

MAGNESIUM

By Bob Brown, Magnesium Monthly Review

Magnesium production increased slightly in 2003, but there were some other very big changes that occurred by December 31, 2003. The year saw some very interesting and nostalgic occurrences. The production of the original Volkswagen Beetle came to an end after nearly 70 years of production in one form or another. Over 21.5 million Beetles were produced, each with 20-25 kg of magnesium.

Chinese producers increased their production and share of the world market for the 10th consecutive year, but ran into many difficulties that caused the price of magnesium sold into the world market to increase. Many orders were defaulted on because the costs of coal, electricity, and transportation created some hardships in both the ferrosilicon business and the magnesium business that is a heavy user of ferrosilicon for a reducing agent. Prices for ferrosilicon (which is power-intensive) increased from US\$500/t to over US\$800/t, directly affecting the production costs of magnesium by the Pidgeon process used in China.

By the end of the year there was a panic in the general market place and shortages forced the spot prices up. Customers with long-term contracts with major Western producers were not badly affected as the producers continued to fulfill their contracts at the negotiated contract prices.

Noranda's 63,000 t/y capacity Magnola magnesium plant in Danville, Quebec, started to produce metal in September 2000. The plant had struggled through 2001 and 2002 to overcome many problems in the feed preparation areas. By the end of 2002, nearly all of the cells were operating, but at a rate far below the design capacity. The plant was shut down and put on care and maintenance in April 2003. It has been estimated that it would take a year and C\$100 million to get the plant back into production.

Australian Magnesium Corp ran short of money during the initial phases of construction of the 96,000 t/y electrolytic magnesium production plant in Queensland. Fluor Corp was brought in to review the project numbers and agreed that an additional large amount of capital would be needed. Engineering and construction was halted and the project was shut down.

The International Magnesium Association, which was suffering from declining membership and loss of revenues, closed its Washington, DC offices and disbanded the local staff. The association's management was placed under a professional association management group in the Chicago, Illinois area.

The world's largest magnesium rolling mill facility was sold to the UK firm, Magnesium Elektron of Manchester. Spectrulite Corp was in Chapter 11 bankruptcy in respect of the large magnesium rolling and extrusion facility that

it had bought from Dow. The plant is located at Madison, Illinois in the greater St. Louis, Missouri area.

An investment company in Michigan purchased out of Chapter 11, Rossborough-Remacor, a diversified producer of reagents, additives and other magnesium-based products for the steel industry.

In Ohio, a very large magnesium fire, destroyed Garfield Alloys' magnesium recycling operations in Garfield Heights, just south of Cleveland. The fire was very large and spectacular and made the major world news reports for several days. Garfield had been in business at the site for over 50 years.

Magnesium consumption

Magnesium consumption has been growing over the past several years. Our estimates show that 2003 was a record year for magnesium usage (Table 1). Notably, there was a big increase in die casting, primarily for automotive uses.

The International Magnesium Association (IMA) gathered the basic consumption information up to the middle of 2003. Western companies supply much of the information, and usage numbers for the CIS and China were estimated from export and import statistics. The IMA is now not publishing the statistics and we have made estimates based on published statistics and some calculated assumptions.

Aluminium Alloying: the largest single use for magnesium has been in aluminium alloying. This market started growing with the aluminium beverage can. As can use has increased, there have been a number of changes in the designs to reduce the aluminium used. Originally there were 17 cans/lb of aluminium; today there are 29 cans/lb and the goal is 32 cans/lb. The body stock is 3004 series aluminium alloy, which is about 1% Mg and the lid stock (5182 series Al Alloy) is nearly 5% Mg. The can designers are working to build strength into the design, as the walls get thinner. They have also reduced the size of the lid. Shredded can scrap analysis showed 1.9% Mg at one time; it is now more like 1.6-1.7% Mg.

The other large use for magnesium in alloy form is in the sheets used for auto bodies. This market is growing very slowly as the steel research groups are coming up with stronger and lighter steel sheets. And the understanding of the maintenance and repair of aluminium and magnesium sheet bodies among car body repair personnel is limited.

Desulphurisation: the use of magnesium powder based reagents to remove sulphur from steel was a good market for magnesium in North America for many years. However, the North American steel industry is not growing. The rest of the world and the newer steel production processes do not use large quantities of magnesium. It is primarily used to remove sulphur from hot metal from the blast furnace in the torpedo car as it is being transported to the converters or BOF's.

Die-Casting: this is becoming the largest use for magnesium. The end die-castings are primarily going into vehicle production. However, this market is constantly under attack from aluminium, plastic and steel, all of which have larger and better-financed research programmes than magnesium. There has been a change in the general approach of the auto industry. As one automobile company spokesman said: "We do not buy magnesium, we do not buy castings, we buy components."

Other uses: other uses for magnesium were tracked by the IMA but it has had many organisational problems, and the gathering and publication of statistics seems to have been dropped when the office was moved. The usage of magnesium in the various categories for 2003 is based on extrapolated numbers and personal files

Representative magnesium price ranges for the year 2003 are shown in Table 2. We have added some latest information about price changes that are occurring in the first part of 2004. Chinese producers were cancelling their contracts for the first quarter of 2004, many of which had been signed in November 2003. Reportedly some of the prices were as low as US\$1,550/t. The weakened US dollar and the increased cost of production in China have prompted these seemingly drastic actions by the producers.

The price of magnesium sold is a transaction price. There are a number of existing places where the prices are published, but mostly it is historical. Many transactions are carried out with the terms and conditions kept secret. For many years, major metals publications gave a list price for magnesium and its alloys. There was very little correlation between what was printed and the real transaction price. There are price differences between various areas of the world and between various end users.

Anti-dumping duties in the European Union were doubled from 31.7% to 63.4% in the second half of 2000. However, with the closure of Pechiney Magnesium and Norsk Hydro Magnesium's smelter, there is no longer any magnesium production in the EU and the anti-dumping duties were officially dropped on April 1, 2003.

Magnesium metal, both alloy and pure, is sold into the market place by the world's primary producers, either directly through a company trade representative or a trading company. Chinese contracts and sales agreements are not always strong and binding, should the producer decide not to honour the agreement. The producer may decide not to fill the contract that a trading company made, even though it agreed to the terms at the time of the sale. If the price of spot market magnesium is considerably higher than the contract price, producers often just refuse to ship the metal.

This also happens on China's domestic market, and some Chinese companies buying pure magnesium for alloying purposes sometimes have trouble getting delivery if the Chinese domestic price increases.

Magnesium shipments from China and from the CIS have grown to approximately 65% of the total shipments of magnesium to Western markets, up from 56% in 2002.

United States

Primary magnesium production in the US in 2003 was estimated as 43,000 t. The only remaining US magnesium producer continues to be US Magnesium LLC (formerly MagCorp). US Magnesium operated the plant at the Great Salt Lake, near Salt Lake City, Utah using the same management and workforce. The 30 new electrolytic cells and plant modifications are nearly three years old. Cell life estimates for the new cells have been met and exceeded. The plant was recognised by the state government of Utah for its environmental upgrades, there having been a 95% decrease in toxic air emissions since 1996.

A UK company has bought the magnesium fabrication assets from Spectrulite Consortium Inc, after approval in federal bankruptcy court. Magnesium Elektron North America of Manchester bid US\$3 million for the remaining assets at the bankrupt foundry. The magnesium rolling mill is the largest in the world.

The Spectrulite plant originally covered 1,125,000 ft² and was operated by Standard Steel Spring. It was part of the wartime plant complexes built to provide necessary military products in the 1940s. Dow Chemical purchased it from the General Services Administration (US Government agency) in 1951. An 84 inch wide reversing mill, plus several other finishing mills were installed in the plant. Special melting and refining units comprising numerous magnesium melting furnaces were built. Continuous DC casting units were installed. The furnaces and caster set ups were designed to melt, refine, and cast continuously. The DC casters had flying saws to cut off the billets at standard lengths.

Spectrulite also has operations in Findlay, Ohio where it produces magnesium photo-engraving sheet and plate. This operation was part of the magnesium assets of Spectrulite.

Luxfer Group Ltd owns Magnesium Elektron (owned by Luxfer Group Ltd) is well-known worldwide as a producer of high-performance magnesium alloys, extrusions and powders, and is Europe's leading refiner of magnesium alloys for the die-casting industry Luxfer said that the Spectrulite unit will operate as Magnesium Elektron Wrought Products and Magnesium Elektron Graphic Arts Products.

In April 2003, Universal Alloy Corp of Canton, Georgia (a division of Alu Menziken Aerospace) bought Spectrulite's aluminium production assets, including the 14,000 t extrusion press, which it will move to Georgia and upgrade to 16,500 t/y.

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 financial resources. Garfield Alloys was put out of business by a major fire. Remag of Alabama suffered severe plant damage from a tropical storm and was closed at the end of the year as the owners reviewed the options available to them at the facility. MagReTech continued to operate, melting Class 1 scrap only.

Bioconvergence, Inc continues to operate a magnesium alloy turnings recycling plant in Niagara Falls, NY. It is reported to be looking at possibly melting the scrap and pouring magnesium ingots.

Canada

The Norwegian company Norsk Hydro is the largest primary magnesium metal producer in Canada, and uses 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.

Noranda Inc's 63,000 t/y capacity Magnola magnesium production plant at Danville, Quebec was totally shut down and the work force laid off. It is in care- and-maintenance mode and continuing to work to sell its technology. Noranda has signed an exclusive contract for the use of its AJ alloy family to BMW Group. Magnesium die-casting alloys for elevated temperature applications are coming of age. Many companies are working to sell their own proprietary alloy technology. Noranda's Mg-Al-Sr alloys are among some of the new systems that possess superior creep resistance and excellent high-temperature performance at temperatures up to 150-170°C and stress levels of 50 Mpa – 70 Mpa

The usage rights for engine block and engine accessories will be exclusive to BMW Group for a three-year period. Noranda's AJ alloy family is designed for use in high temperature systems where superior tensile properties, creep strength and bolt load retention are important. Until recently, appropriate magnesium alloys have not been commercially available to meet the demands of applications like automobile transmission cases and major engine components. The use of lighter-weight materials, such as magnesium in place of aluminium, can save up to one-third the weight of a similar part, which translates into improved fuel economy, reduced emissions and better vehicle handling through improved weight distribution.

Timminco is now owned by Safeguard Industries and continues to operate the 7,000 t/y silicothermic (Pidgeon) process plant at Haley, Ontario, and a magnesium extrusion plant in Aurora, Colorado. Timminco is going to start an active and aggressive programme to restore the company's profitability. The restructuring steps will involve closure and relocation of certain operations:

In April 2004, manufacturing of strontium and calcium products will cease at the Company's Westmeath, Ontario plant and production will be consolidated at its Haley, Ontario facility.

At the Aurora magnesium fabricated products facility outside Denver, Colorado, a portion of the anode fabrication operations will be relocated to Mexico.

Magnesium Alloy Corp (Mag Alloy) has plans to become a low-cost producer of magnesium metal. The group continued to work during 2003 to get funding in place for the 60,000 t/y Kouilou magnesium project in the Republic of Congo. The plant site is to be in Point Noire, a port city on the Atlantic Ocean. 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. The contract calls for rehabilitation of a hydroelectric power plant and transmission of power to the Kouilou plant site. Mag Alloy also signed a preliminary offtake agreement with Stahlex Metals (formerly Stinnes GmbH) whereby Stahlex will purchase and market up to 100% of the magnesium and magnesium alloys produced at the plant. The group has regionally exclusive rights to magnesium extraction technology from the Russian and Ukraine National metals institutes, VAMI and UTI.

Globex Mining continued to work on the development of a magnesium production plant.

Leader Mining International signed an operating agreement with Emil Anderson Construction (EAC) for quarrying, ore transportation, residue management and other earthworks for the Cogburn magnesium project located near Hope, British Columbia. This agreement expands the December 2001 agreement between the two companies for road building, road maintenance, drill site preparation and geotechnical test pitting for the recently completed Cogburn feasibility study.

The agreement includes EAC forming a 50:50 jv with local First Nation bands to perform the earthworks activities stated in the agreement. Leader Mining presented the jv concept in public meetings held with local First Nations bands and the communities of Hope and Agassiz during 2002.

In May 2003, Leader received a positive production feasibility study for Cogburn from Hatch Associates, indicating that the US\$1.24 billion project (131,000 Mt/y plant) was technically feasible and economically viable. Based on the positive results, Leader is said to be entering a more aggressive phase with potential major financial and operating partners for project development.

Brazil

Brasmag has continued to run its special process silicothermic plant at Bocauiuva. The plant is estimated to have produced 9,000 t in 2003. The plant uses a special modified silicothermic (Bolzano) process developed by Ravelli.

The company has been investigating other technologies, but no decisions had been made by the end of 2003

Norway

Norsk Hydro AS continues to run the 20,000 t/y capacity magnesium-casting plant in Porsgrunn. The plant remelts scrap and some imported pure magnesium. Norsk Hydro has doubled capacity at its recycling plant at Bottrop in Germany to 15,000 t/y.

The Netherlands

Antheus Magnesium formed a jv with Remag of Austria and is now operating a 10,000 t/y magnesium recycling plant in northern Holland. Scrap is obtained from the various magnesium-casting operations in Europe. The plant is owned 40% by NOM (Agency for Development of Northern Netherlands), 40% by Remag Recycling GMBH and 20% by a private owner. The Remag Alloys plant will mostly work on a tolling basis, turning scrap magnesium from die-casters into ingot and returning it to them for re-use. The plant's location was chosen because of its proximity to a wide range of metal companies that share the same type of engineering and contractor services. In a recent move to help the northern provinces of the Netherlands, the Dutch Government has made grants of federal aid to several plants in this area, including €1.4 million (US\$1.73 million) to Dutch magnesium metal producer Retag Alloys in Grainger, in the northern Netherlands.

France

Pechiney halted production of primary magnesium at its Magnetherm process plant in Marginal, France.

Iceland

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

Serbia

Bella Sterna operates a Magnetherm process plant and is estimated to have produced 2,000 t in 2003.

Germany

Tyson Krupp Stahl AG continues to work with Magnesium Flat Products at Freiberg. The company is participating in a project to produce magnesium strip by continuous casting on a twin roll caster. The company also signed an offtake agreement for all of the magnesium produced by Magnesium International, the Australian group that is searching for a project site for a primary magnesium production plant.

Sweden

Finnveden, the Swedish component supplier, has signed a five-year contract with Spanish seat specialist Grupo Antolin. Under the contract, Finnveden will supply seat sides made out of magnesium to the Spanish company. The contract is worth around SK200 million (US\$27.5 million) over the five-year

period. Finnveden's Metal Structures division will handle the supply contract. Finnveden's expertise in magnesium cast part and structures will put the company in a good position in the future as carmakers are increasingly looking at ways to reduce the weight of their vehicles to improve their fuel consumption performance. Finnveden's Metal Structures division was created in 2003 following the merger of its Sheet Metal Components division and Finnveden's die-casting plant in Sweden.

Saudi Arabia

Dass Al-Khaleej Co was reported in 2002 to have 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. No further word was available on any work in 2003.

Israel

Dead Sea Magnesium (DSM), the 65% Israeli-owned company continued to produce magnesium in 2003 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. SMZ is Russia's second-biggest magnesium producer and exports almost all of its rare-earth metal products and about 60% of its magnesium and alloys. There was a rift on the SMZ board during the summer of 2003 caused by a dispute between the largest shareholder, Russia Growth Fund, and finance company ZAO FTK Co, a minority shareholder. There was a linked dispute over the marketing of Solikamsk's products in North America. In October, Russia Growth Fund sold its share in SMZ to Silvinit, a Russian-

Ukrainian company based in Solikamsk, giving Silvinit 56% of the shares. A new board was elected with seven representatives of OJSC Silvinit, seven from Swiss magnesium trader Minmet and one from ZAO FTK.

Pavel Detkov was elected as general director of SMZ at a board meeting on November 2, 2003, receiving 99.6% of the votes at an extraordinary shareholders' meeting, with no negative votes cast. The election of Mr Detkov, who worked for many years as SMZ's sales director before moving to Minmet Financial Co, should help bring about a unified sales strategy

Avisma's magnesium operations continued to struggle in 2003. 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 all-Russian board of Aluminum-Magnesium Institute (VAMI) was joined by managers from Russian Aluminum (Rusal), which acquired a 90% stake in the institute and promises to invest US\$1 million in its development. VAMI closely co-operates with Rusal, which accounts for 90% of the institute's order book. VAMI specialists have developed projects including Rusal's Sayanogorsk aluminium smelter's second phase construction, the upgrade of the Krasnoyarsk smelter, the Achinsk alumina refinery and the Nikolayevskiy refinery. Rusal had already been one of VAMI's several large shareholders, holding a 23% stake via Krasnoyarsk AZ. At the beginning of 2003, 25.47% was held by Aly-Key, an offshore company (Cyprus), 15.4% by Mining Metallurgical Technologies Co and 7.1% by Evrostep SA (France).

The new board of directors was elected by the shareholders at an extraordinary meeting of VAMI held on December 10, 2003. The board was joined by 11 managers from Rusal and the director general of VAMI, Viktor Chzhen. In 2004, Rusal plans to invest US\$1 million in VAMI. Under the new ownership, VAMI will be limited in what contractual work it performs for the general light metals industry, and will not undertake work if it is determined that it would affect the realisation of Rusal's current projects. Its magnesium work will continue under the parameters listed.

In the Sverdlovsk region, Russia's second largest aluminium maker, SUAL, has set up a company with Uralasbest to recycle the latter's magnesium-rich waste from asbestos production. The project will cost between US\$100 million and US\$300 million, which will be recouped in six years, depending on the plant's future output. The least expensive option would be to set up magnesium production at the Malyshevskoye mines, making use of their existing buildings and concentrating plant. Such a project would cost about US\$100 million. The waste that Uralasbest produces has an Mg content of 20%-25% and asbestos content of 1%-2%. More than 4,000 Mt of serpentinite – the waste left over from asbestos production – has built up at Uralasbest. This too, has a magnesium content of 20%-25%, and is growing by 30 Mt/y. Uralasbest employs over 10,000 people in the one-company town of Asbest, and is one of the world's largest producers of chrysotile asbestos and construction materials.

The company produces 24% of the world's asbestos and supplies 60% of Russia's needs. The company operates the Bazhenovskoye asbestos deposit, the largest in the world.

Ukraine

ONVI Ltd operates a small magnesium-atomising operation that makes products for desulphurisation from scrap metal purchased on the world market. ZTMK, a state-owned, titanium producer also produces goods made from magnesium, germanium and silicon.

The Ukraine has two magnesium plants, Zaporoshe and Kalush. Zaporoshe has a rated capacity of 40,000 t/y and Kulush has a rated capacity of 10,000 t/y. The Ukrainian Titanium Institute has worked with VAMI and the National Aluminum and Magnesium Institute to develop magnesium electrolytic production processes. There is some interest in reopening the Kulush plant, which has been out of production for several months. The government of Ukraine has offered Chinese corporations the opportunity to take part in a number of major investment and privatisation projects, and China has agreed to consider several projects, one of which is the possibility of a joint venture to produce magnesium in Ukraine.

Kazakhstan

There were no production figures available for the Ust Kamenogorsk magnesium plant. The Kazakhstan Government was trying to sell its 15.5% share in the Ust Kamenogorsk Titanium and Magnesium Combine, also known under its Soviet-era abbreviation UKTMK. Located in eastern Kazakhstan, UKTMK produces high-quality titanium sponge and magnesium. Belgium's Specialty Metals owns 65.77% and ZAO Central Securities Depository 7.28%. In 2003, the net profit of UKTMK, audited to international accounting standards, totalled Te1,200 million or US\$7.8 million (US\$1 = 139.50 tenge)

South Africa

Mintek and a consortium comprising Anglo American, power utility Eskom Holdings, and the Department of Science and Technology, have been working on the Mintek Thermal Magnesium Project for three years. The aim is to develop a continuous thermal process so as to minimise the number of operators required and to achieve efficiency gains. Mintek feels that the labour-intensity of the Chinese batch process is not an issue in that country, given the low labour costs there, but would add to costs significantly in other parts of the world. The project is expected to cost R45 million, of which, R35 million have been committed by the consortium partners. Eskom has thrown its weight behind the project as it stands to benefit from an energy-intensive magnesium industry in South Africa; Anglo American hopes that successful development of continuous thermal magnesium-production technology could form the basis of a feasibility study into a magnesium project, possibly in the Western Cape, in which it would play a leading role.

In 2003 Mintek established the technical feasibility of producing liquid

magnesium at atmospheric pressure, with continuous extraction of magnesium (typically over 80%) from the feed material and effective (about 75% efficiency) condensing of magnesium vapour in the novel liquid-phase condenser system. The 2003 report says that a particular achievement was the successful on-line tapping of liquid magnesium directly from the condenser during operation of the plant – a world first for such technology. A novel condenser design has been patented, and further runs will aim at achieving 48 hours of continuous operation and confirming the target recovery of liquid magnesium from vapour. Additionally, Mintek plans to fast track R&D on the final refining and alloy-making stages and, in conjunction with industrial partners, the downstream manufacture of commercial products.

Australia

By the start of 2003, there were three projects that seemed to be active in magnesium. Australian Magnesium officially shut down engineering and construction on the 91,000 t/y Stanwell primary magnesium plant in Queensland. The company has been modified into groups to continue to sell its technology. Magnesium International (formerly Pima Mining) has a 100% offtake agreement with Thyssen Krupp Metallurgie. The company has proposed several plants of various size, approach and location. The plant will use magnesium production technology licensed from Dow Chemical Co. Magnesium International has been working diligently to identify a plant size and to select a location and to find the financing for the project, but was still unsuccessful by the end of 2003.

LaTrobe Magnesium (formerly Rambora Technologies Ltd) 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. A prefeasibility study estimates that a 100,000 t/y magnesium metal plant will cost A\$857 million, with an estimated direct production cost of A\$0.705/lb.

Latrobe is discussing the technology to be used with several of the world suppliers of magnesium reduction technology. International Power owns the Hazelwood Power station, the site planned for the plant. If it goes ahead, Latrobe Magnesium will sign a 200 Mw power offtake agreement with Hazelwood.

CSIRO (Commonwealth Scientific & Industrial Research Organisation) is running an industrial-scale pilot plant now producing near-net-shape, or close to production thickness, low-cost magnesium sheet. CSIRO has now completed successful installation of a new coil line for its magnesium sheet plant, and the first coils of magnesium sheet of 60 kg each have been supplied to one of the leading manufacturers of magnesium-forming products in Japan for rolling and forming trials.

Magnesium sheet is used to produce a new generation of stronger, lightweight motorcars, DVDs, printers, cameras, computers and many other

consumer goods. Previously, its commercial uptake has been hindered by the high cost and availability of magnesium sheet.

The CSIRO Twin Roll Caster aims to produce as-cast magnesium sheet in commercial quantities using patented CSIRO systems specifically developed for handling molten magnesium. CSIRO has been developing technology to cast magnesium alloy sheet since 2000. An exhaustive proving programme has demonstrated its technology is reliable, low-cost, efficient and potentially suitable for both continuous (large) and batch (small and medium) production, and for producing good-quality magnesium alloy sheet from a large range of conventional and new magnesium alloys.

Commercial quality sheet samples from 2.3–5 mm thick have been successfully cast in standard alloys (AZ31, AZ61 AM60 and AZ91), along with new magnesium wrought alloys. These samples have already been rolled down to 0.5–0.6 mm gauges, using a unique finish-rolling schedule developed by CSIRO specifically for cast magnesium alloy sheet.

Japan

Nippon Kinzoku Co Ltd plans to double its magnesium alloy sheet production from the current 5 t/mth to 10 t/mth in the April-June period on the back of a contract to supply alloy sheet to Casio for use in digital camera cases, the company said April 9, 2003. The newly-supplied AZ31B magnesium alloy sheet, which contains 3% Al and 1% Zn, enables the weight of the camera to be cut by 20% from existing models, according to the company. Nippon said it had received a number of inquiries for the alloy sheet as a raw material to make mobile PC chassis.

Bhutan

The Kingdom of Bhutan has a company that produces calcium carbide and ferroalloys including magnesium ferrosilicon. Owners of Bhutan Carbide and Chemical Ltd are reviewing technology for a small primary magnesium plant that would be located in Bhutan. It is reported to be in discussion for a newly piloted silicothermic process that would use an electric retort.

China

The Chinese magnesium industry was thriving and growing throughout 2003. Production reached 354,000 t, and exports of magnesium in all forms reached 298,000 t. Total annual production capacity is estimated at 600,000 t, and plant expansions are being announced every day. In spite of increased prices due to the internal problems with coal, electricity and transportation, China's magnesium sales continue to be strong.

China continues to consume more and more magnesium and this takes some of its available magnesium production off the world market. The domestic use was about 52,000 t in 2003 and is projected to expand to 100,000 t by 2007.

Magnesium may be heavily used in Chinese auto manufacturing. Many of the world's automakers are planning to start or expand production of cars in

China! Car sales grew by 68% in 2002 and by 80% in 2003. The potential market is very large as there are only eight cars for every 1,000 people of driving age. In the US, the ratio is 1:1. By 2007, analysts project that China will be able to produce 15 million vehicles annually. By 2020, it is expected to become the world's largest auto sales market, surpassing the US.

The Chinese magnesium industry is expanding its downstream product market. Die-casting, extrusion and rolling projects are all being implemented or considered. It is an excellent opportunity to help magnesium gain more acceptance into auto production. The more progressive magnesium fabricators and alloy producers from around the world are aggressively reviewing the various possibilities of participating in this market.

Hydro Magnesium's 10,000 t/y remelting plant in Xi'an has received ISO 9001:2000 as its first external certification after the start-up in 2002, and has proven its effective quality management systems. Hydro put in place Chinese-built equipment based upon Hydro cast-house technology, and operates the plant with a 100% local workforce. The successful ISO certification has proved that effective management systems are in place. "It has been challenging to compile all the required documents and ensure compliance. We received strong support from our magnesium plant in Porsgrunn, Norway. The staff in Xi'an are very proud about the certification and publicly celebrate it by placing a banner above the main entrance", says Zhang Huiping, manager of the quality department. The plant succeeded with its target to reach the ISO 9001:2000 certifications, but Mr Huiping is already working to achieve other external certifications including ISO TS 16949.

Meridian Technologies Inc, the world's largest supplier of magnesium die-cast automotive components and assemblies, signed a JV agreement in June 2003 in Shanghai, China with SCAAC, a subsidiary of Shanghai Automotive Industry Corp (SAIC), to manufacture automotive die-castings starting later this year. The total investment will be US\$20 million, with Meridian owning 60% of the JV. The facilities will be strategically located in the Shanghai Anting Automotive Supplier Industrial Park. The agreement represents Meridian's first strategic expansion into the Asia-Pacific region and follows its latest successful launch of a similar UK facility earlier this year. John Chen will head the operation in China.

Volkswagen will follow the example of Ford and GM and begin sourcing parts (including magnesium die-castings) for its global operations in China, which is VW's largest market. It expects to sell more than 600,000 cars in 2003. The automaker will boost its production capacity in China to close to 1.5 million cars and light trucks over the next five years by building a new plant in Changchun and adding capacity at Shanghai Volkswagen. Ford has said it will source US\$1 billion in parts from China this year, and GM has announced plans to source US\$10 billion in parts there, without naming a time frame.

Minhe Magnesium Plant in Qinghai Province suffered a power supply problem. The company, which has a 7,000 t/y ingot capacity, cut output by 50% at the

end of March, 2003 as a lack of rain reduced its hydroelectric power supply. Minhe expected to produce between 3,000-4,000 t of ingot in total for 2003. The electrolytic production of magnesium was not restarted after April 2003, but production of ingot continued by procurement of magnesium from other producers.

There is a continuing effort to build industrial projects in this western province of China. A large electrolytic magnesium plant has been discussed for several years. It is well known that Qinghai is rich in mineral resources, which are mainly concentrated in the Chaidamu Basin. There is also one of China's four largest resources of natural gas. The magnesium project that has been discussed will use the magnesium-rich resources of the Chaidamu Basin Salt Lake, natural gas, hydropower, and technologies using natural gas-acetylene and electrolysis of $\text{MgCl}_2 \cdot 6 \text{H}_2\text{O}$ for producing magnesium metal and chlorine.

This project is planned either for Golmud City or in the Economic Zone to the southeast. There are good infrastructure systems in place such as water supply, telecommunications, and a transportation system for raw material and final products. Qinghai Western Chemical Co (QWC) is the main group working to bring industry to the province. It hopes to produce magnesium metal, magnesium alloys, acetylene (from natural gas), VCM/PVC and methanol. The first phase is a 50,000 t/y magnesium metal production plant. See www.western-chem.com

In December 2002, QWC reached a JV agreement with Magtech Co Ltd for the construction of a plant to up to 20 million magnesium castings per annum. The project is expected to generate annual sales worth US\$36.23 million.

In April 2003 it was reported that Magtech, a magnesium alloy producer, based in eastern China's port city of Qingdao, had received an injection of US\$28 million from Singapore-based MMI Holdings Ltd for a joint venture magnesium alloy project. Because of the investment, Magtech expects to receive an additional investment of US\$20 million from MMI during the second phase of the joint venture, which should enable the supply of magnesium alloy-made components to manufacturers of mobile phones, laptop PCs, digital cameras and hard disk storage components.

Magtech was co-founded by Beijing-based Qinghua University, Shanghai-based Jiaotong University and three companies in Qingdao and Hong Kong, and has a registered capital of RMB4 million (US\$483,000). Magtech mainly engages in the development of magnesium resources, developing magnesium alloy smelting technology and processing equipment, commissioning magnesium alloy production, and the domestic and international trade of magnesium alloy products. The company has been selected by the Chinese Government to be the state industrial base for the research and applications of magnesium alloys. It is now capable of producing 200,000 aluminium alloy castings on a monthly basis.

Taiwan

Taiwan has formally approved the establishment of a magnesium alloy association. The Taiwan Magnesium Association became a legal entity in July 2003 although it had begun informal operations informally in 1999. Paul Cheng, president of Gatetech Technology Inc, was elected as chairman of the board. There were 63 registered member manufacturers and 42 individual members. The members include the important related manufacturers and important personnel from research institutes. The number of members is increasing as interest in magnesium continues to grow.

The TMA aims to combine the industry, government, academic and research sectors related to magnesium, and jointly promote the magnesium industry and its technical development. In 2002, consumption of magnesium metal in Taiwan (including pure magnesium) reached 11,076 t. Magnesium alloy made up 6,470 t. It is estimated that Taiwan's consumption of magnesium will reach 15,000 t and magnesium alloy will be 8,000 t in 2003.

The number of notebooks (laptop computers) adopting magnesium alloy chassis is expected to double from the 2003 level of 6.0-7.5 million units, according to estimates by Taiwanese magnesium alloy manufacturers. Global notebook sales are expected to reach 36 million units in 2003, of which 13-15 million have at least one sheet of magnesium alloy in the chassis, according to the manufacturers.

Major notebook brands, including Dell, Hewlett-Packard, Samsung Electronics, and Apple Computer, have increased their orders to Taiwanese magnesium alloy manufacturers significantly, because the Taiwanese have managed to offer thinner and lighter products at lower costs than their competitors. Samsung expects to order over one million sheets of magnesium alloy from Taiwanese suppliers in 2003. Dell also expects to see about 60% of its notebooks adopting at least one sheet of magnesium alloy this year, sources said. Some of the Taiwanese magnesium alloy manufacturers are now producing 0.80 mm magnesium alloy sheets for use in notebook chassis. As the thickness of the magnesium alloy can now be less than 0.90 mm, notebook chassis made with the alloy become lighter in weight than plastic chassis, local manufacturers said.

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. Whereas die casting remains the main area of interest in the auto market, both magnesium sheet and magnesium extrusions are receiving research and development attention.

Magnesium die-casting in Germany is on the increase. It reached 23,000 t in 2003, compared with 20,600 t in 2002 and 18,300 t in 2001. This excludes sand- and low-pressure castings, which are estimated to be running at 500-1,000 t/y. In addition to production growth in Germany, some die-casters are shifting part of their production base to eastern European countries in the

pursuit of cost savings. This will of course reduce output of magnesium parts in Germany, but it has little or no bearing on overall original equipment manufacturers' (OEM) magnesium consumption rates.

BMW is focusing on research and technology to develop materials that can make its cars lighter. The weight savings can be used to increase performance, or in specific areas to aid the vehicle's weight distribution or just to counteract the added mass of modern safety and emissions equipment. One of the more remarkable lightweight building blocks for BMW is magnesium.

It would have hardly seemed like the ideal metal to use for a powerful six-cylinder engine. However, BMW is using the metal as a key ingredient. Magnesium weighs 33% less than aluminium and is 77% lighter than steel. Its limitations (reacting with water in a water-cooled engine is a fairly major limitation) mean aluminium still has to be used, especially in the heart of the engine where temperatures are hottest and pressures greatest, and in components that come into contact with the cooling system.

But a composite crankcase that has magnesium around an aluminium insert means the six cylinder engines being built at the BMW plant at Landshut, Germany weigh 10 kg less than if they were made purely from aluminium. It is a saving that goes straight to the bottom line in terms of performance, handling, fuel economy and even CO₂ emissions.

Magnesium alloys are already being used for some components in the 7 Series and 5 Series, along with the new Rolls-Royce Phantom. The magnesium alloy composite engines, on the other hand, are still two years away from regular production. BMW says it is scheduled to introduce magnesium to its engines by 2005 in a bid to save weight. The material is said to be 77% lighter than steel and stronger than aluminium when used in engine blocks, and likely to save 10kg when used in a standard four-cylinder crankcase.

In the redesign of the Jaguar XJ, magnesium is used for the steering column panel (IP), which runs the width of the car behind the dashboard. In steel, it would be very heavy. In magnesium, it can be lifted easily with one hand and represents a 30% weight saving over aluminium. The magnesium steering column locator not only saves weight, but it is stiffer than steel, which steadies the steering column and contributes to better handling.

German carmaker Audi, a unit of German vehicle manufacturer Volkswagen, plans to launch on the Spanish market its allroad vehicle Audi V8 Quattro. The car is equipped with a 4.2 litre, 300 hp engine and can develop from 2,700 to 4,600 rpm. The model has five-speed, Tiptronic automatic transmission with Dynamic Shift Programme, which allows an acceleration from 0 to 100 km/h in 7.2 seconds. The car can reach a maximum speed of 240 km/h. Audi V8 Quattro will use magnesium components. The engine weight of the Audi V8 Quattro model has been reduced by some 11 lb (4.99

kg) compared with other Audi eight-cylinder engines. Tiptronic is a registered trademark of Audi.

The new 7G-TRONIC seven-speed automatic transmission will be a standard feature of the Mercedes E 500, S 430, S 500, CL 500 and SL 500 models from autumn 2003, replacing the five-speed automatic version currently fitted. Despite significant technical advances, the 7G-TRONIC automatic transmission is barely any larger or heavier than the five-speed automatic transmission currently fitted in Mercedes passenger cars. Credit for this impressive achievement goes in particular to the transmission casing, which is constructed in lightweight magnesium - also a world premiere in volume production. The new seven-speed automatic transmission will be produced at the Mercedes plant at Stuttgart-Unterturkheim, the original location of the company's very first production facility. DaimlerChrysler has invested some €400 million at the plant in the construction of a new complex of buildings containing state-of-the-art production equipment and installations for around 1,100 employees.

The new Porsche Carrera GT will use magnesium wheel rims supplied by BBS and a magnesium console supplied by Stoflig. The total number of car units produced will approximate 1,500.

Table 1. Consumption by major markets (t)

Market segment	1999	2000	2001	2002	2003^e
Aluminium	159,800	165,100	142,810	145,610	137,000
Alloying					
Die Casting	133,400	154,700*	150,000*	167,800*	179,000
Desulfurization	41,700	51,600	41,940	57,385	75,000
Sub totals	334,900	371,400	334,750	370,795	391,000
Minor markets					
Electrochemical	11,200	7,500	7,500	5,180	6,000
Chemical Uses	5,200	6,000	6,000	4,790	5,000
Metal Reduction	2,400	3,600	3,400	1,000	2,000
Gravity Casting	2,000	2,200	(with other)	1,860	2,000
Wrought	4,100	3,400	3,200	3,100	8,000
Products					
Nodular Iron	8,900	8,800	8,400	3,000	5,000
Other uses	6,800	8,000	10,400	9,330	9,000
Sub totals	40,600	39,500	38,900	28,260	37,000
Totals	375,500	410,900	373,650	399,055	428,000

Table 2. Representative magnesium prices in 2003 (98%+ Mg)

Period 2003	US Western US\$/lb		US spot dealer import US\$/lb		Eur free mkt US\$/t		Metal/ Bulletin Free mkt US\$/t		Chinese free market US\$/t	
1st Q end	1.05	–	1.01	–	1,650	–	1,950	–	1,550	–
	1.12		1.08		1,800		2,000		1,600	
2nd Q end	1.05	–	1.01	–	1,750	–	2,000	–	1,620	–
	1.12		1.08		1,850		2,050		1,650	
3rd Q end	1.05	–	1.03	–	1,850	–	1,760	–	1,620	–
	1.10		1.08		1,950		1,810		1,650	
4th Q end	1.10	–	1.05	–	1,850	–	1,850	–	1,650	–
	1.17		1.10		1,950		1,950		1,660	
2004										
1st Q middle	1.15	–	1.10	–	1,850	–	1,850	–	1,850	–
	1.20		1.15		2,000		2,000		2,000	

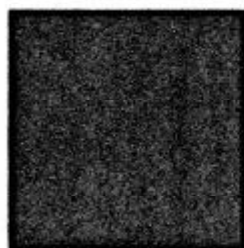
Source: US Geological Survey – Quarterly Commodity Reports

Table 3. World magnesium production

Country	1996	1997	1998	1999	2000	2001	2002	2003
US (1)	143	140	117	85	74 ^e	43	35	43
Brazil (1)	11	9	9	7	9	9	7	6
Canada (3)	52	54	57	54	55 ^e	65	86	50
PR of China (85e)	56	92	120	157	195	195	232	354
France (1)	11	16	15	17	17	7	0	0
Israel (1)	--	7	25	25	25 ^e	30	34	30
Kazakhstan (1)	12 ^r	15 ^r	15 ^r	15	10 ^e	10 ^e	10 ^e	14
Norway(1)	38	52	49	52	50 ^e	35	10 ^e	0
Russia (2)	51 ^r	51 ^r	53 ^r	56 ^e	40 ^e	50	52	45
Ukraine (2)	13 ^r	7 ^r	6 ^r	6 ^e	2 ^e	2 ^e	0	0
Serbia (1)	2	3	3	1 ^e	2 ^e	2 ^e	2 ^e	2
India (1)	1	1	1.5	1	0.5	0.5	0	0
Total	390	447	470.5	476	479.5	448.5	467.7	544

Source: USGS, IMA, CMA, Author Estimates e=estimate r=revision

() = number of plants in the country



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