However, the safety of the pipeline also has to be guaranteed, and this demands, first, that any brittle fracture occurs at operating temperature and, second, that any ductile crack will be stopped in a short distance, and since grain size is important in this respect.

Since 1980, pipe steel development has shown that a decrease in carbon content together with grain refining – implemented in practice by normalising, thermomechanical rolling and accelerated cooling – has led to the necessary combination of properties. X 70 relies on the thermomechanical rolling process followed by air-cooling. In order to guarantee the strength required, vanadium is included as a microalloy, adding to the increase in strength via precipitation hardening, as well as niobium, the characteristic and indispensable element for TM-processing.

Accelerated cooling after TM-processing, a process installed in modern plate mills, produces a further refined grain size and some bainite in the microstructure. In pipe steel of higher strength than X 70, bainite becomes the characteristic microstructural constituent. The finer effective grain size results in improved strength and toughness, while the higher dislocation density adds to further strength increase. There are two ways to obtain a bainitic microstructure: by increasing the amount of alloying elements or by increasing the cooling rate. The latter is usually applied: it is more economic and has no negative effect on weldability. Depending on the cooling rate of the installed device (often accelerated cooling devices prepare a mean cooling rate of about 15°C/s for 20mm plate) combinations of both measures are possible. Typically X 80 requires a microstructure of about 50 % ferrite plus 50 % bainite, while X 100 relies on a 100 % bainitic microstructure. Since a bainitic microstructure may contain martensite islands, the carbon content has to be limited to < 0.06 percent. Martensite with higher carbon content and being not tempered represents brittle phases and thus impairs the toughness in such steels.

In the last two decades the steel grade X 70 used to be the workhorse for main gas pipelines. However, in the last ten years or so, X 80 has also proven to be a suitable steel grade, after the first major gas pipeline using this steel grade was built in Germany in 1992/93 over a length of about 250 km. Since then several other gas companies, especially in North America, experienced positive results with X 80. X 100 has been developed and intensively tested. However, full scale burst tests indicated that the traditional equations describing ductile crack arrest cannot be used any longer for such high strength steels. The X 100 pipes tested exhibited a wall thickness of 16 to 20mm and crack arrest was obtained only when the Charpy-V-notch energy was as high as 260 J, much higher than the predicted value of 190 J. Even though the leading pipe plate and pipe producers are confident of producing such impact energy values, up to now the usage of X 100 has been limited to test sections only.

Current discussions on future pipelines even include steel with the strength level of X 120. The case study in Figure 2 underlines the driving force for such an approach: as can be seen, considerable cost advantages can be achieved by using high strength steel. The present design recommends using crack arresters in a pipeline based on X 120. Several production steps, such as pipe forming and welding, need further optimisation.

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The T.I.C. is an association internationale under Belgian law.
Case Study of ExxonMobile: X 70 versus X 120
Example: Onshore gas pipeline for 85 mil m$^2$/day over 2000 miles (=3220 km). Price difference between X 120 and X 70 is US$250 per tonne

<table>
<thead>
<tr>
<th>$</th>
<th>X 70</th>
<th>X 120</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td>58&quot;</td>
<td>46&quot; (=1473mm) (=1168mm)</td>
</tr>
<tr>
<td>Pressure</td>
<td>10Mpa</td>
<td>19.3Mpa</td>
</tr>
<tr>
<td>Amount of pipelines</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Compressor stations</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>**Costs in mil US$$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line pipe</td>
<td>1850</td>
<td>1820</td>
</tr>
<tr>
<td>Freight</td>
<td>800</td>
<td>530</td>
</tr>
<tr>
<td>Other materials</td>
<td>490</td>
<td>480</td>
</tr>
<tr>
<td>Construction</td>
<td>1620</td>
<td>1300</td>
</tr>
<tr>
<td>Compressor stations</td>
<td>1100</td>
<td>1050</td>
</tr>
<tr>
<td>Indirect costs</td>
<td>910</td>
<td>830</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6770</td>
<td>6010</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td>760</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Case study

OFFSHORE AND SOUR GAS RESISTANT PIPELINES

Crossing a sea is often the shortest and cheapest solution for a pipeline project. Just recently the 'Blue Stream' pipeline has been finished, connecting Russia with Turkey via the Black Sea. The pipes were laid at a depth of 2150m and the applied pipe steel was X 65 in 31.8mm wall thickness. Around the world several similar projects are actually under construction and many more will follow. The most demanding project is under still discussion, this is a gas pipeline connecting Oman and India, laid in a maximum water depth of 3500m. The steel grade under consideration is X 65 again but with a wall thickness as high as 41mm. Under offshore conditions thick wall pipe is preferred over pipe with very high strength, but the toughness requirements must have to be fulfilled. Keeping in mind the typical deformation-temperature schedule for thermomechanical rolling, this is not an easy task for such thick wall pipes. Consequently such plates rely on relatively low carbon, one successful means of improving toughness.

In order to avoid hydrogen-induced cracking (HIC), which may occur when transporting sour gas containing media H_{2}S or CO_{2}, the steel has to fulfill two prerequisites:
- In order to reduce the possibility that atomic hydrogen recombines into the molecular form causing high internal pressure, a very low sulphur content (< 0.0001 %) and the modification of remaining sulphides by a proper calcium treatment is needed.
- Flaws originated by these stresses will form cracks by propagating along brittle phases in the microstructure. Carbon and the major alloying element manganese must be limited to avoid such harmful brittle phases, which are a result of the crystal segregation during solidification.

As a result of these considerations, HIC resistant steels have to rely on low carbon levels, often below 0.04 %. Most of the sour gas pipeline projects do not require very high strength, and mainly X 65 with relatively thick wall of around 25mm is applied. But the use of higher strength steel is under consideration.

NIOBNIUM IN LOW CARBON PIPE STEEL

The trend in modern pipeline grades is for low carbon levels and values below 0.06 % C have become common in order to fulfill the toughness demands of high strength and thick wall pipes as well as the sour gas resistance. Such low carbon content has its own advantages - high impact energy, excellent low temperature toughness and improved weldability. With low carbon, and nitrogen fixed by titanium to avoid the formation of NbC and NbN, higher niobium levels can be dissolved at typical reheating temperatures in a plate mill. Thermomechanical rolling can take place at higher processing temperatures. This has the economic advantage that the delay time to achieve the necessary rolling temperature can be reduced and even plate mill not comprising high rolling forces is able to produce TM plate.

LOW CARBON AND HIGH NIOBNIUM

<table>
<thead>
<tr>
<th>Element</th>
<th>X 70</th>
<th>X 120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.03-0.05</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>1.50-1.80</td>
<td></td>
</tr>
<tr>
<td>Copper + chromium + nickel</td>
<td>&lt;0.10-0.70</td>
<td></td>
</tr>
<tr>
<td>Niobium</td>
<td>0.07-0.10</td>
<td></td>
</tr>
<tr>
<td>Titanium</td>
<td>Approx. 0.015</td>
<td></td>
</tr>
</tbody>
</table>

CBMM has organised two demonstration trials with 0.03 % C and 0.10 % Nb steel. Almost independently of the processing parameters, plates and pipes show excellent Charpy-V-notch energy values and brittle fracture resistance. Different strength levels can be achieved, depending on the amount of alloying elements and the processing conditions such as:
- finish rolling temperature, which determines the amount of solute niobium,
- cooling speed after rolling and
- cooling speed after transformation, which offers the possibility of maximising precipitation hardening.

The most prominent application of this alloy and processing concept up to now is for large diameter pipe plate. Recent major projects include a sour gas resistant pipeline (Cantarell), a thick wall (26.6mm) pipe X 70 with acicular ferrite microstructure and outstanding toughness (West East China) and the first X 80 pipeline in the U.S. (Cheyenne Plains).

STEEL SHEETS FOR AUTOMOBILES

The automobile and steel industries are closely bound by the strong links between their supply and demand. The application of high strength sheet originated from social needs. Due to an increase in vehicle accidents with the motorisation of the 1960's, the U.S. government established the Federal Motor Vehicle Safety Standard (FMVSS) in 1968. The automotive industry began to adapt high strength steels for use in car parts such as bumpers, door reinforcements and brackets. Before the FMVSS, technology activities in automotive steel sheets were mainly focused on the improvement of formability in mild steel. Following the oil crises in the 1970's, high strength steels that reduced the thickness of steel sheets in both inner panels and outer panels had been developed. In the 1970's the first continuous annealing facility was commercialised in Japan. This technological innovation formed a turning point in the improvement of productivity and quality of automotive steel sheets, which now demonstrated a wide range of strengths and deep drawing qualities.

The keen issue for automakers in recent years has been to reduce the weight of the automobile body while maintaining sufficient safety by using high strength steel sheets to ensure both fuel efficiency and crash-worthiness. The characteristics of steel sheets for an automotive body have changed dramatically according to changes in demand.

Changes in materials for Japanese passenger cars reported by the Japan Automotive Manufacturers Association show an increase in car weight, especially in the last 15 years. This overall increase in weight was mainly due to measures geared toward crash-worthiness and demand for luxury functions. Whereas steel, which accounted for 81.8% in 1973, dropped to 73% in 2001, over the same period plastics increased from 2.9% to 8.2% and
non ferrous metals such as aluminium from 5.0% to 7.8% (see Figure 4).

Figure 4: Changes in the make up of materials for passenger cars in Japan (JAMA)

Hot rolled steel sheets are used in chassis parts such as suspension arms, cross members and wheels. The majority of them are made of 540-590MPa grade. 780 MPa grade was applied to wheels about 10 years ago, and successful application to the lower arm has been achieved recently, but use of 780 MPa grade is still limited, being no more than 2%.

Cold rolled sheets are used in the body of the automobile. 590MPa grade is used for the side rail, B-pillar, roof rail and rocker to ensure crash-worthiness. Interstitial Free (IF) steel is an important material in automobiles and ranges from extra mild steel to 440MPa grade.

Hot rolled steel sheets are used for the chassis and wheels, as high Total Elongation (EI) and high stretch formability are demanded. The relationship between Tensile Strength (TS) and the hole expanding ratio, EI and Yield Strength (YS) of various kinds of hot rolled steel is important to the characteristics of steels used in automobiles. Ferrite-bainite steel of 780MPa grade is widely applied for chassis and wheels, and elimination of cementite, which is one cause of micro-cracks, also contributes to the improvement of the hole expanding ratio.

Niobium in a state of solid solution retards astatistic and dynamic recrystallisation during hot rolling, as well as austenite to ferrite transformation. The addition of niobium to Dual Phase (DP) steel provides noticeable grain refinement and thus improves higher strength ductility. DP steel is employed for wheel discs. Researchers are interested in hot rolled Transformation Induced Plasticity (TRIP) steel, and Hashimoto et al. showed that the addition of niobium is effective in improving strength and elongation balance.

Cold rolled steel sheets are used for unexposed panels such as inner door panels and side panels, where steel sheets with excellent drawability and stretch formability are required. For exposed panels such as doors and hoods, steel sheets with high yield strength are required, to ensure dent resistance as well as good press formability. The steel sheets for these parts are mainly IF steels, with strength levels up to 440MPa grade. For structural parts, steel sheets above 590MPa tensile strength dual phase steels are mainly used.

For automotive panels, deep drawability, evaluated by 'r-value' is one of the most important characteristics. Mechanisms for attaining high r-value have been under discussion since IF steel was invented at the end of the 1960's. and metallurgical factors for its improvement are: scavenging effect by fixing carbon and nitrogen as stable precipitates, grain growth during annealing, grain refinement of hot band and cold reduction. As production of cold rolled steel sheets has decreased year by year, zinc coated IF steel sheets have increased, in 1998 the latter was ahead of cold rolled sheets in Japan for the first time.

In TRIP-aided steels, retained austenite transforms to martensite during cold forming, resulting in a combination of high tensile strength and excellent ductility. Steel with niobium added shows about 50MPa higher TS than steel without niobium.

Niobium is the essential element for the production of automotive steel sheets through various mechanisms: for IF steels niobium stabilises interstitial solute carbon and nitrogen, for steels containing low temperature transformation products, such as ferrite-bainite steel, DP steel and TRIP-aided steel, niobium controls grain size and transformation behaviour.

MEMBER COMPANY NEWS

Cabot Supermetals KK
The Japanese company in the Cabot group has moved its Tokyo office to the following address: Sumitomo Shiba-Daimon Bldg., 11F., 2-5-5 Shiba Daimon, Minato-ku, Tokyo 105-0012, Japan.

Telephone and fax numbers have not been changed.

Commerce Resources / Kazatomprom
Following the strategic alliance on delivery of concentrate by Commerce Resources to Kazatomprom reported in Bulletin 126, it was announced by Commerce Resources on August 21st that Mr Alexander Gagarin of Kazatomprom's Ulba Metallurgical Plant would join the company's Advisory Board. Mr Gagarin would 'actively participate in the metallurgical investigations, lab work, analysis and reporting', said Commerce Resources, and would, in addition, 'play a key role in the processing of Commerce's commercial bulk sample to end products'. His technical experience in the processing of tantalum and niobium would be instrumental in bringing a practical approach to developing the Blue River project, added Commerce. Mr Gagarin said that he believed his knowledge and experience would be of value in developing "this world-class deposit as the demand for tantalum and niobium continues to increase".

DM Chemi-Met: DLA purchase
On July 5th the DNSC announced that it had awarded 1,680 lbs of tantalum in tantalum carbides to DM Chem-Met. This sale exhausted the Annual Materials Plan for fiscal year 2006, and sales would resume only when the Plan for 2007 was in operation, after October 1st 2006.

Epcos / Kemet
Following the acquisition of the Evora plant of Epcos by Kemet (see Bulletin 124), the plant has been re-named Kemet S.A. As Kemet S.A., it remains a member of the T.I.C., and the nominated delegate is still Dr Werner Lohwasser. The address and contact numbers have not been changed; Dr Lohwasser's e-mail address is wernerlohwasser@kemet.com.

Sons of Gwalia
The Deed of Company Arrangement has again been extended, it is now effective until November 30th 2006.

The administrators have reported progress in restructuring the troubled company. Their preferred restructure would result in a 'stand-alone Tantulam Group' free of any pre-administration

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liabilities and/or obligations', but as it is subject to 'third party consents and approvals' it also remains subject to change.

**Haddington / Mitsubishi / Zinifex**
An alliance formed in October 2005 will be brought to an end after one year, explained Colin McCavana of Haddington on September 5th 2006. Mitsubishi Development and Zinifex had funded Haddington’s tantalum exploration during the year, but the state of the tantalum market and the length of time being taken to resolve the administration of Sons of Gwalia were given as reasons for ending the alliance.

**Kemet**
For the quarter ended June 30th 2006, Kemet reported net sales up 49% over the same quarter in 2005 and up 27% over the preceding quarter. As the recent acquisition of the former Epcos plants had to be taken into account, without these the results were increases of 27% and 9%, respectively. Chief Executive Officer Mr Loof said that the company was ‘extremely pleased’ to report another solid quarter of increased sales and profitability’. Strong demand across all regions and channels had contributed to sales for the quarter.

Sales generated by the former Epcos plant in Portugal exceeded previous estimates, and the German manufacturing operation was being ramped down as planned. Mr Loof commented favourably on the progress made in integrating the Evor6 plant into Kemet, adding that the response from customers had been very positive. ‘Our integration team, including our new employees in Europe, has worked diligently to make this transition virtually seamless’, he said.

Kemet continues to introduce new products, including conductive polymer and fused tantalum capacitors; the former combine low ESR and high capacitance and are ideal for a whole range of applications, stresses the firm.

**Mamoré Mineração e Metalurgia**
Ms Patricia Stumpt, Commercial Manager, has been nominated as the delegate of Mamoré Mineração e Metalurgia to the T.I.C., succeeding Mr Raul Giesta, who has left the company.

**Mekios (UK)**
Mekios is now shipping minerals from Nigeria, and it has a new address for the office of Mekios (UK) Ltd:
Argyle House,
1 Dee Road,
Richmond upon Thames,
Surrey TW9 2JN,
England.

**NAC Kazatomprom**
On August 16th, Interfax reported on an announcement by Mr Alexander Gagarin of Kazatomprom’s division Ulba Metallurgical Company that commercial production of tantalum powder was planned for 2007. Mr Gagarin, Deputy General Director, explained that the plant’s strategy included plans to add value to its products, and it was currently creating production of high-capacity tantalum powders for capacitors, with the intention of beginning commercial production in 2007. Ulba was also investigating the possibility of a joint venture with ‘a leading producer of capacitors from the United States’ to establish a plant for capacitor manufacture in Kazakhstan.

**Ningxia Non-ferrous Metals**
Metal Pages reported that Ningxia Orient Tantalum Industry had shown an increase of 13.6% in net profit for the first six months of 2006 compared with the same period in 2005. Investment in new projects was confirmed, including Rmb100 million for an expansion in tantalum powder capacity and Rmb55 million for increased production of tantalum wire.

**Osaka Trading / Metal Do**
Our member company Osaka Trading has changed its name to Metal Do Co. Ltd. The address and contact numbers remain the same, but the general e-mail address is now metaldo@raremetal.co.jp.
Mr Kunihiro Fujita is the nominated delegate.

**Tantalum Australia / ABM Resources**
Tantalum Australia NL will be known as ABM Resources NL, by decision of the shareholders at the General Meeting held on July 31st 2006. The address and other contact information have also been changed:
ABM Resources NL,
Level 1, 141 Broadway,
Nedlands,
Western Australia 6009.
Tel.: +61 8 9423 9777
Fax: +61 8 9423 9733
E-mail: admin@abmresources.com.au

The nominated delegate to the T.I.C. is Mr Imants Kins, Managing Director.

**Vishay**
The address of Vishay Intertechnology, where the nominated delegate to T.I.C. Mr Richard Mager has his office, has been changed to Vishay Intertechnology Inc.,
63 Lancaster Avenue,
Malvern, PA 19355,
U.S.A.