Vanadium - Recent Developments in Supply and Demand

Overview

Surging demand for vanadium, most notably in China, has continued since 2004. This led to an unprecedented price spike in 2005 which stimulated increased vanadium production most notably as by-product from steel production. Most of this increase in vanadium production has taken place in China.

These increases in vanadium production and some capping of vanadium usage in China (due to higher vanadium pricing encouraging some Niobium substitution) all combined to bring the market more into balance.

The more balanced but still very buoyant market since 2005 has led to more stable vanadium pricing – albeit at a level still significantly above the previous long-term market average.

Today I will briefly review the pattern of vanadium demand in the recent past and outline the variables and potential developments that might impact on vanadium supply and demand in the future.

Uses of Vanadium

The most important thing to remember about vanadium is that its demand is dominated by steelmaking. More than 90% of vanadium usage is in steelmaking with the balance of demand evenly divided between titanium alloy production and a wide range of chemical applications. (See Chart 1).

Since steel production has grown rapidly, especially in China over the last four years, vanadium demand has seen equally rapid growth – again most notably in China. (Chart 2, Chart 3)

But it is not just the growth in total steel production that drives vanadium demand. Since vanadium is mainly consumed in the production of high strength and specialty steels, it is the growth in worldwide production of these steels that really drives vanadium demand. The move to consume a greater proportion of higher strength steels also leads to acceleration, at times, of vanadium usage – which can see stronger growth than that of the growth in overall steel production. (Chart 4, Chart 5).

The form in which vanadium is consumed by the different sectors is, however, not the same. Steelmaking consumes vanadium as ferrovanadium and vanadium carbo-nitride (Stratcor’s Nitrovan® vanadium), titanium alloy production uses vanadium as vanadium aluminum alloy, and chemical and catalytic applications use a variety of oxides and other vanadium compounds.
Vanadium Production

Vanadium is a common and widely dispersed element. It frequently occurs as a minor constituent in other ores, most notably in iron ore and uranium ore. There are also many specific vanadium ore bodies. Vanadium also occurs in fossil fuels, for example in crude oil from the Caribbean region and in coal (notably in China). (Chart 6). Burning vanadium bearing fossil fuels leads to ashes which contain vanadium which can be extracted. Processing vanadium bearing oil results in spent vanadium-bearing catalysts which can also be processed to supply vanadium.

Because vanadium occurs in so many different forms, its production depends more on the comparative economics of extraction than anything else. Because there are so many sources of vanadium, it is the comparative cost of building an extraction facility and the cost of processing in that facility that determines whether or not any given source is viable.

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 10% to 25% V₂O₅ contained. Since this slag is a by-product of steel-making and the cost of extracting vanadium from it is relatively low, this tends to be the lowest cost vanadium source.

It is also very important to note that with steel production booming, demand for iron ore has risen very strongly too.

Let’s look at the Chinese situation. In 2002, China imported $2.8 billion worth of iron ore. China’s iron ore imports in 2006 were $20.8 billion, and are on track to reach $30 billion in 2007. So, even though China’s own vanadium-bearing iron ore deposits are not as rich as some iron ore deposits in other countries, they are under considerable pressure to expand their own production. Not surprisingly, the production of vanadium-bearing slag in China has grown, since 2002, at almost exactly the same rate as the overall Chinese demand for iron ore.

This is the main reason why Chinese vanadium production has risen so sharply over the last few years, (Chart 7) in fact it has risen so sharply that China’s exports of vanadium have also increased very rapidly (Chart 8). It all comes back to the very interesting synergy – more steel production leading to more vanadium consumption, but also leading to a seemingly proportionate increase in iron ore production and at the same time proportionately more vanadium generation from iron ore.

I fully expect to see this trend continue, not only in China but also in Russia and South Africa -- increased generation of vanadium from vanadium-bearing iron ore slag.

Next on the scale of vanadium supply is supply from vanadium ore. (Chart 9) Most such production is currently 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 most such ventures unlikely to be viable unless vanadium demand climbs above 250MM lbs. V₂O₅ per year (vs. the current c. 216 MM). Even then, viability might be temporary if vanadium-bearing iron ore slag generation continues to grow as rapidly as it has over the past couple of years in China, and potentially in Russia and South Africa.

Oil and coal residues, and spent catalysts make up the balance of current production.

Production from uranium ores resumed last year, but was not sustained. Over the past 25 years one would usually have seen strong vanadium prices result in some generation of vanadium from uranium ores. It is interesting that so little of this action has occurred this time. It could simply be that the uranium market is itself so strong that processing for vanadium pales in comparison to straight uranium production. Nevertheless, I do expect to see some vanadium generated from this source, perhaps 5-10 MM lbs. V₂O₅ per year over the next few years.

**Consumption**

Worldwide steel production has risen very strongly over the past five years (Chart 10).

Extremely strong growth in China has been the main increase – growth in the rest of the world pales in comparison (Chart 11), but there has been steady and increasing growth in the Former Soviet Union and Commonwealth of Independent States (FSU/CIS) and also in other developing countries.

As previously stated, the 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 12). Note, however that a pull back in Chinese consumption in mid-2005 – which coincided with a big increase in Chinese imports of Ferro Niobium (Chart 13) – led to a slow down in vanadium consumption growth (Chart 14). As vanadium prices have softened in 2006, and more recently – as niobium prices have increased, the growth trend in vanadium substitution has at least slowed, and in some cases has probably been reversed. However, the switch to production of higher strength (Grade 3) rebar in China is putting upward pressure on demand for both vanadium and niobium.

**Supply**

South Africa is still the biggest vanadium producer (Chart 15), with three large oxide producing plants, including Stratcor’s Vametco facility.

China’s vanadium output is running a close second to South Africa, largely due to the big increase in generation and processing of vanadium-bearing slag. It could well over take South Africa during 2007. Russia (Chart 16) comes next in the order of scale of supply, with approximately 38MM pounds per year of vanadium production, all generated from steel slag generated at Evraz’s mill at Nishni Tagil. Russian production from steel slag is likely to grow sharply over the next year or two.
**Worldwide Production vs. Consumption (Chart 17)**

This chart is a snapshot of the 2006 position, comparing consumption and production by region.

China is still consuming less vanadium than the other Asian countries combined, and also less than North America and Western Europe – despite the fact that China produced almost as much steel as these three regions combined!

South Africa maintained its lead as the biggest producer of vanadium, but China is closing fast.

(Chart 18) Shows the long-term comparison between worldwide production and worldwide consumption. The most notable features being the excess production between 1999 and the end of 2002, which led to the building of a large excess of stocks. This was followed by a three year period during which consumption significantly exceeded production. Initially, the market was kept in balance by the liquidation of these excess stocks, but when they ran out in early 2005 the market spiked.

Since 2005, production has increased sharply and has kept in close balance with consumption.

**What Next?**

Historically, the vanadium market has been driven by, and completely dependent on, demand cycles in the U.S. Western Europe, and Japan.

China’s development over the last 3 or 4 years would seem to have changed the game completely.

China’s increased vanadium consumption has been the biggest impact on the vanadium demand side – yet China remains a very small consumer when one compares their consumption with the amount of steel they are producing.

(Chart 19) Shows the “intensity” of vanadium consumption by region in 2006. North America has the highest usage of vanadium per ton of steel produced, and China has the lowest – even Russia and the other Former Soviet Union countries have a higher rate of usage than China.

If China froze its steel production at the 2006 level (which it hasn’t) but produced the same qualities of steel (with vanadium) as the U.S. does – this would require an extra 77MM lbs. V2O5 per year, equal to a third of current worldwide consumption – or the entire annual production in South Africa. If one also notes that in the U.S. the usage of vanadium in rebar production is quite low and that China’s aim is to produce rebar which meets a quality that can only be achieved practically with micro-alloying. And if one also notes that the growth in apparent consumption of steel in China has slowed over the past three years from a growth rate of twenty percent per annum to approximately ten percent per annum – but this still requires the same growth in raw materials being consumed because a ten percent growth on 400MM tons requires the same increase in raw material supply as twenty percent growth on 200MM tons.
Then it seems clear that vanadium demand is likely to remain strong for the foreseeable future unless there is a sudden reversal in the direction that the Chinese economy is taking.

In my view, it would take a major reversal in the direction of the Chinese economy to interrupt the prospects for strong vanadium demand, and this is probably the only event that could cause vanadium demand to fall. The traditional impact of a slowdown in the economies of the U.S. and Western Europe is likely to matter much less than in the past.

On the supply side, booming steel consumption will continue to also generate a strong growth in vanadium supply – by way of additional generation of vanadium bearing slag, as it has over recent years in China – but also in Russia and South Africa. There will probably be additional supply from ore-based production, for example the Windimurra project in Australia.

Other than the possibility of a collapse in the Chinese economy, the only real potential downside I see to the vanadium market is the possibility that the rate of increase in supply, due to sudden surges of new production, might exceed the rate of increase in consumption. If this were to happen then the vanadium price would fall. This, in turn, would stimulate consumption and have a rebalancing effect on the market.

This sounds fine in theory, but if this occurred at the same time as a general economic downturn, then the over supply might take several years to be corrected.

**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.

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.

After the market shock and supply concerns that every consumer of vanadium had in 2005 and 2006, vanadium production has increased and supply has come up to meet demand.

Despite the recent stability seen as supply and demand have come back into balance, there are still considerable risks for future market disruption. In any situation where both demand and supply are racing forward there is increased potential for a sudden dislocation. (For example, a sudden shortfall in supply due to an unexpected production problem, or a downturn in the world economy that could significantly reduce demand). Such occurrences could happen, and are particularly dangerous if they happen at a time of such strong growth in both supply and demand as we have seen over the last three years.
Vanadium
Recent Developments in Supply and Demand

INTERNATIONAL TITANIUM ASSOCIATION
ANNUAL CONFERENCE
ORLANDO, FLORIDA
OCTOBER 9, 2007
USES OF VANADIUM

- Steelmaking - 91%
- Chemical and Catalyst - 5%
- Titanium - 4%
WORLDWIDE CRUDE-STEEL PRODUCTION RATE

Millions of Metric Tons per Year

WORLDWIDE VANADIUM-CONSUMPTION RATE

Millions of Lbs. of V₂O₅ per Year

130 140 150 160 170 180 190 200 210 220 230

1999 2001 2003 2005 2007
Worldwide Crude Steel Production Rate vs. Worldwide Vanadium Consumption Rate

- Millions MT of Steel per Year
- Millions of Lbs of V2O5 per Year

Steel Production
Vanadium Consumption
VANADIUM CAPACITY UTILIZATION

- **Steel Slag**: 95% Capacity, 95% 2006 Production
- **Vanadium Ore**: 77% Capacity, 72% 2006 Production
- **Oil Residues**: 0% Capacity, 0% 2006 Production
- **Spent Catalysts**: 72% Capacity, 0% 2006 Production
- **Uranium By-Products**: 0% Capacity, 0% 2006 Production

Millions of Lbs. of V₂O₅
VANADIUM SUPPLY TRENDS
CHINESE NET EXPORTS

12-Month Moving Average

Millions of Lbs. of V₂O₅ per Year

WORLDWIDE VANADIUM-CONSUMPTION RATE

Millions of Lbs. of V₂O₅ per Year

1999  2001  2003  2005  2007
CHINESE FeNb IMPORTS

Millions of Lbs. of FeNb per Year

2002  2003  2004  2005  2006  2007
VANADIUM SUPPLY TRENDS
RUSSIAN NET EXPORTS
12-Month Moving Average

Millions of Lbs. of V₂O₅ per Year

1999  2000  2001  2002  2003  2004  2005  2006
PRODUCTION AND CONSUMPTION IN BALANCE

2006

Consumption
- All Others: 21
- FSU / CIS: 23
- North America: 43
- Western Europe: 48
- China: 35
- Other Asia: 43

Production
- All Others: 12
- FSU / CIS: 22
- North America: 64
- Western Europe: 38
- China: 78
- Other Asia: 78
- South Africa: 12

Millions of Lbs. of V_2O_5
WORLDWIDE PRODUCTION VS. CONSUMPTION

12-Month Moving Average -- Annual Rates

Production

Consumption

Millions of Lbs. of V$_2$O$_5$ per Year

VANADIUM USAGE PER MT OF STEEL

2006

Kg V PER MT OF STEEL

North America

Western Europe

FSU / CIS

China

76.5 Million Lbs. V2O5