

MAGNESIUM

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Magnesium Monthly Review*

Production of magnesium metal continued to grow in 2000, but at a slightly slower pace than in several previous years. The growth of magnesium continued to be advanced by automotive industry requirements. During the year many new magnesium applications in cars were introduced. Die-casting uses continued to grow in Western world statistics. Shipments of magnesium for die-casting increased according to our estimates. The actual amount of magnesium shipments for die-casting, as reported by official agencies, has been modified to separate the prime or virgin metal from recycled ingots produced by remelting and refining magnesium scrap (recycling). The number presented in this report is the estimated total amount of magnesium used in die-casting. At the end of the year, excluding China, there were 16 operating plants which produced an estimated 284,500 t of magnesium. Production in China was reported to be about 195,000 t. Many new projects were still being studied at the end of 2000, with one large plant in start-up phase.

The new Noranda Magnola Magnesium plant in Danville, Quebec, started to produce metal in September 2000. The plant is having more than normal problems in getting all the cells operating at full capacity. At the end of the year, ten cells of a total of 24 were running. However, the cells are not able to be run at full current design input because of problems producing sufficient anhydrous magnesium chloride. Cells which were designed for 180,000 amps are running slightly over 110,000 amps. The plant cost was reported to have escalated from the initial C\$720 million per ton to over C\$920 million with the latest modifications being allowed for. The plant uses Alcan electrolytic cells which are producing good quality magnesium in spite of being operated under non-ideal conditions.

New and better alloys for higher temperature operation are continuing to receive much of the attention from magnesium researchers. The ultimate goal is to increase usage of magnesium in basic engine and transmission parts. The US leads the world in total usage of magnesium in automobiles, but Europe and Japan and Israel continue to expand their research efforts introducing more new parts each year. Interest in rolling and extruded magnesium for parts has been much greater in areas outside of the US.

There was pressure on the pricing of magnesium due to increased quantities of Chinese magnesium being available in Western markets including Europe and North America. Magnesium shipments from China and from the CIS have reached approximately 43% of all shipments of magnesium. The Western world 2000 year-end inventory was up slightly to 46,500 t representing 47 days supply. Inventory data does not include PRC/CIS stocks, stocks of secondary ingot or stocks of scrap.

The European Commission continued to monitor imports of magnesium from Russia as well as imports from China. A quota had been established for a set maximum of magnesium to be imported from Russia without the imposition of a duty. After the quota number (which is confidential) is reached, any further imports are subject to a minimum price of €2,602.

The review of magnesium imports from China caused the EC to double the existing duty of 31.7% *ad valorem* to 63.4% in October. At the end of 2000, magnesium prices at Chinese ports actually dipped below US\$1,300/t and some smaller plants were being closed.

The US International Trade Commission (ITC) established the following anti-dumping duties for pure magnesium from Canada, 0% for August 1, 1998 to July 31, 1999. The countervailing duty for pure and alloy magnesium was set at 1.38% for calendar year 1998. Magnesium Corp. of America (MagCorp) and the United Steelworkers are petitioning the ITC for anti-dumping duties on pure magnesium and pure magnesium powder. The petition asks for anti-dumping duties of 85-95% for magnesium imports from Israel, 22-47% for Russian imports, and 218-393% for Chinese imports.

Prices

Representative magnesium price ranges for the year 2000 are shown below. *Metal Bulletin*, has tracked magnesium prices by quarters for many years. *MB* started tracking the Chinese free market price in the third quarter of 1999 and it has dropped every quarter since the first report.

The overall prices of magnesium dropped during 2000 as they did during 1999. Exports from China continued to be priced at very low prices. The anti-dumping duties in the European Union were doubled from 31.7% to 63.4% in the second half of 2000. This action caused the Chinese magnesium producers to reduce the price of magnesium cif at the Chinese ports during the last part of 2000 when the increased anti-dumping duties took full effect.

The Chinese Magnesium Association was formed to help develop the total magnesium industry in China. It was started as a very close association of magnesium producers. In 1999, the CMA attempted to get the association members to agree on a minimum

Magnesium Production ('000 t)			
COUNTRY (Plants)	1998	1999	2000
US (2)	117*	85	74 ^e
Brazil (1)	9	7	9
Canada (3)	57	54	55 ^e
PR of China(85 ^e)	120	157	195
France (1)	15	17	17
Israel (1)	25	25	25 ^e
Kazakhstan (1)	15 ^r	15	10 ^e
Norway(1)	49	52	50 ^e
Russia (2)	53 ^r	56 ^e	40 ^e
Ukraine (2)	6 ^r	6 ^e	2 ^e
Serbia (1)	3	1 ^e	2 ^e
India (1)	1.5	1	0.5
Total	470.5	476	479.5

Source: USGS, IMA, CMA, Author estimates
^e estimate ^r revision

market price of US\$1,950/t. This price level did not hold. In 2000, the CMA set a reference price of US\$1,500/t for pure magnesium and that was ignored by many producers when the market tightened. The CMA held an internal meeting in May 2000. Representatives of all major plants agreed not to cut their prices below US\$1,500/t fob their plant. This price is just about the average production cost for Chinese plants. However, faced with the continued lowering of prices at Chinese ports, by the end of the year, the Association head admitted that some plants are able to make a profit by selling at prices below US\$1,500/t. And, in some cases, the drive to obtain hard currency overcomes the possible small losses.

Statistics on magnesium consumption in major market areas are basically gathered from Western world producers and in some

Representative Magnesium Price Changes in 2000 (Pure Mg-98%+)				
Period covered	US Western US\$/lb	Eur Free Mkt US\$/t	<i>Metal Bulletin</i> Free Mkt. US\$/t	Chinese Free Market US\$/t
1 st Quarter end	1.38 – 1.44	2,200 – 2,300	2,270 – 2,350	1,520 – 1,570
2 nd Quarter end	1.32 – 1.44	2,000 – 2,200	2,040 – 2,100	1,450 – 1,500
3 rd Quarter end	1.32 – 1.44	2,000 – 2,200	1,950 – 2,000	1,355 – 1,420
4 th Quarter end	1.23 – 1.30	1,800 – 2,000	1,900 – 2,000	1,300 – 1,310

cases primary and secondary magnesium are lumped together. Since the methods have been same for many years, there are good industry trends that can be identified through the use of these numbers. In the gathering of Western statistics by the International Magnesium Association, the magnesium that is recycled is not being reported in the production numbers as it was for many years. Not to confuse the big picture by showing some drastically changed numbers, recycled magnesium from companies such as Norsk Hydro, remain in the magnesium production statistics.

Total magnesium consumption for all uses has been increasing steadily for the past several years. While there is some fluctuation in the various categories from year to year, it is quickly evident that the major users, aluminium alloying and die-casting, have increased steadily, while desulphurisation has fluctuated.

US

Magnesium production in the US decreased again in 2000 to an estimated 74,000 t. Cutbacks in production at MagCorp were made for replacement of the older electrolytic cells in Building One (of four) with a new cell developed by the MagCorp research group. Northwest Alloys also cut back production due to power shortages in the western US.

Magcorp has installed new electrolytic cells which will start up in April 2001. It also continues to run its T-Bar caster to produce both T-Bars and round billets. Northwest Alloys (Alcoa) operated its modified Magnetherm process plant at Addy, Washington, and continued to fight power costs and process inefficiencies.

Xstrata AG, a Swiss-based diversified natural resource group, has acquired new technology to convert magnesium scrap into high-purity secondary magnesium ingots. The company will locate a 25,000 t/y recycling facility in an old General Motors plant in Anderson, Indiana.

The equipment and land of Alabama Cathodic Metals, an Alabama magnesium recycler, was sold to Austria-based Remag Recycling GmbH and has been renamed Remag Alabama LLC. The purchase included all the magnesium recycling facilities, including the plant office, the melting building with furnaces and equipment, the maintenance and storage building, plus six acres of land.

IMCO has discontinued the magnesium recycling operations at its Sapulpa, Oklahoma, plant. The company was originally founded as International Metals to recycle magnesium. Over the years, the company has expanded widely into aluminum and zinc recycling, maintaining only the magnesium at the original plant. Company officials said that magnesium was a very small part of their business and that larger die casters are recycling their own Class I plant.

Spectrulite continues to operate both recycling operations and fabricating operations at its plant in Madison, Illinois. It produces extruded products and rolled sheet and plate. Sheet continues to be supplied to the Japanese who are making stamped cases for the Sony Walkman. Spectrulite is supplying rolled AZ31 sheet that is approximately 2 mm thick. Sony is using a hot press-forging method to produce the

Magnesium Markets (t)			
Market Segment	1998	1999	2000
Aluminum Alloying	154,400	159,800	165,100
Die-casting	110,100	133,400	154,700*
Desulphurisation	48,200	41,700	51,600
Electrochemical	10,000	11,200	7,500
Chemical Uses	6,800	5,200	6,000
Metal Reduction	4,900	2,400	3,600
Gravity Casting	2,600	2,000	2,200
Wrought Products	4,500	4,100	3,400
Nodular Iron	11,750	8,900	8,800
Other uses	7,500	6,800	8,000
Totals	360,250	375,500	410,900

*Adjusted for estimated recycled magnesium usage

small cases. The production lines are being automated and the number of parts that can be made in one hour is very large. By carefully controlled design of the press-forging process, the average thickness of the parts has been reduced to 0.6-0.7 mm, with some parts as thin as 0.4 mm. The strengths of these parts is also superior to those of similar die cast parts.

Canada

Norsk Hydro is the major magnesium metal producer in Canada, using magnesite imported from China to produce approximately 43,000 t/y of primary magnesium by a special proprietary process in Quebec. The plant also operates a 10,000 t/y recycling facility. Low magnesium prices have caused the layoff of about 20-25% of the 400 plus employees at the Becancour plant. Both hourly and salary employees were affected.

The Noranda Magnola 63,000 t/y magnesium production facility at Danville, Quebec, started to produce magnesium in September 2000. At the end of the year 10 of 24 - 180,000 amp electrolytic cells of Alcan design were running. The plant has been having startup problems and is running at 110,000 amps. Impurities in the feed and problems producing fully anhydrous magnesium chloride for the cells were the chief problems. Metal quality from the operating cells is very good and alloy products are being made and sold into the die casting industry.

Timminco continues to operate the 7,000 t/y silicothermic (Pidgeon) process plant at Haley, Ontario. The company suffered a severe fire in the new DC casting plant in November. The plant was being rebuilt at the end of the year. The fire was caused by the spilling of some magnesium on lines containing combustible liquids, but there was no explosion. The company has also announced that it is consolidating the company corporate and marketing functions in Denver, Colorado. The Toronto, Canada,

and Buffalo Grove, Illinois, offices will be closed.

Cassiar Magnesium had a fire in its northern British Columbia plant that produces fire-resistant chrysotile fibres. The company had previously announced plans to develop the plant site further to produce magnesium metal. Deepgreen Minerals of Sydney, Australia, owns 30% of the company stock mainly for the potential of establishing a magnesium metal plant. The magnesium metal project was originally planned for 75,000 to 100,000 t/y to be produced from a serpentine mineral resource stockpile at Cassiar plant site.

The Canadian development group, CLD de la MRC de L'Amiante, is investigating the possibility of building a magnesium production facility using asbestos tailings for the feed stock at Thetford Mines. The area is located on the same asbestos deposit as the Noranda Magnola process. Unlike the Magnola electrolytic technology, the group is looking at a modified silicothermic process called MFL Technology being developed by the Italian "Montelibreni" Research area, Rome.

South America

Brasmag has continued to run the silicothermic plant at Bocaiuva. The plant is estimated to have produced 9,000 t in 2000. The plant uses a special modified Bolzano process developed by Ravelli.

Europe and the Middle East

Norsk Hydro is the largest magnesium producer in the world. In 2000, Norsk Hydro produced 80,850 t of primary magnesium and 20,000 t of recycled magnesium. The plant in Porsgrunn produced 50,000 t, including recycled metal. The Norwegian company lowered its prices for primary magnesium to €2.22/kg from €2.33/kg and lowered prices of magnesium alloy to €2.62/kg from €2.79/kg, effective January 15, 2001. It was reported that the action was taken to keep market share.

Feasibility studies on the Dutch Antheus Magnesium project and the potential economic and technical viability analysis for an integrated magnesium complex at Delfzijl in northeast Netherlands were completed. The company has issued requests for proposals for a 15,000t/y primary magnesium plant, a die-casting plant, and a recycling facility to several major engineering companies. Feed would be magnesium chloride from brine deposits at the location of the present Nedmag brine-mining facilities. A final decision is scheduled for later in 2001.

Pechiney has produced magnesium metal at its Magnetherm process plant in Marignac, France, for many years. The plant produced at a level of 16,000 t in 2000, but suffered heavily from the low magnesium prices in the European market due to low priced Chinese material and the lowering of prices by Norsk Hydro. It was being widely rumoured that the company would close the magnesium facility in mid 2001.

Iceland magnesium production still seems to be on hold. Australian Magnesium Investments holds a 40% stake in the Icelandic Magnesium project. There are several other companies looking at Iceland and could presumably move ahead independently.

The Serbian magnesium producer, Bela Sterna, operates a Magnetherm process and is estimated to have produced 3000 t in 2000.

Abu Dhabi National Oil Co. has been discussing the construction of a magnesium metal facility using a brine aquifer as a source of magnesium credits. A UK firm was chosen to do a feasibility study on the project.

Arab Potash Co. is continuing to investigate the production of magnesium using its chloride-based chemicals complex on the Dead Sea to produce feed material for a magnesium metal plant.

Dead Sea Magnesium, the Israeli-owned company, continued with reorganization in 2000, and the production output was increased from 25,000 t/y. Volkswagen of Germany continues to own 35%. The company is installing a DC caster and is planning to increase the amount of alloy that it produces. The company has signed metal supply contracts with GM and with Alcoa and has received approvals for its magnesium alloys from Daimler-Chrysler.

Magnesium Elektron Ltd (MEL) is building a 10,000 t/y magnesium recycling plant in the Czech Republic, NW of Prague. The plant will process magnesium scrap from Germany and will produce a high-quality ingot to be returned into Germany. It could be expanded to 20,000 t/y if the market increases.

Solikamsk Magnesium Works (SMZ) had a 35% drop in profits in 2000. SMZ is the largest Russian magnesium producer and produced about 20,000 t. Control of the company has been taken by Russia Growth Fund which joined with Ukraine's Sozidanie group and some minority shareholders to get control of 50% + 1 share. Pavel Detkov, the general director, has been challenged for his general management style and has been asked to step down. Solikamsk has been working on an expansion and has operated a pilot plant at 3 t/d. The prognosis of the plant expansion plans is unknown. SMZ also processes 2,000 t/y of secondary materials.

Avisma is also working on a new magnesium production process using carnallite from Siberian brucite ore. Russian titanium fabricator, Verkhnyaya Metallurgical Production Association, is planning to gain full control of the titanium and magnesium plant. Avisma produces over 30,000 t/y of magnesium, but more than half is magnesium that is recycled and re-used to produce titanium.

VAT Oriana, Ukraine's biggest chemical company, is soliciting bids for a partner. The company is hoping to find someone who

would invest in and improve the subsidiaries such as the magnesium producer and the Carbomide resin maker.

Australia

There were nine magnesium projects in some form of study or development at the start of 2000. By the end of the year, there were five projects still being discussed and worked on. Of these, Australian Magnesium Corp. was the leading candidate for financing during the year, but the project is still waiting for financing arrangements to be finalised.

Australian Magnesium Corp. possesses the oldest magnesium project. It is an Australian company based in Brisbane that was established to complete the development and then to commercialise the Australian Magnesium (AM) process technology to produce magnesium metal. Originally sponsored by Queensland Metals and CSIRO, the AM process has been developed and patented in a number of countries. A large (1500 t/y) demonstration plant has been built and is still being run at Gladstone. The project has completed environmental impact reviews, has an engineering and construction programme already in place, and hopes to conclude all financing arrangements by mid 2001.

The **South Australian Magnesium Project** has the rights to use the Dow electrolytic magnesium production technology for the purposes of building a 52,500 t/y magnesium

plant.

The definitive feasibility study concludes that the total capital costs will be around US\$375 million. Operating costs are indicated to be less than US\$0.60/lb. The company has obtained an off-take contract with ThyssenKrupp for 100% of all the plant output of magnesium metal. The company is also negotiating with a consortium of Theiss-Krupp Uhde for engineering and construction with a guaranteed maximum price and a process guarantee. Target dates include financial close by October 2001.

Golden Triangle Resources, Ltd is concentrating on the serpentinite tailings at the abandoned Woodsreef Mine in New South Wales. This is a resource that could supply a 80,000 t/y of magnesium for more than 50 years. The company has signed an agreement with an Israeli research group to use synthetic carnallite from the deposit with a special process that uses Magnetohydrodynamics as its main source of anhydrous feed production and special electrolytic processing to produce magnesium metal.

Mt. Grace Resources has licensed the Mintek Thermal Magnesium Process for its Batchelor magnesium project. A definitive feasibility study for the Batchelor project has been award to Bateman Multiplex JV, a venture between Bateman Engineering Pty Ltd and Multiplex Construction Pty Ltd. The

Australian Magnesium Projects End Of 2000					
Location	Company/Project	Capacity t	Operating Cost US\$/lb	Capital Cost US\$	Status
Tasmania	INDCOR formerly Crest	flexible	0.55	3.60-4.45/lb	Study done need partner
New South Wales	Golden Triangle	80,000	0.57	423 million	Feasibility Study
Queensland	Australian Mag	90,000	0.66	520 million	Pilot Plant
South Australia	Pima/SAMAG	52,500	0.52	2.50/lb Mg Production	Feasibility Study 7/01
Northern Territory	Batchelor/Mt Grace	50,000	0.70	120 million	Feasibility end of 2001

study will be managed through Bateman Engineering's Perth office, but significant input will come from Bateman's Titaco division (arc furnace design) and the project's technology provider, Mintek, both located in Johannesburg, South Africa.

Crest Magnesium has changed its name to INDCOR and continues to work on its magnesium project in Tasmania. It has had reorganisation and refinancing of its obligations and retains the exclusive rights to the VAMI-UTI magnesium processes. It is looking for a partner.

Anaconda Nickel worked hard during the first part of 2000 to develop the magnesite found in Western Australia near the Murrin Murrin nickel laterite project. However, continued problems at Murrin Murrin and internal corporate manoeuvring has caused the company to put the magnesium project in a hold status.

A new magnesite project, WestMag, was announced for Western Australia. It will use the by-product magnesium chloride brines from the Cargill operations to produce magnesite. There are no announced magnesium metal plans.

India

India's magnesium plants are small and use the silicothermic process. The plant in the north of India that was run by the Tamil Nadu Magnesium and Marine Chemicals Co. was sold and the operation discontinued. Southern Magnesium and Chemical Co. 1,000 t/y silicothermic plant in Hyderabad is the only producer. India has requirements of about 1,000 t/y of magnesium and some of that demand is being filled by imported Chinese magnesium.

China

China has more installed magnesium production capacity than any country in the world. The exact capacity and how much is actually being produced at any one time is unknown, because the bulk of the production

Chinese Magnesium Production and Exports			
Year	1998	1999	2000
Production	120,000	157,000	195,000
Exports	99,937	137,000	165,000

Source: Chinese Magnesium Association

is from small and widely scattered silicothermic Pidgeon process plants (ie: small, horizontal steel retorts charged with briquettes of calcined dolomite and ground 75% ferrosilicon as a reductant). There are 27 magnesium production plants with capacities larger than 5,500 t/y production. At the end of 2000, there were ten plants with over 6,000 t/y capacity and four companies that had over 10,000 t/y of capacity.

The continued internal competition to sell magnesium has caused the Chinese to lower the selling price, cif their ports to very low numbers. At the end of 2000, pure magnesium was available at Chinese ports, cif, for less than US\$1,300/t. The Chinese Magnesium Association has attempted again in 2000 to establish a minimum export price. The recent price was US\$1,500/t. The same group tried to set a minimum price at US\$1,950/t in 1999. These efforts have not been successful.

In 2000, China produced 195,000 t of magnesium and exported a total of 165,000 t of magnesium in all forms. The estimated production capacity is 200,000 t and plant expansions are being announced every day. Magnesium industry growth in China has averaged 40% annually for the period 1994-2000.

Magnesium Uses

The interest in magnesium usage in the global auto industry continues to increase. While die-casting remains the main area, both magnesium sheet and magnesium extrusions are getting research and development attention.

For the new 2001 models, North American auto mobile manufacturers are expecting to average between 3.9 and 4.1 kg (8.5 and 9

lb) of magnesium components per vehicle, a 12.5% increase from the 2000 average. Most of the increase will result from the use of existing part applications in new models. The principal magnesium components are instrument panel support beams, engine cam covers, four wheel-drive transfer cases, steering column and pedal bracket supports, and steering wheel armatures.

European automakers are becoming increasingly aware of magnesium advantages and have many excellent development programmes. The total number of magnesium castings produced in Germany increased from 15,346 t in 1999 to 21,129 t in 2000, a 37.7% increase.

The Japanese manufacturing industry is also increasing the use of magnesium in many areas. While the country no longer produces magnesium metal, the consumption in 2000 increased to 31,000 t, up from 29,330 t in 1999.

Export Categories of Products from China ('000 t)*			
	1998	1999	2000
Unwrought Mg (Mg 99.8%)	73.7	91.6	98.0
Other unwrought Mg	11.4	17.4	18.4
Mg Scraps	0.8	1.6	3.6
Filings, turnings, granules, powder	11.2	24.5	41.3
Wrought Mg	2.6	1.7	4.7
Mg Products	0.2	0.3	0.5
TOTAL	100	137.1	166.5

*Pidgeon Process in China, *AJM* 2001, Weinan Ding, Jingchun Zang