Overview

After the huge spike in price experienced during 2004 and most of 2005, the Vanadium Market has become much more stable over the last 12 months – albeit at a relatively high level compared to historic averages.

Given the critical importance of vanadium in titanium alloy production, I will give my views on why the market has stabilized and what variables exist to influence the future of this market. I will also update the worldwide supply/demand picture and provide what detail I can with regard to changes in production and consumption of vanadium.

Uses of Vanadium

It is important that the Titanium Industry recognizes that more than 90% of vanadium usage is in steelmaking, and only 4% of worldwide consumption is in the production of titanium alloy. The balance of consumption (5%) is in a wide variety of chemical and catalytic uses. (See Chart 1).

The dominant market driver over the past three years has been the rapid growth in worldwide steel production (most notably in China), and also a move to produce a higher proportion of steel of higher strength grades. This means that demand for vanadium has been growing strongly, and it appears that this strong growth will continue in the future. It also means that vanadium usage in non-steel applications (including titanium) is likely to decline further, in percentage terms, in future years. Furthermore, worldwide vanadium pricing will continue to be mainly influenced by steel sector demand.

The vanadium used by these different sectors is not chemically identical. In steelmaking, vanadium is consumed as ferrovanadium and vanadium carbon nitride (Stratcor’s Nitrovan® vanadium), titanium uses vanadium as vanadium aluminum alloy, and the chemical and catalyst applications use a variety of oxides and other vanadium compounds.

Vanadium for titanium alloy production and some chemical applications requires the most stringent specifications both in terms of chemistry and product form. In addition, vanadium for titanium alloying must be thoroughly inspected for inclusions to ensure that no unwanted foreign particles are present.
As a result, there is a significantly higher cost in producing vanadium suitable for titanium alloy production than producing vanadium for steelmaking.

For steel applications vanadium is a commodity metal, but for titanium it is not.

**Sources of Vanadium and Capacity**

Vanadium is a common and widely dispersed element. It frequently occurs as a minor constituent in other ores, notably iron ore and uranium ore, and there are many specific vanadium ore bodies. It also occurs in fossil fuels, for example in crude oil from the Caribbean region and in coal (notably in China). *(Chart 4).*

Producing vanadium depends much more on the economics of extraction from any given source than on finding vanadium by exploration.

In other words, there is plenty of vanadium lying around but the cost of building a plant to extract it and the cost of processing in such plants covers a wide range. Unlike most metals, finding vanadium sources is easy, but extracting it economically is the hard part.

Vanadium bearing iron ore is by far the biggest and, in general, the most economic source of vanadium. Such deposits occur in South Africa, China and Russia. Slag from the consumption of iron ore (in steel production) varies from 5% to 25% V$_2$O$_5$ contained. Since the slag is essentially free and the cost of extracting the vanadium from it relatively low, this tends to be the lowest cost vanadium source. Not surprisingly, this source supplies the most and has the most capacity to produce vanadium. Furthermore, with steel production booming, demand for new sources of iron ore will lead to expanded production of vanadium-bearing slag and further vanadium production from this source most notably in Russia and China.

Production from vanadium ore is in South Africa with a smaller amount of such production in China. Many other vanadium ore bodies exist in Russia, China, Canada, South Africa and Australia --- but high capital costs of new plant and high operating costs of most ore sources make such ventures unlikely to be viable unless vanadium demand climbs above 250MM lbs. V$_2$O$_5$ per year (vs. the current c. 218MM). Even then, viability might be temporary if vanadium bearing slag generation continues to grow as rapidly as it has over the past year in China, and imminently in Russia.

Oil and coal residues, and spent catalysts make up the balance of current production. The vanadium concentration in these materials varies considerably and, consequentially, so do the production economics.

Production from Uranium ores recently resumed in the U.S. Initially output will be small, but this could rise to 5-10MM lbs. V$_2$O$_5$ per year over the next few years – especially if both uranium and vanadium prices remain strong.

**Vanadium Consumption**

Worldwide steel production has risen very strongly over the past four years. *(Chart 5)*
Extremely strong growth in China has been the main increase, but growth in the Former Soviet Union and Commonwealth of Independent States (FSU/CIS) has been quite strong also.

The overall volume of steel production is the main driver of vanadium consumption, but a shift to production of more high strength steels has further compounded growth in vanadium consumption, again most notably in China. (Chart 6) Note, however, that a pull back in Chinese consumption in mid 2005 led to a slow down in vanadium consumption growth.

During 2004 North America too saw strong growth in vanadium consumption due to higher production of high strength low alloy and specialty steels, a rebound in demand from the titanium sector and growth in vanadium chemical application. (Charts 7-10) In 2005, U.S. consumption dropped sharply in the steel sector, but has rebounded in 2006.

**Vanadium Supply**

South Africa is the biggest vanadium producer with three large oxide producing plants, including Stratcor’s Vametco facility. From these facilities, South Africa exports oxide. It also exports ferrovanadium and Nitrovan® vanadium converted from oxide. In addition, large quantities of vanadium-bearing steel slag is exported, primarily to Europe, for subsequent conversion into oxide and ferrovanadium.

China is now the second largest vanadium producing country ---- output there having risen sharply in response to recent strong demand and pricing.

Russia remains a large producer, all production coming from the Kachkanar vanadium-bearing iron ore mine in the Urals, primarily via steel slag generated at the Nishni Tagil steel mill. Russian production from steel slag is likely to grow sharply over the next year or two.

The U.S. remains a significant vanadium producer, the biggest oxide facility being Stratcor’s Hot Springs, Arkansas facility.

**Worldwide Production vs. Consumption** (Chart 11)

This chart compares worldwide production and consumption since 1998. Through 2002 there was a long period of over production mainly caused by the startup of unneeded uneconomic capacity being added in Australia. This new production occurred as a direct result of the 1998 price spike which stimulated investment in new vanadium production capacity at a time when vanadium consumption was barely increasing. (Chart 6). This oversupply resulted in historically low vanadium prices (Chart 2) and stagnation in investment in the vanadium industry. Worldwide inventory soared (Chart 12), prices collapsed and remained at historically low levels for a long period of time. This led eventually to the closure of some facilities, notably in Australia and South Africa.
Ironically, at about the time of these closures, vanadium consumption started to rise sharply and the balance quickly tipped to undersupply with the result that inventories began to fall and the price of vanadium started to climb sharply (Charts 11 and 12).

The large market inventory helped the gap between soaring demand and reduced production through 2004. In early 2005, however, the stockpile was exhausted and, with added impetus from panic and speculation, the vanadium price skyrocketed to unprecedented levels.

The price rose to such a high level that in China there was a sudden cutback in the usage of vanadium. Meanwhile, vanadium production rose in response to the price and, by late 2005, the market became more into balance.

This balance has been maintained so far through 2006. World steel production has continued its strong climb, and vanadium consumption has resumed its climb as prices have fallen to more attractive levels for Chinese steelmakers. Now, unlike in 2004/5, producers of vanadium have been able to keep pace with growing demand with increased production --- most notably in China.

**Where to from Here?**

If we assume that vanadium consumption continues to grow at the same rate (5%) as it has, on average, since 1998. And if all currently projected vanadium production increases all happen (notably in Australia, South Africa, Russia and China) there will be an excess supply of vanadium from 2007 onwards.

Even if, as one would expect, this leads to lower prices and a further big resultant boost to Chinese consumption (effectively quadrupling Chinese consumption!), there will still be a surplus of vanadium supply between 2007 and 2009. Such a surplus would likely cap pricing at around today’s level, and make a repeat of the 2004/5 price spike unlikely. Similarly it would suggest that we are also unlikely to see a collapse in pricing to the levels seen in 1999-2003, since the potential surplus is unlikely to build to the level of over supply seen pre 2004.

**Vanadium and the Titanium Industry**

Titanium alloy producers need vanadium in a form that can be guaranteed to meet their exacting need for extremely high chemical and physical quality. Their need for vanadium which meets these standards is crucial and very different from the quality needs of steelmakers.

To achieve this objective, I can only repeat what I said at this conference last year. The titanium industry should encourage and strengthen long-term bonds with their vanadium sources. These relationships should include long-term commercial and technical ties not only with their master alloy suppliers, but also with the vanadium oxide that the master alloy is made from and even the sourcing of the vanadium bearing raw material.
**Summary**

Much of the concern that was present at last years’ conference about vanadium availability and pricing has subsided. Vanadium production has come much more in line with consumption and the market has settled down at a much more sustainable and manageable level.

Vanadium prices remain high by historic terms, even high enough to encourage some speculative investment in new ventures and the potential restart of old capacity.

Whereas, in theory, strong potential new consumption could match up with new supply --- we know from past experience that any market balance is fragile. A worldwide economic downturn or a curtailment of Chinese growth could rapidly generate a vanadium surplus and a collapse in price. Too rapid a growth in supply could do the same – in fact, historically, new vanadium capacity has frequently hit the market at the precise moment that demand has started to drop. One would be very brave (or foolish) to suggest that would never happen again!
USES OF VANADIUM

- Steelmaking 91%
- Chemical and Catalyst 5%
- Titanium 4%
VANADIUM CAPACITY UTILIZATION

- **Millions of Lbs. of V₂O₅**
- **Capacity Utilization**
- **Capacity**
- **2006 Production**

- **Steel Slag**: 95%
- **Vanadium Ore**: 95%
- **Oil Residues**: 77%
- **Spent Catalysts**: 72%
- **Uranium By-Products**: 0%
WORLDWIDE CRUDE-STEEL PRODUCTION RATE

Thousands of Metric Tons per Year


Increasing for Five Years
WORLDWIDE VANADIUM-CONSUMPTION RATE

Record Vanadium Usage


Millions of Lbs. of V₂O₅ per Year

130  140  150  160  170  180  190  200  210  220
CONSUMPTION EXCEEDS PRODUCTION

Consumption vs Production in Millions of Lbs. of V₂O₅ per Year

- 2004 Consumption: 208
- 2004 Production: 185

- All Others: 19, 23, 47, 42, 38, 39
- FSU / CIS: 9
- North America: 25
- Western Europe: 41
- China: 36
- Other Asia: 74
- South Africa: 39
- U.S.A.: 25
- Russia: 41

Legend:
- Yellow: Consumption
- Orange: Production
CONSUMPTION EXCEEDS PRODUCTION

2005

Consumption

Production

 Millions of Lbs. of V₂O₅ per Year

201

200

160

120

North America

FSU / CIS

All Others

U.S.A.

North America

Other Asia

China

Russia

South Africa

Western Europe

China

32

42

21

23

40

43

2005

193

All Others

U.S.A.

China

Russia

South Africa

23

38

73

23

50
WORLDWIDE PRODUCTION VS. CONSUMPTION

12-Month Moving Average -- Annual Rates

Production

Consumption

Millions of Lbs. of V₂O₅ per Year

SUMMARY AND OUTLOOK

• Vanadium Consumption: Strong and Growing after 2005 Dip

• High Pricing Led to Strong Increase in Production from Existing Sources (Notably Slag), Especially in 2006
SUMMARY AND OUTLOOK

• Rapid Growth in By- and Co-Product Sources in China, U.S., and Russia especially by Existing Producers

• Growth in Supply Beginning to Exceed Growth in Demand