Estimating Domestic Titanium Requirements

For the 90's

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Abstract

The U.S. Bureau of Mines publishes quarterly reviews of production statistics for titanium. Data obtained from this Mineral Industry Survey has been compiled into a titanium raw materials model. This model is based upon data developed over the past three decades. Mill shape production rates are used to estimate end product and scrap generation rates. Average market growth rates were computed using five year increments. Future market growth rate has been estimated by regression analysis of this data. Comparisons are made between anticipated sponge metal needs and installed sponge capacity. Trends in scrap inventory levels are predicted from the model. This paper discusses the development of this model at RMI Titanium Company and presents one potential market growth scenario based upon a historical market growth estimate.

Introduction

Commercial titanium production began in 1948. Demand for products manufactured from titanium has been cyclic and varies in a cycle approximately ten years in length.

The greatest demand for titanium is in aerospace applications. Alloys of the metal are particularly well suited for use in the engines and airframes of modern jet aircraft. Periodic increases in the demand for titanium have occurred during the build up of commercial airliner fleets and acquisition of large numbers of modern jet aircraft by the military. A second major market area makes use of titanium's excellent corrosion resistance in a variety of industrial applications.

Demand for titanium for industrial applications has increased steadily since 1965 when this market area experienced rapid growth from a base level of about three-quarters of a million pounds per year. Since 1967, industrial markets have shown an average growth rate of about 2.6% per year. Two significant "accelerated" demand cycles occurred as a result of shortages which occurred during the late 1970's and 1980's. These "growth spikes" both occurred when large demands in aerospace markets triggered raw materials shortages and extended delivery times for mill product shapes. Expansions of sponge production capacity during the late 70's and 80's satisfied these short term raw materials requirements.

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The U.S. Bureau of Mines has published an excellent review covering distribution of titanium raw materials, ingot, mill products and scrap for the 1960's.(1) This review contains production and inventory statistics compiled from reports issued quarterly by the U.S. Department of Commerce.(2) A study detailing scrap utilization in titanium production was contained in a report published in 1975. (3)

Similar data summaries covering periods from 1978 through 1991 were published by the Bureau of Mines and complied by the Titanium Development Association (TDA). (4) Data estimating titanium utilization (buy to fly ratios) for aerospace applications was obtained from a study published in 1983 for the Federal Emergency Management Agency. (5)

In 1985, data from all available sources was compiled into a computer model which was used to track and predict changes in domestic scrap supplies. (6) The original Bureau of Mines tabular model was used as a basis to upgrade the original scrap model to reflect current market distributions. In early 1991, this model was modified to provide capabilities for estimating market trends, raw materials needs, and scrap inventories. The model can be used to estimate mill products requirements and raw materials needs for a range of aerospace and industrial market growth assumptions.

Development of the Model

The RMI Titanium Company raw materials model was based upon a titanium scrap flow diagram developed in 1975. A tabular summary of data covering the period from 1960 through 1969 is included as Table I. This summary provides an excellent review of production data, but does not include scrap inventory data for the period.

Information compiled by the TDA was used to expand this tabulation to include data for the period from 1978 to 1984. (2) Other sources were used to develop data for periods between 1970 and 1977. Data published by the Bureau of Mines in reviews are annualized and posted into the model quarterly. (4)

Lag times were built into the model to account for shipping and conversion schedules. Mill products shipped in 1983 are assumed to be converted into final products and scrap during 1984. In the original version of the model, predictions of scrap usage were estimated from five year running averages of historical data. Similar techniques were used to generate estimates for imports and exports. Prediction of future mill product needs were based upon marketing estimates.

Additional categories have been added to the original Bureau of Mines data table to handle more input and recycle loops. Discrete categories were added for sponge capacity, sponge imports, scrap import and export data and scrap recycle to the system from used end products. Conversion ratios for mill products are estimated from a ratio of aerospace to industrial markets. The original model was useful for predicting trend changes in scrap inventory, either increases or decreases in level. See Figure 1. Changes in scrap inventories could be directly associated with future scrap availability, price and sponge production needs.

TABLE I. Titanium Scrap, 1960-69
(Tons)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Total
Raw metal supply:											
Sponge consumption	5,487	6,991	7,136	8,865	11,131	12,105	19,677	20,062	14,237	20,124	125,815
Scrap consumption	2,527	2,501	3,160	2,235	2,877	3,303	4,857	5,822	4,701	7,566	39,549
Total raw metal supply	8,014	9,492	10,296	11,100	14,008	15,408	24,534	25,884	18,938	27,690	165,364
Ingot production[1]	8,297	9,371	10,400	11,138	13,964	15,294	24,253	25,960	19,234	28,490	166,401
Ingot consumption	7,978	8,878	9,773	10,506	13,501	14,694	22,317	25,386	18,323	27,082	158,438
Mill shapes production[3]	5,071	5,147	6,521	6,112	7,708	9,358	13,996	13,634	11,900	15,940	95,387
Estimated percent to fabricated products	25.0	26.3	27.6	28.9	30.4	31.9	33.5	35.2	36.9	38.8	33.1
Fabricated products production[3]	1,268	1,354	1,800	1,766	2,343	2,985	4,689	4,799	4,391	6,185	31,580
Scrap supply:											
Ingot production minus mill shapes production	3,226	4,224	3,879	5,026	6,256	5,936	10,257	12,326	7,334	12,550	71,014
Mill shapes minus fabricated products (previous year)[4]	2,408	3,803	3,793	4,721	4,346	5,365	6,373	9,307	8,835	7,509	56,460
Total scrap supply	5,634	8,027	7,672	9,747	10,602	11,301	16,630	21,633	16,169	20,059	127,474
Yearend scrap stocks[5]	NA	NA	NA	NA	NA	NA	4,318	4,894	4,434	4,727	-
Scrap consumption:											
Titanium recycle	2,527	2,501	3,160	2,235	2,877	3,303	4,857	5,822	4,701	7,566	39,549
Steel production:											
Direct alloying and deoxidizing[6]	630	972	1,076	1,305	*1,525	*1,800	*2,100	*2,500	*2,900	3,447	18,255
Exports	879	886	818	1,261	1,817	2,132	1,733	1,429	2,756	2,802	16,513
Ferrotitanium production (contained titanium)[7]	946	716	580	759	1,151	1,180	1,569	785	1,099	1,195	9,980
Total steel production	2,455	2,574	2,474	3,325	4,493	5,112	5,402	4,714	6,755	7,444	44,748
Aluminum-base hardeners (contained titanium)[8]	933	1,115	1,569	2,170	1,586	1,002	793	682	700	668	11,218
Nonrecoverable metal losses (estimated at 25 percent of ingot production)[9]	2,075	2,343	2,600	2,785	3,487	3,824	6,064	6,490	4,809	7,122	41,599
Total scrap consumption	7,990	8,533	9,803	10,515	12,443	13,241	17,116	17,708	16,965	22,800	137,114

*Estimated. NA--Not available.

[1]Includes imported sponge and alloy addition.

[2]The percent of mill products which became fabricated products was estimated at 25 percent for 1959-60. After 1960, yield is assumed to increase at the rate of 5 percent per year.

[3]Includes minor amounts of castings.

[4]Mill shapes production for 1959 was 3,211 tons, and estimated fabricated products production was 803 tons.

[5]Scrap stocks held by ingot and mill shapes producers.

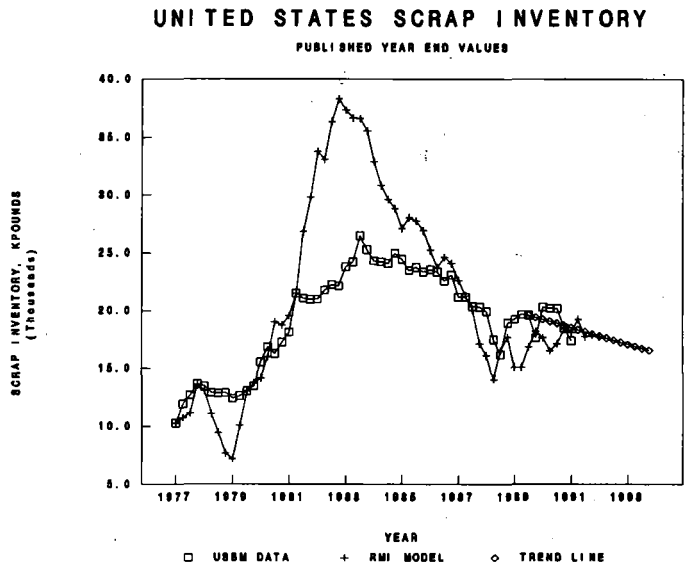
[6]Data for years 1960-63 obtained from American Iron and Steel Institute Annual Statistical Report 1961 and 1963. The data include some offgrade sponge.

[7]Includes minor amounts from ilmenite-magnetite slags.

[8]The hardeners contain 5 to 10 percent titanium; 10 percent was used in calculating the titanium content to compensate for titanium scrap consumed for direct alloying of casting alloys.

[9]General shrinkages from missegregation, grinder dust, pickling, etc. See section on nonrecoverable losses for explanation.

Figure 1 - Original Scrap Inventory Model



Improvement of the Model

In late 1990, an internal review of domestic scrap markets was completed. (6) This review showed that scrap inventories would begin increasing during 1991. The study also indicated that a market turndown might occur during the next year. See Figure 3. Since industry market estimates for 1991 showed continuing high demand, the significance of this trend was not realized. The unusual results were inconsistent with accepted market projections. The model was expanded to include better forecasting capabilities for mill product market needs. Data was obtained for historical market growth for the period from 1960 through 1990. This data was averaged in five year intervals.

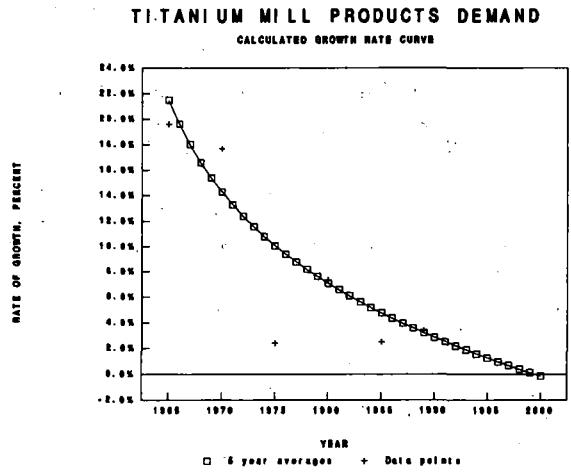
These averages were evaluated statistically to generate a best fit equation. This equation was logarithmic and of the form:

$$y = 0.38247 - 0.1040794 * \text{Ln}(x) \qquad (1)$$

where x equals the time increment in years from a base year, 1960. This equation is shown graphically in figure 2 together with the actual data points.

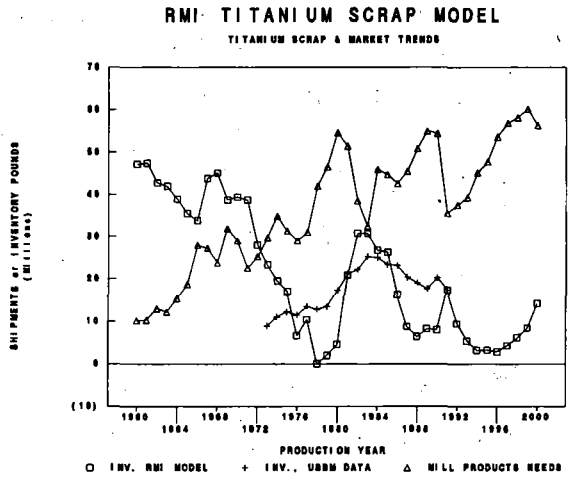
Evaluation of historical market growth data by strict mathematical methods infers that traditional markets have matured. Periodic spikes in demand have been the result of high growth rates caused by short term demand for military aircraft and wide bodied commercial jets. An average market growth rate for the 1990's estimated from historical growth rates is estimated to be 1.43%.

Figure 2: Historical Titanium Market Growth Rate Curve



The raw materials model was updated in early 1991 during an economic study of scrap usage and availability. The model predicted the domestic mill products market, including castings, would be approximately 36.5 million pounds in 1991. Data from this evaluation is shown graphically in Figure 3.

Figure 3 - Raw Materials Model Estimates, February 1991



This estimate was based upon a titanium market growth rate of 3.0% for the 1990's. This value was consistent with average growth rates during the 1980 era. The goal

of the study was to estimate scrap availability rather than to predict mill product shipments during 1991. Therefore, little significance was given to the market estimate until later in the year when the mill products markets deteriorated. It was recognized that the raw materials model had predictive power and could be used to estimate future raw materials needs for various market growth assumptions.

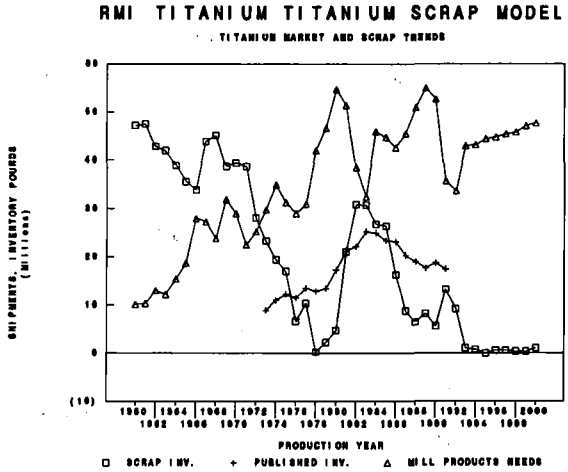
Market data for the period between 1960 and 1991 was separated into the discrete market areas of commercial aviation, military aviation and industrial applications. These markets areas were adjusted by applying individual growth rates. Growth was adjusted to the average 1.43% value obtained from statistical evaluation of historical growth data. These major market areas were adjusted as shown in Table II.

Table II - Assumed Growth Rates for Titanium Markets
Historical Statistical Evaluation

Market Area	Share %	Growth %
Commercial Aerospace	59%	2.00%
Military Aerospace	18%	-1.30%
Industrial Applications	24%	2.05%
Weighted Average		1.43%

These values were then used in the model to estimate titanium requirements for the decade ending in the year 2000. Sponge requirements and scrap inputs were computed based upon estimated final product needs. A tabular summary of this model is included as Table III. These results are shown graphically in Figure 4.

Figure 4 - Mill Products Estimate for the 1990's with Derived Growth Rate



Conclusions

Titanium market growth rates can be estimated from an evaluation of historical data. Evaluations indicate that traditional markets have matured and the rate of market growth in these areas will continue to decrease during the next decade. Reductions in military aerospace spending and a severe economic recession caused an abrupt drop in demand for titanium in 1991.

Use of industry indicators such as inventories, backlogs, and estimated market growth rates permit estimations of raw materials needs to be made. Evaluation from this model indicate that the domestic industry can support a scrap recycle level up to about 43 percent of ingot production. United States sponge capacity appears to be adequate to supply estimated domestic market needs through the late 1990's.

Future increases in market growth rate depend upon the development of new uses for titanium. This growth potential is most likely in industrial applications. Moderate growth in this area will not drastically impact future mill products needs. Conversion yield for mill shapes into end products is high for most industrial applications. Since market growth is really in end products, mill shape needs will grow more slowly for industrial uses than for aerospace or defense applications.

Raw materials models are easily modified to reflect any projected market growth rate estimate. A model of this type provides a convenient tool for predicting raw materials needs and for forecasting market trends.

References

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Table III – Titanium Raw Materials Model

1991–2000 DATE										
22–Jun–92	(Kpounds)									
HISTORICAL GROWTH MODEL	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Sponge Capacity	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Percent of Capacity used	58.6%	55.3%	67.5%	67.0%	68.0%	68.0%	65.0%	70.0%	76.0%	75.0%
Raw Metal Supply: Scrap usage	45.7%	51.6%	43.9%	43.7%	43.0%	44.3%	44.4%	42.6%	39.3%	40.8%
Sponge Production	29,405	27,641	33,750	33,500	34,000	34,000	34,000	35,000	38,000	37,500
Sponge Imports	1,349	620	3,500	4,000	4,500	4,500	5,000	5,500	6,000	6,000
Sponge Consumption	29,907	29,973	35,388	35,625	36,575	36,575	37,050	38,475	41,500	41,325
Scrap Consumption	25,038	32,058	29,000	29,000	30,000	30,500	31,000	30,000	28,500	30,000
Master alloy supply	2,804	3,203	3,782	3,907	3,909	3,909	3,960	4,112	4,467	4,417
Total Raw metal supply	57,749	65,235	68,170	68,432	70,484	70,984	72,010	72,587	74,767	75,742
Ingot Production	54,745	62,084	66,124	66,379	68,369	68,854	69,849	70,409	72,524	73,469
Ingot Consumption	53,324	53,161	66,124	66,379	68,369	68,854	69,849	70,409	72,524	73,469
Mill Products Shipments	35,658	33,590	42,981	43,147	44,440	44,755	45,402	45,765	47,141	47,755
% mill products converted final shapes	30.6%	30.9%	31.4%	31.5%	31.6%	31.7%	31.8%	31.9%	31.9%	32.0%
Fabricated Products production	16112	11024	10546	13536	13627	14076	14216	14461	14616	15095
Estimated product demand	13775	12880	12880	13008	13269	13967	14077	14640	15225	15691
Shortfall/Customer Inventory Level	7,076	5,220	2,886	3,412	3,770	4,160	4,319	4,140	3,531	3,035
Market Growth Rate	−11.0%	−6.5%	0.0%	1.0%	2.0%	3.0%	3.0%	4.0%	4.0%	2.4%
	3.0%	40.00	43.00	43.60	44.22	44.85	45.50	46.16	46.84	1.45% 47.54
Scrap Supply: Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Off–grade Sponge (10 to 5% of Prod)	1470	1382	1688	1675	1700	1700	1700	1750	1900	1875
Ingot minus mill shapes production	19087	28494	23144	23233	23929	24099	24447	24643	25384	25714
Mill Shapes minus Fabricated Shapes (previous year)	36518	24633	23044	29446	29520	30364	30539	30941	31150	32046
Imports	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
Recycled end products, (15 yr life)	4,184	3,882	4,060	5,619	6,238	7,317	6,939	5,150	4,334	6,153
Total Scrap Supply	69,260	66,392	59,935	67,973	69,387	71,480	71,626	70,484	70,768	73,788
Scrap Consumption:										
Titanium Recycled to products	25038	32058	29000	29000	30000	30500	31000	30000	28500	30000
Steel Production:										
Direct alloy and deoxidizing	9000	9000	9000	9000	9500	9500	9500	9500	10500	11000
Exports	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000
Other Alloying, Superalloys etc	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
Total steel production	22100	22100	22100	22100	22600	22600	22600	22600	23600	24100
Nonrecoverable metal losses (estimated at 25% of raw materials)	14437	16309	17042	17108	17621	17746	18002	18147	18692	18935
Total scrap consumption	61,575	70,467	68,142	68,208	70,221	70,846	71,602	70,747	70,792	73,035
Published Yearend Scrap Stocks	17,391	16,925								
Computed Scrap Inventory Level	13,307	9,231	1,024	789	(45)	589	613	351	326	1,079
Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000