MAGNESIUM

By Bob Brown, Magnesium Monthly Review

Magnesium production increased slightly overall in 2002 when compared with 2001. The Chinese producers increased their production and their share of the world market for the 9th straight year. Worldwide magnesium selling prices continued to be dominated by the Chinese magnesium industry.

The total magnesium consumption increased slightly and the increase of magnesium used in automobiles resumed. Inventory numbers from the International Magnesium Association showed that inventory at the end of 2002 was 18,834 t compared with 45,180 t at the end of 2001. This excludes any inventory in China or the CIS.

Magnesium prices continued to be low for the first part of the year, but did show some strengthening in Europe in the latter part of the year. This was primarily due to some higher production costs in China because of increases in coal and power costs. Prices for ferrosilicon (which is power-intensive) increased, directly affecting the production costs of magnesium by the Pidgeon process used in China.

Noranda's 63,000 t/y capacity Magnola Magnesium plant in Danville, Quebec, started to produce metal in September 2000. The plant has struggled through 2001 and 2002 to overcome many problems in the feed preparation areas. By the end of the year, nearly all of the cells were operating, but at a rate far below the design capacity.

The company was not able to sell metal at a price that would enable the plant to make a profit even if full capacity was reached. The decision to "temporarily" shut the plant down was announced on January 28, 2003. The plant is to be shut down until magnesium prices increase and the resumption of operations is financially justified. An after tax charge of C$630 million was shown in 2002 year-end financial results.

The plant cost was reported to have escalated from the initial C$720 million to over C$1.2 billion with the latest modifications being allowed for. The plant used the latest Alcan EX2 electrolytic cells that were producing good quality magnesium, but at very low efficiency due to impure feed problems. Total plant production in 2002 was about 24,648 t.

There was continued pressure on the world 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 56% of all shipments of magnesium compared with 43% in 2001.

Prices
Representative magnesium price ranges for the year 2002 are shown in Table 1. *Metal Bulletin,* has tracked magnesium prices by quarters for many years, and started tracking the Chinese free market price in the third quarter of 1999 (Table 1).

The overall prices of magnesium in the US continued to drop during 2002 as they did during 2001. Exports from China continued to be priced at very low prices, although they did increase near the end of 2002. The anti-dumping duty in Europe of 63.4% *ad valorem* slowed down some of the import of Chinese magnesium, but was due to be removed by the end of 2002. (It was actually removed in first quarter 2003.)

Consumption and use
Magnesium consumption increased in 2002 almost reaching the record year of 2000. The total usage was up by nearly 10% over 2001 according to a review of the major market usage in Table 3. Largest major areas affected were the use of magnesium for die casting and desulfurization. Alloying with aluminum increased slightly. The desulfurization quantity reached a new record of 57,385 Mt with 87% coming from China and CIS.

Production
Total magnesium production increased slightly in spite of the closure of Western producers. The total increase in production was nearly 7% according to Table 2. The continued ramp-up of Noranda's Magnola plant and new Chinese production accounted for most of the increases.

Statistics on magnesium production in major market areas are basically gathered from Western producers and in some 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. In this summary, recycled magnesium from companies such as Norsk Hydro, remains in Table 2.

United States
Primary magnesium production in the US decreased again in 2002 to an estimated 35,000 t. The only remaining US magnesium producer was **US Magnesium LLC** that purchased most of the assets of Magnesium Corp. of America (Magcorp). The plant is located at the Great Salt Lake in Utah that supplies magnesium brine for the plant. Magcorp, which was owned by Renco Group, was in Chapter 11 bankruptcy when the assets were sold to US Magnesium for US$24 million. The principal individual owner of Renco is the principal individual owner of the new company, US Magnesium LLC.

US Magnesium continued to operate the plant with the same management and workforce. The 30 new electrolytic cells and plant modifications that were

installed in April 2001 are running very well and meeting all the projected output goals. Emissions from the plant have been substantially reduced.

Xstrata AG, the Swiss-based diversified natural resource group, started up its new recycling plant in Anderson, Indiana in Oct 2001, but in 2002 it announced that it would sell the plant and write off the entire investment of US$22.2 million. The plant was designed to process 25,000 t/y of magnesium scrap. Only one line was commissioned and the total output in 2002 was 5,440 t. The company said it had trouble obtaining scrap for the plant and that the sales prices had been lowered for the product in response to sales of low-priced material from China.

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 Sony in Japan for 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 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 are also superior to those of similar die-cast parts.

Spectrulite is also continuing to supply rolled magnesium sheet materials to the automotive industry for testing programmes to develop fabricated magnesium parts for automobiles. Spectrulite is also the main source of supply for magnesium slabs for other rolling mills in the world for use in rolling experiments in either aluminum or steel rolling mills.

The company has had labour problems and a major strike that began in August 2002 continued into 2003. The size and duties of the workforce have been problems for many years in a very strong union area. The company is in Chapter 11 Bankruptcy, but is taking steps to reorganise its operations by mid-2003.

Garfield Alloys, MagReTech, Halaco and **Remag** of Alabama continue to operate independent magnesium recycling operations. However, the die-casting companies are doing more and more recycling of Class 1 die-casting scrap at the die-casting plants**.** Halaco was forced into Chapter 11 bankruptcy to seek protection from creditors and plaintiffs in civil lawsuits. A lawsuit filed by an environmental group had weakened the company's resources.

Rossborough-Remacor continued to work on products for the desulphurising market. A new process was patented which used scrap turnings for the source of magnesium for the desulphurisation mixtures it sells to the iron and steel industry.

Bioconvergence, Inc. (BCI) has constructed a magnesium alloy turnings recycling plant in Niagara Falls, NY. BCI will provide generators of

contaminated, oily magnesium metal turnings with a safe, environmentally-sound service. Special containers will be provided to the turning generator and coolant removed prior to shipping to the processing plant. The turnings are then cleaned and sold as turnings or as compacted shapes called 'pucks'.

Canada

Norsk Hydro is the largest primary magnesium metal producer in Canada, using magnesite imported from China and Australia to produce approximately 43,000 t/y of primary magnesium by a special electrolytic process at Becancour, Quebec. The plant also operates a 10,000 t/y recycling facility. Production capacity was increased to 48,000 t/y by debottlenecking and by increasing the amount of energy available to the plant's dehydration area.

Noranda's 63,000 t/y capacity Magnola magnesium production plant at Danville, Quebec, started to produce magnesium in September 2000. In 2001, the plant produced 10,000 t. There were many operational problems with the plant process and the capital costs kept increasing. The plant produced 24,648 t of magnesium in 2002. The average annual selling price was US$0.92/lb. The capital cost totals were over C$1.2 billion, an increase over the original projected project cost of C$720 million. The company shut the plant down in early 2003, saying it would maintain it in a standby condition and re-open when prices improved. Noranda took a C$630 million charge for the shutdown in 2002. The plant is 20%-owned by SGF, a large Canadian money fund. SGF tried unsuccessfully to find ways to keep the plant operating. The plant will lay off 370 employees and retain just ten to maintain the plant and the plant site.

Timminco continues to operate the 7,000 t/y silicothermic (Pidgeon) process plant at Haley, Ontario, and a magnesium extrusion plant in Aurora, Colorado. The company has improved its casting ability with a new DC cast house in Canada. There was a fire in the cast house in the middle of 2002, but the damage was quickly repaired. The plant had many financial problems. Safeguard Industries bought Timminco in early 2003.

Magnesium Alloy Corp. continues to work to get funding in place for the 60,000 t/y Kouilou Magnesium project located in the Republic of Congo. The company has signed a memorandum of understanding with Eskom Enterprises of Johannesburg, South Africa. This deal would establish a long-term contract for low-cost power for the plant. Mag Alloy also signed an offtake agreement with Stinnes Metall GmbH whereby Stinnes will market up to 100% of the magnesium and magnesium alloys produced at the plant.

Globex Mining continued to work on the development of a magnesium production plant. The Québec Government made a conditional offer to finance part of a feasibility study for Globex's Timmins magnesite-talc project. An initial scoping study by Hatch Associates Ltd had proposed a C$1.5 billion complex in two locations, with a capacity to produce 90,000 t/y of magnesium metal. The Québec Government will finance 25% of the C$17.7 million study if the Federal Government finances 25% and Globex finances the remaining 50%. Negotiations were ongoing at the end of 2002.

In February 2002, **Leader Mining International** awarded Hatch the mandate to complete a production feasibility study on the Cogburn magnesium project. The Cogburn magnesium deposit is a large ultramafic intrusive body containing consistently high-grade magnesium silicate (>24% magnesium). The discovery is located 120 km east of Vancouver, British Columbia, near the town of Hope. There is a significant infrastructure advantage in that electric power, natural gas, mainline rail, provincial highways and barge access to nearby deep-sea ports are all adjacent to the property. Under the direction of Hatch, Process Research Ortech has pilot-tested a composite sample, for hydrochloric leach extraction of magnesium. In addition, leach solution was tested at Messo in Germany to define evaporation and crystallisation parameters for the preparation of cell feed for the STI/VAMI magnesium electrolysis technology.

In April 2002, Leader signed an option with STI/VAMI for the use of the magnesium electrolysis technology for the Cogburn project. Successful testing has resulted in preliminary design parameters for development of a flowsheet.

A market evaluation completed by Hatch and Leader Mining International proposes an aggressive entrance into the magnesium market. Total plant capacity is 131,000 t/y of magnesium metal and alloys. The choice of proven technology will minimise risk for the implementation of the Cogburn project. Hatch has determined cost objectives of US$1.24 billion for the construction of the plant facilities and a magnesium cash cost of US$0.70/lb magnesium.
Chesbar Resources Inc. of Canada acquired 100% ownership of Minera Mayamerica SA. The company is located in Guatemala and owns nickel laterite deposits. Chesbar has commissioned a study to evaluate the possible recovery of nickel, magnesium and cobalt from the deposit.
Brazil

Brasmag has continued to run its special process silicothermic plant at Bocaiuva. The plant is estimated to have produced 9,000 t in 2002. The plant uses a special modified silicothermic (Bolzano) process developed by Ravelli. The company has been investigating other technologies, but no decisions were made by the end of 2002.

Norway
Norsk Hydro closed the primary magnesium production plant in Porsgrunn. The casting plant has been kept open and in operation and is rated at 20,000 t/y. The plant remelts scrap and some imported pure magnesium. Norsk Hydro has also announced that it will expand its recycling plant at Bottrop in Germany to 15,000 t/y from 7,500 t/y.

The Netherlands
Antheus Magnesium group shelved the construction of a primary magnesium facility project because the necessary finance could not be raised. However, the Dutch group has formed a joint venture, Remag Alloys BV, to construct a 10,000 t/y magnesium recycling plant in Delfzijl, Netherlands. Raw material will be sourced from European die casters.

France
Pechiney stopped the production of primary magnesium at its Magnetherm process plant in Marignac, France. The company has converted the melting and casting operation to a 5,000 t/y recycling plant that will produce niche products including turnings and granules. Scrap will be sought in Spain, France and Italy.

Iceland
Magnesium production continued to remain on hold. **Australian Magnesium Investments** holds a 40% stake in the Icelandic Magnesium project.

Serbia
Bela Sterna operates a Magnetherm process plant and is estimated to have produced 2000 t in 2002.

Germany
Thyssen Krupp Stahl AG, the large German steel producer, founded Magnesium Flat Product Ltd at Freiberg in the state of Saxony in 2001. The venture is working to develop a new technology to produce magnesium sheets in collaboration with the Technical University of Freiberg. A special new strip production line uses a Pechiney twin roll caster and a molten magnesium feed system by Rauch Fertigungstechnik. The line began operation in September and quickly achieved its first target of producing magnesium alloy strip that was 700 mm wide and 6 mm in thickness.

Saudi Arabia
Dass Al-Khaleej Co. has received a licence from the Saudi Arabian General Investment Authority to construct a US$213.3 million plant for the production of magnesium and potassium chloride. The project involves joint Saudi-German investments of which 30% are German. The plant will be situated in the Second Dammam Industrial City in eastern Saudi Arabia. There are no announced plans for magnesium metal production.

Israel
Dead Sea Magnesium (DSM), the 65% Israeli-owned company continued to produce magnesium in 2002 and the output was 34,000 t/y of which half was alloy. Volkswagen of Germany continues to own 35%. The company has been losing money since it started up in 1996. It continued to fight the low Chinese prices in the world markets. The company has met with the VAMI and Titanium Institute consortium that designed and constructed the Dead Sea plant. A long-term plan has been implemented to improve process technology, lower operating costs and reduce energy consumption in the dehydration, electrolysis, casting and fume-scrubbing areas. Energy consumption will be reduced by 7-10% over two to three years.

The DSM research group, MRI, is continuing to develop new alloys. The most sophisticated is MRI 153, which can be used in the production of auto engines because of its ability to withstand high temperatures. Several major auto-parts makers are testing the new alloy. It was estimated that sales of the MRI 153 alloy will begin in 2003.

Czech Republic
Magnesium Elektron Ltd (MEL) is operating a 10,000 t/y magnesium recycling plant northwest of Prague. The plant is toll-melting magnesium scrap for customers across Europe.

Russia
Solikamsk Magnesium Works (SMZ) is a large magnesium producer with a 20,000 t/y plant. In 2002, it produced 16,857 t of magnesium and magnesium alloys, of which 60% was exported. The company lost Rb137.5 million in 2002 and will lay off 450 of the 3,000 employees during 2003. SMZ's largest stockholders are Minmet of Switzerland, holding 32%, Russian Growth Fund, 20%, and ZAO Kompaniya, 20%.

The profitability of **Avisma**'s magnesium operations fell sharply in 2002. The company produces over 30,000 t/y of magnesium, of which more than 50% is magnesium that is recycled and re-used to produce titanium sponge.

The company plans to conclude long- term contracts with Alcoa, Meridian-North American, and Georg Fischer Moesner-Europe. Avisma also plans to produce large magnesium ingots and to develop new alloys for automotive use. It reported net profits of Rb104.1 million in 2002 compared with Rb443.8 million in 2001.

Ukraine
Kalush Potassium and Magnesium was bought by a new company, Magnii LLC, owned by Oriana (25%) and Esko-Pivnich (75%). Plans to restart the magnesium plant at Kalush were not completed in 2002, and no explanation was given.

Kazakhstan
There were no production figures available for the **Ust Kamenogorsk** magnesium plant.

South Africa
South Africa's mineral and metallurgical research and development agency **Mintek** is planning to nurture the emergence of new local-component enterprises based on magnesium to feed the country's ever-expanding automotive industry. Mintek announced that, in co-operation with Anglo American and Eskom, it had been "conducting further research and development on the improved process for magnesium production, as well as evaluating the potential for downstream added-value alloys and manufactured products".

The aim would be to establish a 50,000 t/y plant at Saldanha Bay for producing magnesium. Although much progress is being made in developing the technology, it is likely to be some time before the project can be brought to fruition. "There are several important technical issues that require additional research and development work," Mintek suggested: "Mintek and our partners plan to carry out the remaining work over the next six to nine months."

Australia
There were nine magnesium projects in some form of study or development at the start of 2001. By the start of 2002, there were five projects still being discussed and worked on. Of these, Australian Magnesium Corp. has received its financing and is starting design and construction. Pima Mining (now Magnesium International) is reported to be quite close to arranging the necessary financing (Table 4).

Australian Magnesium Corp. is continuing with design and construction work on the A$1.4 billion, 97,000 t/y capacity plant to be built at Stanwell, near Gladstone in Queensland. The plant will use the Australian Magnesium (AM) process technology to produce magnesium metal. Leighton, a large Australian firm, is the main engineering, procurement and construction contractor. The sub-contractors are Kvaerner Worley for dehydration, SNC Lavalin for electrolysis, IMS for the cast-house/metal handling, and Egis for the site establishment and services.

After spending most of 2001 working with the financial community to raise equity for the project, the original target price for design and engineering was A$987 million, but this was later increased to A$1.16 million as Leighton developed more project details.

AMC is working hard to get the cast house designed and built first so that it can train the casting crews and start producing products for the market. AMC has a contract with Ford Motor Co. for 45,000 t/y of the plant's output. AMC has also established marketing groups in the US and in Europe and has been signing other sales and research contracts with several European companies.

Pima Mining NL has changed its name to **Magnesium International** and has completed the bankable feasibility study for a 71,000 t/y capacity magnesium plant at Port Pirie in South Australia. The project cost is reported to be A$733 million with operating costs of A$1.06/lb.

The company has signed a 100% offtake agreement with Thyssen Krupp Metallurgie. The plant will use technology licensed from Dow. Magnesium International has been working diligently to find the financing for the project, but was still unsuccessful by the end of 2002.

Pacific Magnesium (formerly Golden Triangle Resources NL) continues to develop a magnesium process for the serpentinite tailings at the abandoned Woodsreef Mine in New South Wales. This is a serpentinite tailings resource that could supply 80,000 t/y of magnesium for more than 50 years.

Mt Grace Resources NL originally planned to build a thermal magnesium production plant near Darwin in Northern Territory but was unable to secure electric power for the project at a favourable rate. The company has changed its name to **New World Alloys Ltd** (NWA) and plans to invest up to M$570 million during 2003 by relocating the site of its plant to Sungai Siput in Perak, Malaysia and purchasing an existing production plant in the US for relocation to Malaysia. NWA is in the midst of acquiring the plant from US-based

Northwest Alloys Inc (Alcoa), having received shareholder approval in January this year to exercise an asset purchase option agreement with Alcoa. The magnesium plant is located at Addy in Washington, and a feasibility study has shown that the plant could be transferred and restarted in Malaysia and be in the lowest cost quartile of magnesium producers.

NWA's intention is to own and operate the production plant in Malaysia. A feasibility study conducted by independent engineering consultants Worley Ltd estimates that the plant, if operated in Malaysia, would be in the lowest cost quartile of magnesium producers, and would be able to produce metal in one-third of the time and at one-third of the cost of a similar new plant in Australia. Worley's Minerals and Metals division estimated the direct capital cost of the project, with all necessary ancillaries, at US$150 (A$270) million, without contingencies.

The study concluded that the optimum route for the initial stage of the project would be to recommission six furnaces with a projected annual production capacity of >90,000 t of magnesium metal. Upon successful re-commissioning of the first furnace, NWA plans to benchmark the process and will implement incremental improvements so as to optimise furnace productivity. Additional furnaces will be brought on line during 2004, with the full complement of six furnaces planned for production by the end of that year. A significant advantage of using furnace technology for magnesium production is that the tempo of recommissioning can be scheduled to suit market demand.

Thus far, NWA has been unable to arrange the financing for the purchase of the Alcoa plant in the US and the project is on hold.

LaTrobe Magnesium is the new name for Rambora Technologies Ltd. It continues to work on the project that will involve the extraction and production of magnesium metal from the brown coal fly-ash produced in the generation of power from coal deposits in the Latrobe Valley, Victoria. The first deposit to be exploited for this purpose is located adjacent to the Hazelwood power station.
A new dehydration technology to be provided by Alcan International Ltd of Canada will contribute to the low capital and operating costs verified by the pre-feasibility study. The electrolysis plant will incorporate Alcan's high efficiency EX2 electrolytic cell technology. The selection of the EX2 cell capitalises on the higher productivity from each cell, thereby reducing the number of cells required, with a resultant saving in capital and operating costs. A prefeasibility study estimates that a 100,000 Mt/y magnesium metal plant will cost A$857 million with an estimated direct production cost of A$0.705/lb.

India
There is now no magnesium production in India, both silicothermic plants there having been closed.

Bhutan
The kingdom of Bhutan has a company that produces calcium carbide and ferroalloys including magnesium ferrosilicon. Owners of the company are

reviewing technology for a small primary magnesium plant that would be located in Bhutan.

China

The Chinese magnesium industry was thriving and growing throughout 2002. Production is estimated at about 235,000 t, and exports of magnesium in all forms at 180,000 t. Total annual production capacity is estimated at 500,000 t, and plant expansions are being announced every day. Magnesium industry growth in China has averaged 40% annually for the period 1994-2000.

The main source of magnesium production last year continued to be the silicothermic or Pidgeon process. In this process, calcined dolomite is ground to powder, mixed with ground 75% ferrosilicon and briquetted dry into walnut-sized pieces. These are charged into 10" inside diameter horizontal retorts made of heat-resistant alloys that are located in coal- fired furnaces and maintained under vacuum. Magnesium is liberated as a vapour and flows to the end of the retort outside the furnace and condenses. The process has been considered obsolete by most Western standards because it is very labour intensive.

Just three years ago, Chinese Pidgeon process plants capable of producing 3,000 t/y of magnesium were considered large. The situation has changed dramatically and in a short period of time. Chinese producers continue to use the 'obsolete' Pidgeon process but have expanded and increased their production significantly through careful modifications, and new plants are being built with less capital and more capacity. These developments in China have kept the world selling price of magnesium low and have led Western (and Russian) producers to rationalise their output. Capital costs for a new plant in China are said to be US$300-500/t of installed capacity, and operating costs of the larger and more efficient plants are reported as US$0.55-0.65/lb.
About 93,000 t of new Pidgeon process capacity was added in all of China in 2002. Most was in production at the end of 2002, and all of it will be in production by April, 2003. The largest plants are being built with a capacity of 20,000 t/y.

Two of the most recent 20,000 t/y plants will be at nameplate production in one year from the start of construction. One of them has a very simple and clean lay-out, with steam ejector vacuum systems and the recuperation of heat from the discharged waste briquettes. It was said to have cost just US$6 million to build. In one county in Shanxi Province there had been no magnesium production in 2001 but this year there are three plants in operation and one (3,000 t/y capacity) under construction. The plant engineer said he would complete the construction of the plant within three months for US$1.0 million. After 40 days, the plant already had two very tall tapered brick smoke stacks and four shaft kilns installed, along with several partially constructed furnaces.

It is estimated that there are about 150 magnesium plants in China. Not all are operating. We estimate that the total capacity is close to 500,000 t/y and that

between 300,000 t and 350,000 t of this annual capacity is likely to be very competitive.

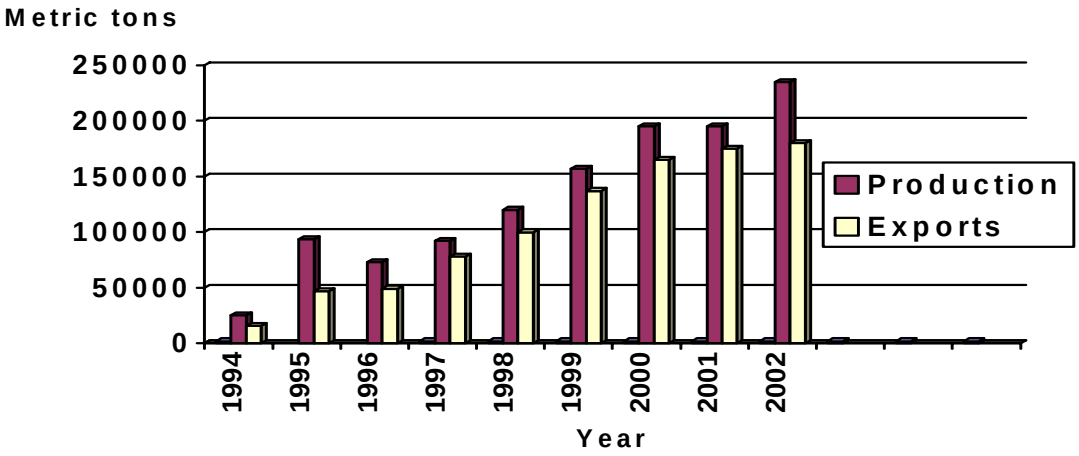
There is a move to develop a magnesium industry in Qinghai Province in Western China. The main source of magnesium chemicals is in the Chaidamu Basin. Magnesium is found as carnallite, the mixed salt of magnesium and potassium chloride. There are hundreds of millions of tonnes of raw material available for a new plant, and most of it is readily accessible. One of the side benefits of carnallite use is the production of fertiliser in the feed preparation and the production of strong chlorine as a by-product. The electrolytic process using anhydrous feed produces about three pounds of strong chlorine to each pound of magnesium. The chlorine would be available for sale.

The area is reported to have a good railway which is being expanded. The Qing-Zang railway has a capacity to carry several million tonnes per year of goods. Also, the hydro power in Qinghai should ensure that the project will have sufficient electricity at a favourable price. The province has superior natural resources that will change the future of Qinghai Province by combining chemistry with metallurgy.

However, talks held with several Western companies concerning technology and financing have thus far generated very little interest. The investment needed for an electrolytic magnesium plant is quite large and it is hard to see how such a plant could compete with the new thermal Pidgeon process plants in Shanxi and Ningxia.

Norsk Hydro's magnesium alloy plant in Xi'an is spacious and well organized, and the staff and labour force are entirely Chinese. The plant purchases pure magnesium ingot from Chinese producers and mixes it with aluminum, zinc and manganese to make magnesium alloys. The plant is already running above its rated capacity of 10,000 t/y of alloy production. All equipment in the plant was built in China, except the ARL spectrograph. All of the furnaces are electric, either induction for melting or resistance for holding, ingot conveyors were made in Shanghai and run very well and there is a 400 t/y water heater anode facility that is a very compact operation (Table 5).

CHINESE MAGNESIUM PRODUCTION AND EXPORTS



China continues to lead the world in magnesium production and exports. Production increased by 93,000 t in 2002 and exports increased slightly. Major production is by the labour-intensive Pidgeon thermal production process that uses ferrosilicon as a reducing agent. There are many small plants in many areas, but the largest magnesium producing province is Shanxi followed by Ningxia and Hebei.

Uses

The largest single usage for magnesium is in die casting. For many years the largest major market was in aluminium alloying, but this has changed in the past two years as interest in magnesium usage in the global auto industry continues to increase. While die casting remains the main area of interest in the auto market, both magnesium sheet and magnesium extrusions are getting research and development attention.

Ford has new applications for magnesium in its autos. It started to put magnesium valve covers on its 5.4 –litre Triton V-8 engines. The engines will be used in standard-size and heavy-duty pick-up trucks and in some Sport Utility Vehicles (SUVs). Magnesium consumption for this application will use about 2,000 t/y. In addition, Ford is developing a magnesium frame for the liftgate for standard-size SUVs. This frame will support inner and outer aluminum or plastic panels, with an estimated weight saving of 50% over the currently-used steel assembly.

Ford also decided on magnesium for the Front End Support Assemblies (FESAs) for light-duty trucks. Magnesium was said to have been favoured ahead of hydro-formed steel tubular steel, extruded aluminum and molded plastics composites. Die cast AM60 was the final choice. The reason for the magnesium success was the projected weight and cost-savings, size and space considerations, performance and dimensional control. The assemblies will first be incorporated into the 2004 standard-size F-150 pick-up trucks. It is estimated that the parts could use 11 Mlb/y of AM60.

The finished FESA castings will each weigh more than 13lb, or more than the total average of all magnesium used in North American cars. This is the first application in a structural part that will support the radiator and other front-end components. Castings will come from Meridian, with magnesium from Norsk Hydro. Ford reviewed the aluminium supports used by GM and plastic parts from Europe before deciding on the magnesium.

Georg Fischer AG of Switzerland has a contract for magnesium steering-column components that will be used in the Ford 500 sedans, Freestyle sports wagons and Mercury Montegos. Parts will be produced by die casting at a North American location. Fischer will die cast magnesium steering/ignition lock housings for Visteon, a Tier 1 supplier that is the system designer.

General Motors also expanded the use of magnesium for instrument panel (IP) support beams for the new Cadillac SRX crossover vehicles. The IP will be made as two-piece assemblies. GM remains the auto company with the

largest magnesium use. It continues to use magnesium die castings for IPs on a number of cars.

GM has developed a new family of creep-resistant magnesium alloys that may have the potential to replace aluminum and steel in some large powertrain components such as engine blocks and transmission cases.

In 2002, about 58,000 t of magnesium castings were used in cars produced by the traditional 'big three' auto makers: about 28,000 t by General Motors, 20,000 t by Ford and 10,000 t by Daimler Chrysler.

European automakers are becoming increasingly aware of magnesium advantages and have many excellent development programmes. Volkswagen has built a tiny tandem-seat prototype that uses only 0.99 litres of fuel per 100 km, or 285 miles/gal. The 1/0 litre car is built entirely of carbon fibre – unpainted to save weight. The carbon-fibre skin is stretched over a magnesium spaceframe chassis that is lighter than aluminium. Magnesium is also used for the seat frames.

Table 1. Representative Magnesium Prices in 2002 (Pure Mg-98%+)

Period covered	US Western US$/lb	Eur free mkt US$/ t	*Metal Bull* free mkt US$/t	Chinese free market US$/t
1st Quarter end	1.20 – 1.28	1,700 – 1,800	1,750 – 1,840	1,260 - 1,290
2nd Quarter end	1.20 – 1.25	1,700 – 1,800	1,780 – 1,880	1,320 - 1,350
3rd Quarter end	1.14 – 1.23	1,830 – 1,900	1,880 – 1,980	1,370 – 1,390
4th Quarter end	1.10 – 1.22	1,830 – 1,900	1,880 – 1,980	1,260 – 1,380

Table 2. Magnesium Production ('000 t)

Country	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
US (1)	142	143	140	117*	85	74e	43	35
Brazil (1)	10	11	9	9	7	9	9	7
Canada (3)	42	52	54	57	54	55e	65	86
PR of China (e)	60	56	92	120	157	195	195	234.7
France (1)	10	11	16	15	17	17	7	0
Israel (1)	--	--	7	25	25	25e	30	34
Kazakhstan (1)	12r	12r	15r	15r	15	10e	10e	10e
Norway(1)	35	38	52	49	52	50e	35	10e
Russia (2)	51r	51r	51r	53r	56e	40e	50	52
Ukraine (2)	8r	13r	7r	6r	6e	2e	2e	0
Serbia (1)	1	2	3	3	1e	2e	2e	2e
India (1)	1	1	1	1.5	1	0.5	0.5	0
Total	**372**	**390**	**447**	**470.5**	**476**	**479.5**	**448.5**	**470.7**

Sources: (1) USGS, (2) IMA, (3) CMA, Author Estimates e=estimate r=revision

Table 3. Major Markets (t)

Market Segment	1997	1998	1999	2000	2001	2002
Aluminum Alloying	146,100	154,400	159,800	165,100	142,810	145,610
Die Casting	95,300	110,100	133,400	154,700*	150,000*	167,800*
Desulphurisatn	47,950	48,200	41,700	51,600	41,940	57,385
Sub Totals	**289,350**	**312,700**	**334,900**	**371,400**	**334,750**	**370,795**
Minor Markets						
Electrochemical	8,900	10,000	11,200	7,500	7,500	5,180
Chemical Uses	6,700	6,800	5,200	6,000	6,000	4,790
Metal Reduction	5,600	4,900	2,400	3,600	3,400	1,000
Gravity Casting	2,100	2,600	2,000	2,200	(with other)	1,860
Wrought Products	3,900	4,500	4,100	3,400	3,200	9,020
Nodular Iron	11,300	11,750	8,900	8,800	8,400	3,000
Other uses	6,350	7,500	6,800	8,000	10,400	9,330
Sub Totals	44,850	47,550	40,600	39,500	38,900	34,180
Totals	**334,200**	**360,250**	**375,500**	**410,900**	**373,650**	**404,975**

*Includes estimated recycled magnesium usage.

Table 4. Australian Magnesium Projects End of 2002

Location	Company/ Project	Capacity (t)	Op. Costs (lb)	Capital Cost (million)	Status
New South Wales	Pacific Magnesium	80,000	US$0.57	US$423	Looking for development assistance
Queensland	Australian Mag	90,000	US$0.66	US$952	Engineering and construction
South Australia	Magnesium International Pima/SAMAG	84,000 in two phases	US$0.57	A$628 for module one (41,000 t/y)	Financing being sought
Northern Territory/ Maylasia	New World Alloys Batchelor/Mt Grace	80,000	US$0.70	US$120	Buy Alcoa magnesium plant
Victoria	LaTrobe Magnesium	100,000	A$0.705	A$857	Bankable feasibility study

Table 5. Chinese Magnesium Production and Exports (t)

Year	1996	1997	1998	1999	2000	2001	2002
Production	73,000	92,000	120,000	157,000	195,000	195,000	234,700
Exports	49,126	78,116	99,937	137,000	165,000	173,400	180,000[e]

Source:Chinese Magnesium Association e=estimated