Abstract

After eight decades of stable prices and supplies that met or exceeded demand, molybdenum this decade has exhibited rapid growth in both demand and supply, with long periods of demand exceeding short-term supply. This led to unprecedented volatility and elevated prices in the molybdenum market. In this presentation we examine the broad applications of molybdenum and its more narrow applications in titanium; sources of molybdenum; market changes which contribute to its recent volatility; the relative size of the molybdenum and titanium markets; and fluctuations in the molybdenum market over the past twelve months.

The molybdenum market is experiencing historic changes. This presentation attempts to present current information as well as thoughts on what might be expected in the coming year.

Introduction

Usually the speakers for the Industry Supply Trends/Raw Materials session are drawn from the industries supplying the raw materials of interest. I am an anomaly. My company, Reading Alloys, is not a producer of molybdenum oxides or metal. It is a purchaser of molybdenum oxides, which it converts into master alloys for the titanium and aerospace industries. Our position between the molybdenum producers and the consumers of these master alloys provides Reading Alloys with a little different (and somewhat more limited) view into molybdenum supplies to the titanium industry. Hence the title of my presentation. Today I would like to share with you my observations on the recent state of molybdenum supplies to our industry.

Applications of Molybdenum

As a metallic element, molybdenum has been surprisingly stable in its markets for many years. The dominant market is in ferrous metallurgy, as an alloying element in alloy steels (including tool steels, HSLA and high-alloy steels), stainless steels and cast ferrous alloys. A substitutional alloying element in iron, nickel, cobalt and titanium; molybdenum is required in relatively high levels for effectiveness. Used at concentrations from about 0.2% to as much as 15% or more, it is most typically found at levels from 0.15% to 4%. Ferrous metallurgy consumes 75-80% of all molybdenum, almost entirely as ferromolybdenum alloy with 55-85% molybdenum.
Another 6-8% of molybdenum is used as molybdenum metal, mostly for high-temperature or chemical applications. Roughly 10% goes to a specialty chemicals market for products such as molybdenum disulfide lubricants and catalysts for the petroleum industry. This latter application is expanding with the demand for ultra-low-sulfur diesel fuel.

Another 5% finds its way into superalloys, again at high levels. 718, a workhorse in jet engines, has ~3% molybdenum while A286 has ~16% and the René™ series of alloys has ~10%. Even though these alloys are produced in quite small volumes, the high levels of contained molybdenum make superalloys a significant consumer of molybdenum.

These numbers don’t leave much for the titanium industry, but it is doubtful the titanium industry uses more than 1% of annual molybdenum production.

Sources of Molybdenum

Up until the 1970’s almost all molybdenum was obtained from mines whose single product was molybdenum. With the closure of the massive Climax mine a shortage of supply over demand developed, which led to expanded recovery of molybdenum as a by- or co-product of copper mining and extraction. Currently about 60% of all molybdenum is produced from copper concentrates, while the remaining 40% is from dedicated molybdenum mines.

As mentioned above, a significant amount of molybdenum is used as a catalyst component in the petrochemical industry. The spent catalysts are being processed to recover the molybdenum, as well as other valuable components. As the recovered molybdenum is in the form of molybdenum trioxide, it re-enters the molybdenum source stream and to some unknown degree offsets the molybdenum consumed in the petrochemical industry. Similar recycling and recovery efforts are ongoing in other parts of the molybdenum market. Unfortunately, no volumes or relative percentages are available at this time.

At Titanium 2008 Mark Wilson of Thompson Creek Molybdenum indicated total production of molybdenum in 2007 was in excess of 440,000,000 pounds, with an expected expansion rate of 4%. He also noted in September of 2008 that demand exceeded supply, and “supply was unlikely to keep pace with demand.” Such was the state of the molybdenum market despite over five years of expanding production accompanying growing copper production world-wide.

Molybdenum in Titanium

Titanium products have traditionally fallen into three groups; the roughly 50% of production volume that is CP-Ti (Chemically Pure Titanium), the roughly 45% that is Ti-6Al-4V, and “other” alloys of titanium. While the percentages will vary with time, this has been a reasonable description. While alloys such as Ti-5-5-5-3 and others may be gradually eroding the portion of Ti-6Al-4V, this simple representation can be used to get a very rough estimate of the molybdenum consumed by the titanium industry.
Obviously neither the CP-Ti nor Ti-6-4 portions of titanium production consume any molybdenum, so it must go to the “Other Alloys” which constitute roughly 5% of the total.

While there are many alloys of titanium with molybdenum, the most prominent are:

- Ti-17, with ~4% Mo
- Ti-6246, with ~6% Mo
- Ti-6242, with ~2% Mo,
- Ti-5-5-5-3, with ~5% Mo, and
- Ti-15 Mo, with ~15% Mo.

The other molybdenum-containing alloys are of lower volumes and often lower molybdenum contents. Still other alloys are free of molybdenum. While re-melting of scrap titanium occasionally require small amounts of molybdenum to adjust the alloy composition, this uses a very small volume of molybdenum.

To get a very rough estimate of the molybdenum requirements of the titanium industry, we might assume all the 5% of titanium production in the “other alloys” group require 5% Mo, all going into production from sponge.

Thanks to the “Titanium Statistical Review 2004-2008” recently published by the ITA, we know world titanium sponge production in 2008 was about 490 million pounds. This suggests the titanium industry’s total demand for molybdenum in 2008 was roughly 490 million lbs. of sponge times 0.05 (percentage of Ti “other alloy”) times 0.05 (percentage of Mo in “other alloy”), or 1.25 million pounds. This somewhat generous estimate is well less than 1% of total molybdenum production in 2008, so there should be no concerns about availability of molybdenum, or the impact of changes in the titanium market on the molybdenum market.


From 1970 to 2001 the molybdenum industry passed through several recessions and periods of turmoil with barely a ripple. As may be seen on the graph below, molybdenum values were relatively low, with a major upturn in the late 1970s-early 1980s, after which values returned to prior levels. A much smaller disturbance occurred in the mid-1990s, again returning to prior levels. The first upturn was caused by a shortage created by the closure of a major molybdenum mine, which encouraged the growth of by-product molybdenum from copper to
meet the supply shortfall. The second upturn was associated with the end of the Soviet Union. Considering the time span and the magnitude of changes occurring during this period, the stability of the molybdenum market is quite impressive.

Moving into the current decade the pattern is quite different, as seen below.

Beginning in 2003 the market saw a continual and rapid increase in values up to the middle of 2005. By this time the market value was over seven times the level seen in the previous decade (the scales are matched for comparative purposes). The precipitous fall in 2005-2006 is similar to the drop in the early 1980s, but the brief drop was followed by generally increasing but unsteady values up to the third quarter of 2008.

The increasing and sustained values from 2003 to the fourth quarter of 2008 were the result of demand out-pacing supply as the steel industry world-wide recovered and then expanded. Much of this growth occurred in the BRIC group (Brazil, Russia, India and China), with particularly impressive growth not only in China, but also in India and Brazil. Not only were these countries steel industries growing at double-digit rates, but the mix of steels was shifting to more sophisticated steels to feed the automobile and appliance markets.

We tend to focus on expansion in the BRIC group, but the European and North American steel industries were growing as well, although their mix of steels was “mature.” This five-year period clearly was a time of “short supplies” in the molybdenum industry, even though the molybdenum supply continued to expand. This also was a period of major expansion in the copper industry, which brought more molybdenum on stream. The rate of demand growth simply exceeded the rate of supply growth.

A series of natural disasters and changes in government import-export policy in China probably contributed to the value uncertainties over this period, but they were not the root cause of the elevated valuations.

In October of 2008 a wide range of commodities seemed to fall of a cliff; copper lost over half its value, molybdenum lost 60% of its value, aluminum values dropped about 40%. Unless molybdenum suppliers were far more prescient than the rest of the world, there should have been a large excess of supply over demand in the fourth quarter of 2008. But molybdenum values did not fall to the levels at which they entered the decade, but held at two- to three-times prior levels.

The period from October of 2008 to the very near present is detailed in the following graph. The decline in values occurred in the span of one month, followed by eight to nine months of very consistent values.
With a world molybdenum supply of about 220,000 mtons in 2008, in the second half of 2008 China lowered exports by 20,000 mtons, and in the first half of 2009 increased imports by 25,000 mtons, actions which should tighten supplies and increase values -with no apparent effect. This, and the fact that molybdenum values did not fall further, suggests these is a lot of molybdenum out there, but it might be held from the market in hopes of future higher values.

By mid-summer 2009 incentives in China had re-started the Chinese steel industry and China was reporting 7.9% annualized growth. Brazil, after a very brief dip, was back to producing automobiles at a rate over 3 million units per year (the sixth largest auto producer in the world), and even the North American steel industry was improving, up from 49% of capacity to 53%. By July molybdenum values were rising, and the trend accelerated into August. While current molybdenum values are only half their 2005 peak, they can close that gap quickly. Since the end of June they have increased over 70%.

**The Near Future**

My foresight is no better than anyone else’s, but there are some indicators for the next couple of years. In February 2010 molybdenum (and cobalt) will begin to trade on the Minor Metals Contracts of the London Metal Exchange, with contracts going out fifteen months. This might provide improved visibility of stocks, and somewhat dampen the rapid changes of the past six years.

In 2008 there were major molybdenum supply expansions underway in China, Chile and North America. While these projects might have been slowed by the recent drop in molybdenum values, I have not heard of any cancellations. If the Climax mine does re-open as previously announced, it could provide sufficient additional supplies to stabilize the market for a few (2-3) years.

The pace of economic recovery will determine the degree to which molybdenum supply meets demand. If the last few months are any indicator, molybdenum will be in tight supply for at least a year.
Molybdenum, 2009

or,

“Caught Between a Calciner and a VAR…."

By

Dr. James W. Robison, Jr.

Titanium 2009
Reading Alloys is a producer of master alloys for titanium and superalloys. We consume molybdenum trioxide, we don’t produce it. Positioned between the molybdenum source and the consumer, we have some limited vision into each. The following are observations and thoughts on molybdenum in the world of titanium.
Applications of molybdenum are stable over time:

- 75-80% to ferrous alloys (carbon & tool steels, stainless, and cast structural steels);
- 6-8% to molybdenum metal uses, mostly high temperature or chemical applications;
- ~10% to specialty chemicals such as molybdenum disulfide lubricants, petroleum catalysts;
- ~5% to Superalloys like 718 (~3% Mo), 276 (~16%) and Rene\textsuperscript{tm}-series alloys (~10%),
- Only ~1% of molybdenum production goes into Ti.
Uses of Molybdenum in Titanium

- CP-Ti: 50%
- Ti-6-4: 45%
- Other Ti Alloys: 5%
Major molybdenum-containing titanium alloys:

Ti-17 (4% Mo)
  Ti- 6246 (6% Mo)
  Ti- 6242 (2% Mo)
  Ti-5-5-5-3 (5% Mo)
  Ti- 15 Mo (15% Mo)

There are many other less-common titanium alloys with molybdenum; volumes are small.
Overall, molybdenum requirements for Ti alloys are about 0.25% of total sponge production.
490 million lbs. sponge (ITA-2008) => 1.25 MM Mo
Sources of molybdenum:

~ 60% as a by-product of copper production
~ 40% from primary molybdenum mining
~ Unknown MoO3 volumes recovered from spent catalysts, chemicals and metal applications

Total production in 2007 was over 440,000,000 lbs. expanding at 4%/year (Mark Wilson; ITA-2008)

Demand in 2008 exceeded supply; “supply was unlikely to keep pace with demand.” ibid
Molybdenum Values Over the Past Three Decades

Source: M. Magyar, ITA 2005
Molybdenum Values, 2002-2009

Variation in Molybdenum Values

Source: Ryan's Notes
2003-2005 - Run-up due to demand increases from BRIC due to expansions of steel, auto and appliance industries and shift to more alloyed steels.

2006-2008 - Expansion of copper production helps meet demand, China changes import/export policies.

4Q-2008-2Q 2009 – World steel production falls by 30-50+. China's incentives lead to GDP growth of 7.9%.

3Q-2009 – Supply tightens as demand increases. Some supplies held from market for higher prices. Rise in copper demand will bring on more molybdenum.
Molybdenum Values, Past 11 Months

Variation in Molybdenum Values

Source: Ryan’s Notes
Despite drop in demand, values remain well above historical levels, but stable for nine months.

Up-turn started in June, accelerated in July.

In second half of 2008, China exported 20,000 mtons less, but imported 25,000 mtons more in first half of 2009. This swing of roughly 20% of total 2008 supply did not appear to have any impact.

Steel production in U.S. & E.U. is up about 10% in second quarter 2009 over first quarter 2009. Price increases appear to be holding.
Going forward….

London Metal Exchange in February will add Mo (and Co) to Minor Metals Contracts, with contracts going out fifteen months.

Molybdenum production expansions should go on-stream in late 2010 into 2011, in China, Chile and the U.S.

*If* the Climax Mine re-starts as previously announced, it should help stabilize the market.

Current supplies are *tight*…

Lots of *ifs*, no absolutes.