C O B A L T N E W S

PUBLISHED BY THE COBALT DEVELOPMENT INSTITUTE

06/1 January 06

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ISSN: 1353-5587

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COMMENT

Without doubt, the most significant event of 2005 was the agreement on REACH by the European Union Council of Ministers at its meeting of 13 December.

In mid November, the European Parliament had voted on more than 1,000 amendments to REACH proposed by the various stakeholders. The amendments proposed by the metals industry and largely accepted by the European Parliament, included issues such as the scope of REACH, recognition of the special situation of alloys and metals in the massive form and the role of substitution in authorisation. The meeting of the Council of Ministers on 13 December confirmed most of the compromises reached in Parliament.

In addition, ministers relaxed the conditions set by Parliament for authorisation of the most hazardous chemicals. Whereas Parliament had wanted mandatory substitution of hazardous chemicals with safe ones where alternatives exist, ministers agreed that companies seeking authorisation for hazardous chemicals would have to prove that the risks could be adequately controlled and provide information on possible alternatives.

The second reading of the legislation is due to come before the European Parliament in 2006 where these issues will again be considered.

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The Current Legislative Developments in the EU Waste Policy: Challenges or Opportunities for the Metals Industry

Patrick Van den Bossche – Director, Agoria

This article is based on a presentation given by Patrick Van den Bossche at the Eurometaux Environmental Health and Safety Seminar in October 2005.

Recycling is an essential part of the metals industry due to the unique properties that metals possess, these include:

- Durability, physical & chemical properties
- Enhanced life time of products
- No degradation, metals are infinitely recyclable
- Recycling and the associated energy savings

The recycling of metallic raw materials is both economically and environmentally important, yielding a significant impact on materials availability and considerable benefits to manufacturers and consumers. This is also an area of industry that is already competing on the international stage.

Metals recycling is already a reality in Europe, with between 40 to 60% of Europe's metal output coming from recycling. However, this figure is limited through the long life cycle of metal applications and market access conditions. When discussing the recycling efficiency of available metals, this figure reaches 60 to 90%, with the percentage being dependant on the metal itself, the quality of input stream and market prices. Potential improvements could be made by addressing a better collection at the end-of-life for the product in question and ensuring that the recycling processes are optimised. Currently Europe is the world leader in the recycling of base, precious and high-tech metals, with a range of companies that possess unique and complex inter-related process flow sheets. Many of these companies have repeatedly proven themselves to be versatile to new materials, adapting to new market challenges as they occur.

However, there are a number of challenges for the European Non Ferrous Metals (NFM) Industry. These include the availability of raw material, as Europe depends highly on the import of primary as well as secondary resources. The high social and environmental costs compared with other areas of the world are surely a challenge to maintain the competitive position of European industry. Furthermore, recycling in Europe is burdened by cumbersome waste legislation which leads to a further degradation of competitiveness in Europe.

An Overview of EU Waste Legislation

There are two main aspects to EU waste legislation. Firstly, the global horizontal framework which is held within the thematic strategies. These concentrate on the recycling and prevention of waste and incorporate the link to other environmental strategies, such as the resources strategy and the global sustainability framework. The vertical legislations within this strategy are the **Waste Framework Directive** (possible Revision forthcoming), **Transport of waste** (at 2nd Reading in the European Parliament), **End of life – recycling** which sub divides into *Vehicles (ELV)*, *Electronic Equipment (WEEE)* for both of which revisions are foreseen, *Batteries* which is at its 2nd Reading in the European Parliament and *Packaging waste*. Amongst others, there is also the **Co-incineration of Waste** and **Landfill Directive** to take into account.

In constructing the thematic strategy on the Prevention of waste and recycling, the European Commission has revisited the global framework around the European waste policy. The objectives of the Commission in this framework include:

- New approach – link with resources thinking,
- Integrate life-cycle thinking into the legislation,
- Focus on environmental impact,
- Introduce clear objectives and criteria, as well as to
- Tackle the real problems which include the End of waste scenario examining recovery and disposal as well as recycling

The Commission's proposed solution to the end of waste problem is a possible revision of the Waste Frame Directive to set a framework featuring Conditions, criteria and minimum standards. The EC will conduct studies to determine the first wave of waste streams and criteria to be examined and

will elaborate indicators for the identification of the relevance for this approach to certain waste streams. This will follow a comitology procedure within the Technical Adaptation Committee for waste policy. The decision on the specific waste stream will then be officially published as an Annex of the WFD and enhance therefore a coherent enforcement within the European Union.

Whilst this is a positive signal by the Commission, it unfortunately lacks the requisite global approach in strategy needed by ignoring the fact that metals operate in a global, international market. The availability of metals in Europe is distorted through several restrictions which will lead to a negative impact on competitiveness and a negative impact on the global environment. It has to be remembered and acted upon that “Wastes" for recycling are high value resources for our industry.

Whilst we see some positive signs, where is the integration of the thematic strategies in the broad sustainable development framework which the Commission is promoting? Below are some examples which indicate that more progress needs to be made in this matter.

Waste and REACH. In contradiction with sustainable development?

The first Commission proposal on REACH gave no clear exemption of waste for recycling in the scope of REACH. The impacts of this omission, if left out in later drafts, is huge, as supplementary requirements (such as registration & authorisation) for secondary raw materials do not encourage recycling. The very large number of recycling streams will lead to a high number of registrations and most of the times will even lead to authorisation procedure. This would require a large economic and staff time investment from the industry which will further degrade the competitive situation of industry. The environmental impact of recycling is controlled through application of IPPC & BREF notes to the non-ferrous industry, supplementary costs and obligations will have a negative effect on availability of waste (export/import) which overall will mean that innovation & investment in recycling technology become less interesting for companies within Europe and therefore there would be a potential negative impact on recycling.

A solution would be the exception of waste from REACH (art. 2, scope) for which there is currently a broad recognition of the problem and the solution in both the European Council and the European Parliament. But what about the proposed solution for the end of waste, when waste ceases to be waste and becomes a secondary raw material. Will this require registration/authorisation under REACH? This demonstrates that a pragmatic approach is required to solve this problem.

End of Life Legislation: An opportunity or a threat for metals?

In the end of life legislation, several attention points can be identified for the NFM industry. All end of life legislation integrate a "ban" of certain substances. However, the reasons given are often emotional rather than based on sound scientific and technical ground such as:

- Enhancing recyclability through reducing the presence of hazardous material,
- Limiting environmental impact during recycling or landfill operation,
- Limiting the use of 'heavy' metals – an often poorly defined or undefined term.

In these decisions, there is little or no use made of the information from existing Risk Assessments Report (RAR). For instance, the Batteries directive proposes a ban on Cd and Pb, but not only did the targeted Cd RAR of NiCd batteries show that there was no harm to human health or the environment from this application but the voluntary Pb RAR also demonstrated no harm on human health & environment from lead batteries over the life cycle.

From the Non ferrous Metals Industry viewpoint, the consequences & impacts are clear, the lack of recognition regarding the effort put in RAR is clear as the outcomes of the RARs are not used appropriately nor mentioned or even completely ignored by the law makers. This does not bode well for the interaction between Industry and the European regulators when REACH enters into force. The batteries directive discussion saw endless discussions on feasibility of substitution and the need for exemptions combined with the supplementary problems of the presence of impurities in other materials. The potential break-down of the recycling chain was also ignored resulting in a mostly unjustified ban without taking available scientific information into account which is in principle not acceptable by the NFM industry! This clearly demonstrates the need for open scientific dialogue between Industry and Regulators which can lead to the proper use of the generated scientific information.

Within the concept of eco-efficiency integrated in most end of life legislation, it is acknowledged that metals have unique properties and that innovation requires industry to do more with fewer resources. Currently the customer sectors are driving this process

Collection and recycling targets are introduced within the End of Life directives and in certain cases the producers of these equipments intervene in existing recycling chains. Collection and recycling targets normally enhance metals availability for recycling, but intervention in economic driven recycling streams can also have a negative impact

given the supplementary administrative burden and costs.

Finally, in this End of Life discussion we look at the technical obligations for treatment such as partly given in the WEEE directive. The actual strategy under End of Life is a focus on the recycling of all materials rather than the implementation of differentiated strategies for different materials (a need highlighted in the five winds study (http://www.icmm.com/library_pub_detail.php?rcd=7)). Sometimes this approach is incompatible with existing technology and does not provide additional environmental or economic benefits.

Waste Shipment regulation: reducing recycling in EU?

Initially, the "global" objective of this regulation was to avoid waste dumping outside Europe given the lack of available technology, legislation in developing countries and thus enhance the protection of global environment. There are already several tools at international level for this, such as the notification procedure for hazardous waste, lists, criteria, Environmental Sound Management concepts, which all add supplementary administration costs to the exporter.

The global aim is certainly positive however, Europe wants to introduce even more, increasing the administrative and bureaucratic burden for recycling in Europe, leading to a further degradation of material availability and competitive position for the European NFM industry. These measures include a publication of notification information on the Internet with the idea that the public has the right to know. The details of notification can lead to safety problems during transport (e.g. precious metals, where transport data could lead to theft) and these data can also contain sensitive commercial information which introduce a disadvantage for European recyclers. This will have a negative impact on availability of recycling material for import in Europe.

Whilst there is a deletion of provisions for interim operations, this is only partially useful for the NFM industry as the recycling of non-ferrous metals is a complex chain providing a high recycling efficiency, and will only partially fall under this exemption. The deletion of the pre-consented facility in this legislation will increase the bureaucracy, administrative burden for companies as well as the ‘arrangement of transport’ time and risks of delays.

Due to the legislation requesting the proximity principle for recovery (i.e. waste should not travel transboundary for recovery), metal recovery will become more difficult or impossible. This principle should only be applied for disposal, as initially foreseen, rather than recycling too. The provision for waste contaminated with POP's (Persistent Organic Pollutants) also proves problematical with regard to the shipment of waste for *disposal*. It is known that metallurgical processes can irreversibly destroy POP's yet this is ignored in the legislation put forward. Introducing this provision would hamper valuable metals recycling efforts in Europe alongside the increased administrative burden of keeping records of incoming & outgoing waste streams. Adequate control of waste streams is needed but should not introduce supplementary burdens and hamper recycling.

The Way Forward?

Even from this short presentation of the waste policy as it stands at the moment and problems identified, there are actions which can be proposed and lead to some progress, such as:

- Clarifying the status of waste in REACH including the revision of waste definition
- Assure the proper integration of scientific information in policy thus avoiding unjustified bans of metals in waste legislation
- Take the potential opportunities in the field of End of Life legislation and the enforced collection
- Ensure a proportional level of control for the transport of waste without entailing excessive burdens on the EU NFM industry

And most importantly to introduce a global approach in the thematic strategy on prevention and recycling of waste, working on:

- The availability of raw materials in Europe,
- The amelioration of the international competitive position of the EU industry by removing the various legislative burdens for recycling

Incorporating these changes in future legislation and revisions of current legislation will increase even further the contribution of metals recycling to sustainable development.

Outlook for the Global Cobalt Market 2005

INTRODUCTION

There have been many major changes in the cobalt market over the last twenty-five years. We have seen a significant increase in the number of cobalt producers and production has changed from being predominantly copper-based to nickel-based and in most recent years to primary operations. On the demand side, we have seen a move away from low value applications to specialised applications which rely on the unique properties of cobalt.

COBALT PRODUCTION

Between 1980 and the present day, world wide refined cobalt production has more than doubled (Figure 1). Half-yearly estimates indicate that refined cobalt availability for 2005 will exceed 52,000 tonnes.

Since 1980, several major changes in production have occurred. Production has moved from Africa to Europe and more recently to China (Figure 2).

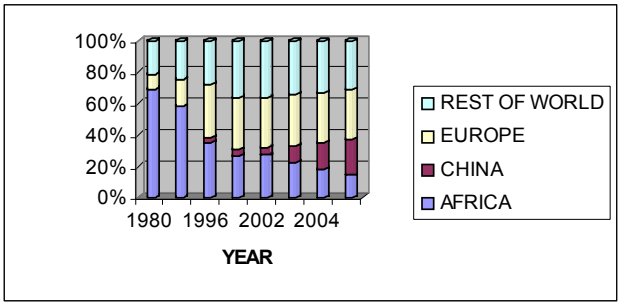

Fig. 2 – Refined Cobalt Production: Geographical Location %

Without doubt, the most impressive increase has been noted in China, particularly in the last four years and in 2005 production is estimated at about 23% of world wide production.

It must be noted however that although refined production from Africa has declined, the DRC still plays a major role in worldwide cobalt markets as most of the production in China and a considerable amount in Europe is produced from feed materials from the DRC.

Production has shifted from being a by-product of copper to a by-product of nickel and a primary product. In 1980 about 73% of refined cobalt was produced from copper ores (mainly in Africa) and about 23.5% from nickel ores. Very little primary cobalt was produced.

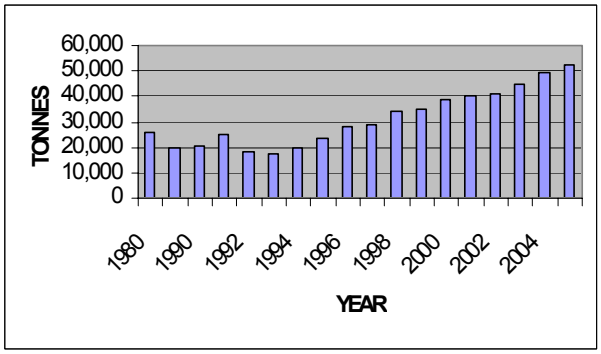

Fig. 1 – Worldwide Refined Cobalt Availability

Although difficult to distinguish accurately, I estimate that in 2005 only about 7% of world wide cobalt will be produced from copper ores, but that from nickel ores will total about 41.5%. More strikingly (excluding China) about 23.6% of cobalt production will be primary production.

COBALT DEMAND

For the past few years the Institute, in conjunction with the World Bureau of Metal Statistics, has calculated apparent refined cobalt demand from import/export statistics. Apparent refined cobalt demand from 1997 to 2005 using these data is shown in Figure 3.

Over the past decade, demand has been very healthy, growing strongly even when the cobalt price was over US$30.00/lb. In the latter half of 2001 demand showed a temporary reduction following the attack on the World Trade Center and a decline in worldwide economies. Since 2002 demand has increased phenomenally and estimates suggest that it could be about 54,000 tonnes in 2005. Care should be taken in interpreting these data as they are derived from import/export data

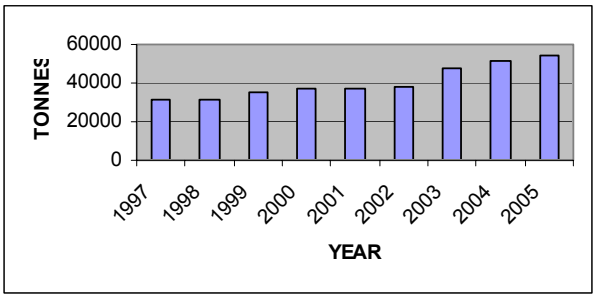

Fig. 3 – Worldwide Refined Cobalt Demand 1997-2005 (T)

and stock changes cannot be assessed and occasionally discrepancies are seen in the import/export raw data.

In view of the fact that production figures do not include those producers who do not report their production (e.g. in the UK and Taiwan) the overall situation suggests a near balance in supply and demand.

Apparent Demand by Geographical Location

As with production there has been a major shift in worldwide cobalt demand patterns in the past decade (Figure 4).

Since 1997 we have seen a major shift in markets to Asia, with China becoming particularly important. Since 1997 Chinese demand has grown from about 1,000 tpa to 9,500 tpa in 2005. However, it is not only China that has seen growth. Demand in Japan and South Korea has increased by 58% and 35% respectively in the last four years. In contrast, a cursory glance at American and European data shows that demand has been relatively stable during the period. In 2004, I estimate that cobalt demand in Asia totalled about 58% of total world wide demand, America and Europe accounting for about 20% each.

This shift in the market is attributable to economic growth in China and massive growth in demand for rechargeable batteries and to a lesser extent catalysts used in the plastics and textile industries.

Apparent Demand by End Use

Figure 5 shows the change in demand patterns between 2002 and 2005. Two points are of major significance:

- Demand increase has in the main been associated with the growth in demand for rechargeable batteries
- Growth in demand has been predominantly in the chemicals sector which is expected to account for about 52% of total world wide demand in 2005

THE FUTURE

Cobalt Production

In the early 1990s Gécamines' production began to fall rapidly at a time when demand was growing. As a result of the anticipated shortfall the price of cobalt rose to over US$30/lb in 1996. This rise in price did not stem the growth in demand. However, a fundamental change occurred in the market. Consumers and producers began treating concentrates and intermediates from the DRC as opposed to buying refined metal. Consequently, although Gécamines production decreased to minimal levels, its raw materials were still a major contributor to the cobalt supply. This change in the structure of the supply side of the market meant that there was never a major shortage of cobalt.

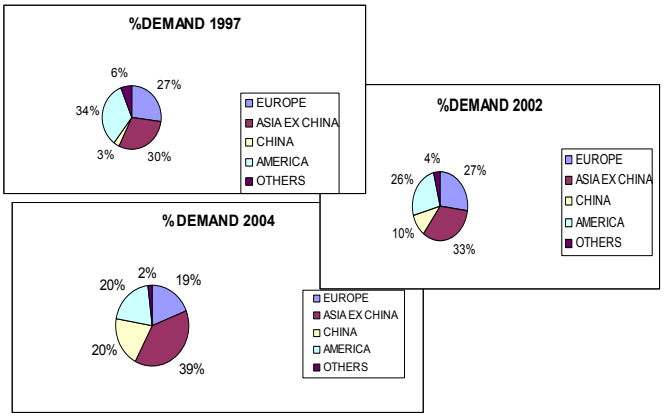

Fig. 4 - % Demand by Geographical Location

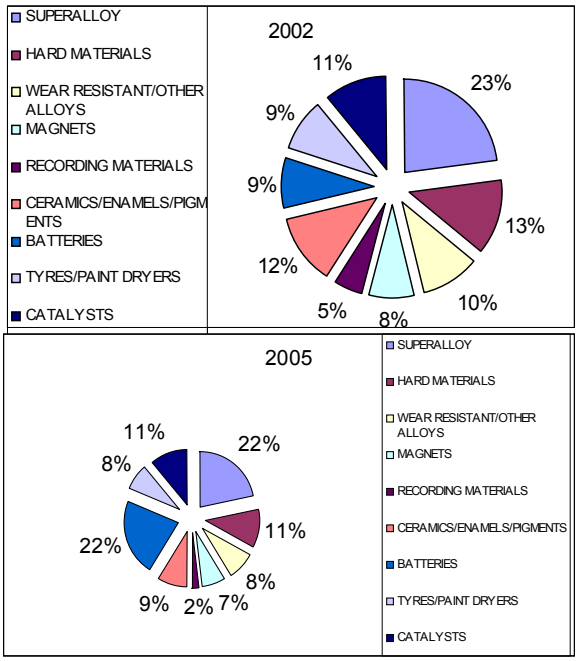

Fig. 5 - % Demand by End Use

Raw materials from the DRC continue to be treated and are extremely important to Chinese producers as they increase production to meet demand. From import/export figures, I estimate that between 75% and 90% of concentrates and ores imported into China between 2001 and 2005 were from the DRC. To a lesser degree, the same applies to imports into India.

So what is the situation regarding future cobalt supplies?

Existing Producers

Table1 lists my estimates of additional cobalt available to the market from existing producers

based on recent and past press releases. Much of the production from these sources will be dependent on several factors:

- Availability of Feed Materials. Much of the production will be dependent on securing feed materials, particularly Chinese production.

Currently, a lot of feed materials for these operations originate from the DRC. Apart from OMG which receives feed from its Big Hill facility, continued availability of material from the DRC is unknown. Zambian production could increase fairly rapidly with the development of the Baluba, Muliashi and Nama projects.

- Technical Obstacles. Any increase from Murrin Murrin will be dependent on them solving ongoing technical problems
- The Cobalt Price

The price of cobalt will be a major factor in determining whether or not producers will process slag/other intermediates and/or import concentrates from the DRC (or elsewhere). Offsetting these possible increases will be the cessation of sales from the DLA.

New Producers

There are numerous projects at various stages of development which are poised to deliver additional cobalt into the market over the next decade. The projected increase in nickel demand over the next decade will ensure that a substantial amount of new cobalt will originate from nickel operations. Some analysts estimate that up to 75% of all new cobalt entering the market in the next decade will originate from nickel operations. Table 2 lists my estimates of cobalt entering the market from new producers in the next few years.

Table 2 – Cobalt Production from New Producers (tpa)

Short Term		Longer Term	
Coral Bay	750	Ambatovy	5,600
Voiseys Bay	2,100	CVED-Vermelho	3,000
Ravensthorpe	1,600	Weda Bay	4,500
Formation Capital	1,500	Adastra	6,000
European Nickel	800	Tenke Fungurume	6,000
Goro	4,500	Ramu	3,200
		Mindoro Nickel	
		Nonoc	

Coral Bay and Voisey's Bay have commenced delivering concentrates to Sumitomo and Inco refineries, with the result that some additional cobalt will be seen in the market place in 2006. European nickel has also commenced deliveries of cobalt to BHP Billiton's refinery. Formation Capital has announced plans to commence production at its Idaho property in the USA during 2006

Table 1 – Additional Production from Existing Producers (Tonnes)

OMG	1,000	2006
Umicore	1,500	2006
Murrin Murrin	1,000	2066
ICCI	1,400	2007
Kasese	450	2006
Zambia	2,000	2006/7
India	1,000	2006
Japan	700	2006
China	?	

In all these cases, significant amounts of cobalt will not be forthcoming until 2007. In the medium term, Inco is proceeding with its Goro Nickel Project in New Caledonia and first production is scheduled in 2007. BHP Billiton has commenced developing its Ravensthorpe Project and first production is scheduled in 2007. Substantial amounts of additional cobalt from all these projects cannot be expected until 2008/2009.

My list includes a number of projects which I consider longer term. Construction of the CVED, Vemelho Nickel Mine operation is scheduled to begin in February 2006 and mine production in 2008. If Adastra Minerals were to commence construction of a refinery in 2006 it could probably commence cobalt production in 2008. The Ramu, Mindoro and Nonoc operations are listed as longer term possibilities now that Chinese enterprises are showing interest them. Other projects under consideration but not included in the list are the Geovik, Malborough Nickel, Fortune Minerals, El Boleo and numerous projects in the DRC.

Cobalt Demand

I believe it is difficult to make accurate worldwide demand forecasts for cobalt in the foreseeable future. However there are indications that demand will increase strongly in the next five years. If cobalt demand continues to rise at the rates of the last two years, some tightness in supply might be expected in the next couple of years before new production projects are commissioned.

I do not propose to look at all end-use markets but simply comment on the applications which I believe are significant to cobalt demand in the future.

Superalloys

Until recently this has been the largest end-use application. Following 9/11 in the USA there was a huge decline in demand but recovery has occurred since then and demand is more or less back to former levels. In the future the sector is projected to grow steadily. Rolls Royce estimates that 96,000 new civil aircraft engines will be required in

the next twenty years. Airbus and Boeing project massive growth in civil aviation. By 2020 global passenger traffic will grow 2½ times and freight by 3 times that of 2001.

The main growth will be in China and Latin America. More fuel efficient engines will increase the need for nickel based alloys as operating temperatures increase. In addition the need for industrial gas turbines and flue gas desulphurization equipment will increase in line with industrial development and tighter pollution controls.

The pressure to develop more fuel efficient, less polluting, lighter engines means that all aero-engine builders are researching new materials for future generation aircraft. Research into the use of exotic materials such as intermetallics and fibre reinforced materials is proceeding rapidly. However, changes will not take place quickly.

Catalysts

In the last decade there has been a significant increase in the use of cobalt as a catalyst. One of the major uses is in the production of terephthalic acid (PTA) and dimethyl terephthalate (DMT) for the manufacture of polyethylene terephthalate (PET) used to produce polyester fibres and synthetic textiles for packaging, PET bottles and recording tape. There has been a large increase in PTA production in Asia in the last few years. This, in part, accounts for the increase in cobalt demand in South Korea. Growth in this sector can be expected in the next few years.

Cobalt containing CoMoX catalysts are used in the desulphurisation of crude oil. However, these catalysts are not good at reducing sulphur to the levels currently being required by regulators (15ppm). Alternative catalysts can be used. Demand in this sector is expected to remain relatively stable or at best increase slowly.

Gas to Liquid Technology

Gas to liquid technology was developed 80 years ago by German chemists to produce synthetic fuels from coal gas. In the 1950s, this technology was used in South Africa by Sasol to produce about 8,000 bpd of synthetic fuel. Catalysts used are mainly cobalt, iron or platinum group metals. Currently there are three commercial GTL plants operating world wide which produce a minute amount of fuel compared to the worldwide production of crude oil. The interest in GTL lies in the future. There are three main reasons for interest in GTL:

- Availability of Energy. The world's proven and potential natural gas reserves are estimated at more than 14,000 trillion cubic feet (tcf). Estimates of stranded gas vary up to 9,000 tcf which is equivalent to about 900 billion barrels of synthetic hydrocarbon liquids. GTL technology has the potential to convert a significant percentage of this gas into several million barrels of liquid petroleum – enough to supply the world's energy needs for the next 25 years.
- Security of Supply. GTL opens up the possibility of oil-importing countries with gas/coal reserves reducing their dependence on imported oil.
- Environmental Regulations. New legislation which will require the sulphur content in diesel fuel to be reduced to 15ppm (in the USA) by 2006.

Three new GTL plants are expected to be commissioned by the end of 2006, one in Qatar, one in Egypt and one in Nigeria. Commissioning of a new GTL plant in Iran has also recently been announced. In addition three huge GTL projects are underway in Qatar which will have a capacity of over 500,000 bpd within the next decade.

Installed world wide GTL capacity today is about 40,000 bpd but this could rise to 1.0 million bpd by 2020. Two thirds of this capacity will be in Qatar. Even with this massive growth diesel fuel derived from GTL technology in 2020 will only be about 5% of the total volume of fuel produced from crude oil.

Estimates of cobalt demand in this application vary widely from a minimum of 2000 tonnes spread over the next five years to a maximum of 2000 tpa over the next decade. The difference depends on the ability to recycle GTL spent catalysts.

Hybrid Electric Vehicles

Electric vehicles have been around for a long time but today their emergence as a major commercial concern has become important for a number of reasons:

- Stricter environmental regulations. Stricter environmental regulations in many parts of the world will require lower CO_2 emissions in the next few years. As CO_2 emissions cannot be reduced by catalytic conversion the above requirements can only be met by reduced fuel consumption.
- Gasoline Prices. Gasoline prices have more than doubled in the USA since December 2001 reflecting higher crude oil prices. Regardless of events such as Hurricane Katrina, crude oil prices are expected to increase steadily over the next decade as oil production from conventional sources peaks in about 2020.
- Security of supply. The industrial nations in general are reliant on imports of energy from the Middle East.

The most promising development appears to be hybrid electric vehicles (HEV) which combine a conventional internal combustion engine with an

electric motor. They use up to 40% less gasoline than a conventional IC engine. The popularity of HEVs is growing fast but will depend to some extent on the gasoline price and the pay back period. Rapid growth in demand for HEVs is forecast mainly in the USA but also in China and Japan. The worldwide market for HEVs is forecast to total between 1.8-2.6 million/year by 2010 and rise to between 4.0-6.0 million/year by 2015. Today most hybrid electric vehicles use nickel metal hydride batteries but in the long term the preferred battery is Li-ion. The amount of cobalt in the Toyota Prius has been quoted between 3 and 7lbs so estimates of cobalt demand in these applications vary widely.

I believe that, without any technological change, a realistic figure for cobalt demand in this application will be about 3,000 tpa by 2010 and up to 8,500 tpa by 2015. These projections will increase if improvements in technology occur and gasoline prices rise unabated.

Tungsten Carbide/Diamond Tools

Cobalt demand in this sector has traditionally been related to industrial activity and is expected to do so in the future. Cobalt is the most suitable binding material for WC components. In the diamond tool sector, alloy powders have been partially substituted for cobalt for economic reasons. Growth prospects for cobalt in the diamond tool sector are limited and most analysts predict that cobalt demand will remain flat or even decline marginally in the next couple of years.

Substitution has been less serious in Cemented Carbide components and a very small annual growth in cobalt demand can be expected in these applications. This will be related to industrial activity.

Rechargeable Batteries

Rechargeable battery demand has risen dramatically over the last decade. In 1993 the global market totalled about 1.4 billion cells, most of which were nickel/cadmium. Since then however, apart from a slight decline in 2001, demand has grown rapidly to an estimated 3.7 billion units in 2004. Li-ion batteries accounted for about 1.3 billion of these. The increase in the use of Li-ion batteries results from changing technology and the increase in demand for mobile phones, portable PCs and portable electronic devices. The chemistry of batteries has changed in recent years (and is still changing). The change in battery type has also been driven by technical advances in electronic devices. For instance, since their introduction, mobile phones have continued to get smaller and lighter.

Total worldwide rechargeable battery demand is expected to reach 4.6 billion cells by 2010. By far the greatest increase in demand will result from the growth in demand for mobile phones which is estimated to reach 2 billion by 2006. The major growth in demand for rechargeable batteries will be for Li-ion systems.

As a result of high cobalt prices, considerable research has been carried out to substitute cobalt in Li-ion batteries with other materials. Alternative composites comprising $LiMnCoO_2$ and $LiNiMnCoO_2$ have been developed which possess similar properties to traditional $LiCoO_2$ batteries. These contain only about a third the cobalt of traditional $LiCoO_2$. The rate of substitution with these alternative materials will obviously determine the rate of growth in cobalt demand in rechargeable batteries. Estimates suggest that growth rates may be reduced to between 3 and 5%/annum by 2010.

Organic Chemicals

Cobalt carboxylates probably account for about 10% of the world wide cobalt market. They are used as paint and ink driers and to promote adhesion between the rubber and steel in radial tyres. No satisfactory substitute has been found for cobalt in radial tyres and growth in cobalt demand will be in proportional to growth in demand for steel braced radial tyres.

There is a growing trend towards water based paints which do not need cobalt driers. A number of paint/ink manufacturers are also looking for substitutes for cobalt in view of the EU hazard classification for water soluble cobalt compounds. To date, a technically equivalent drier for alkyd paints has not been developed. It is possible that substitute materials could have equivalent or worse HS&E considerations than cobalt.

Other Uses

Smaller but specialist uses of cobalt in applications such as prosthetics will continue to grow strongly as the developed world's population ages and technical developments enable procedures to be carried out on younger patients.

SUMMARY

- Cobalt is used in very specialist applications.
- Future demand will depend on economic growth in developed countries and particularly in the rapidly developing economies of China and India.
- There is a great potential for the use of cobalt in new applications such a HEVs and GTL. The former application could increase cobalt demand substantially in the next five years
- The increase in demand up to 2007 will almost exclusively be met from existing producers.
- Production in the next three years will be largely dependent on the continued availability of feed materials from the DRC.

China's Present and Future Position in the Global Cobalt Market

1. China's Cobalt Reserves

China's cobalt reserves are very limited and the majority of their cobalt production over the past few years has been obtained from imported heterogenite from the Democratic Republic of Congo.

The main domestic mines are cobalt-sulphur mines whose main product is sulphur. The mines are Shandong Zibo, which also produces cobalt salts; Hubei Daye and Shanxi. There is also a sulphur-copper-nickel mine at Gansu Jinchang. Reserves are also found at Jinchang Baijiazuizi. Exploration is also taking place at Huangshan Cu-Ni mine, Xiangshan Cu-Ni mine and Dahenglu Co-Cu mine. The general location of China's cobalt reserves is shown in Figure 1.

The vast majority of cobalt produced in China is from imported ores, mainly heterogenite from the Democratic Republic of Congo (DRC).

The main importers of cobalt concentrates in 2004 and 2005 are shown in Figure 2.

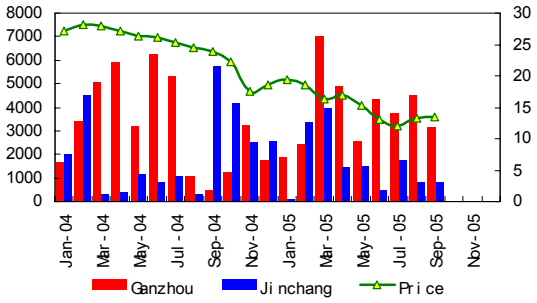

Fig. 2 – Main Import Areas of Concentrates

Figure 3 illustrates the increased imports of cobalt concentrates into China since 1998. It is evident that imports have literally doubled in 2005 as compared to 2004. Figure 4 illustrates the source of these imports since 1998.

This figure shows that in 2005 about 85% of imported ore originated in the DRC. It is likely that the material shown as originating in South Africa was originally from the DRC.

Fig. 1 – China Cobalt Reserves

2. Chinese Cobalt Production

China's refined cobalt production since 1992 is shown in Figure 5. This figure further illustrates China's dependence on imported concentrates, as in 2005 about 75% of total production will be from these materials.

The rapid increase in Chinese refined cobalt production means that in 2005 China will be the world's largest cobalt producer. The change in percentage of worldwide production since 2002 is shown in Figure 6.

It can be seen that in 2005 Chinese refined cobalt production is estimated at about 16,000 tonnes, 27.6% of worldwide production.

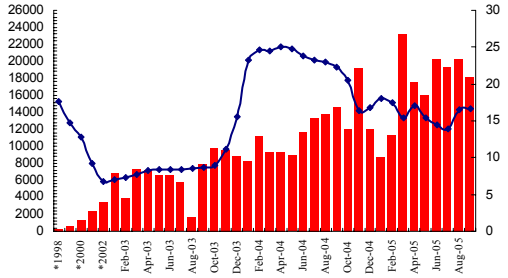

Fig. 3 – Increasing Import Volume

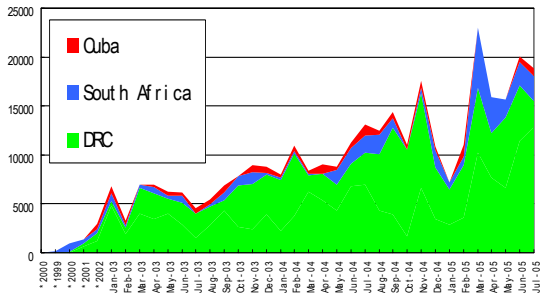

Fig. 4 – Concentrate Import Source

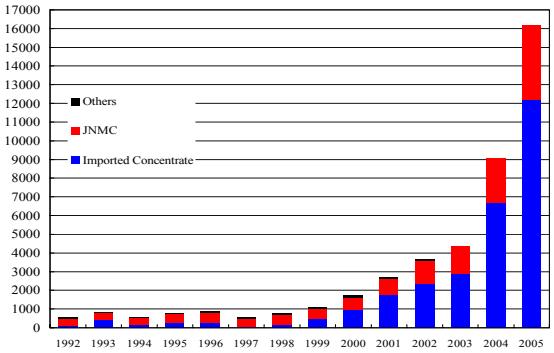

Fig. 5 – China became the largest refined cobalt producing area

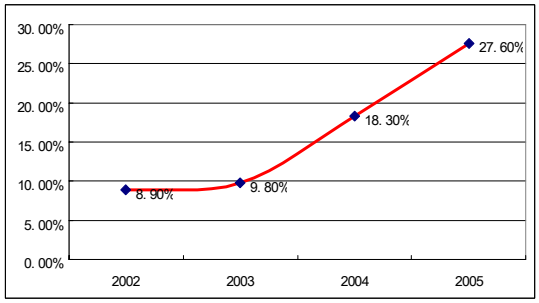

Fig. 6 – The Share of China Refined Cobalt Production in the World

3. Chinese Cobalt Demand

Chinese cobalt demand since 1998 is illustrated in Figure 7.

Chinese refined cobalt demand in 2005 is estimated at about 12,000 tonnes. The increase in the past four years has been mainly attributable to the growth in demand for rechargeable batteries.

China is now the world second largest consumer of cobalt after Japan, accounting for about 22.8% of worldwide demand. The current rate of growth in demand is about 25%/year, four times the average global rate of growth.

Future growth in global cobalt demand will be largely dependent on growth in Chinese demand.

Figure 8 illustrates the major end-use sectors of Chinese cobalt consumption. It can be seen that by far the greatest demand is in the battery sector which accounts for about 48% of total Chinese demand. Cemented carbides and ceramics are the second largest sectors which account for about 13% of Chinese demand each.

Cemented Carbides

Demand for cemented carbide components has increased rapidly from about 2,000 tonnes in 1990 to an estimated 16,200 tonnes in 2005. As a result of a high tungsten price, output in 2005 is estimated to be about the same as in 2004.

Magnets

Magnet demand has more than doubled since 1998. In 2005, growth in magnet demand is estimated at about 13% over that of 2004. The majority of this growth will be in rare-earth magnets. Although demand for Alnico magnets has risen slightly in the last six years, the main growth has been in rare-earth and NdFeB magnets.

Batteries

Without doubt the major growth in cobalt demand has been in rechargeable batteries. It is estimated that in 2005, 5,500 tonnes of cobalt will be used in rechargeable batteries.

Cobalt is used in Li-ion, Ni-MH and Ni-Cd rechargeable batteries. Demand for Li-ion batteries has grown rapidly in the last 5 years in line with the demand for mobile phones.

However, the current production rate of lithium cobalt oxide for Li-ion batteries is below Chinese capacity as a result of a large mobile phone stockpile. However, battery exports are continuing to increase. At the same time, the recycling rate is increasing, which could affect future demand for cobalt in this application.

Bonded Diamonds

Demand for bonded diamonds has increased steadily from about 750 million carats in 1999 to 3000 million carats in 2005. The amount of cobalt used in manufacturing bonded diamonds is expected to decrease in the next few years. However, as this sector is relatively minor user of cobalt, little effect will be seen in overall Chinese demand.

Other sectors

Cobalt consumption in ceramics is increasing by at least 10%/year as the demand for architectural and decorative materials grows.

The increase in demand for PTA and the establishment of new production facilities means that the demand for cobalt acetate is increasing rapidly.

Cobalt demand in metallurgical applications is relatively small and is expected to remain stable. How-

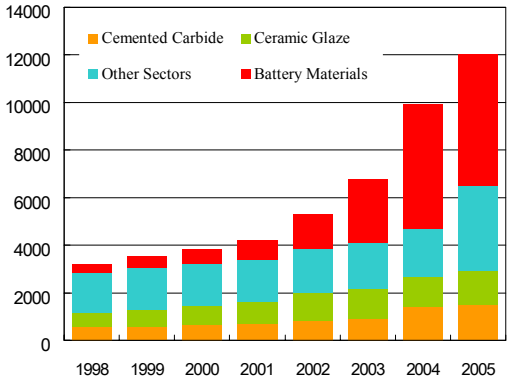

Fig. 7 – Increasing Consumption

ever, the ageing population and improving medical facilities could mean that the demand for prosthetics increases rapidly in the next few years.

Summarising, the potential areas for growth in cobalt demand in China in the next few years are battery materials (both domestic consumption and exports), catalysts and prosthetics.

This contrasts with other areas of the world such as the USA and Europe where growth in superalloys and GTL catalysts will be more prominent.

4. Cobalt Supply/Demand Balance

The cobalt supply/demand balance in 2005 can be summarised as follows:

Cobalt production (metal content)	16,600 tonnes
Cobalt imports (cobalt content)	2,660
Cobalt exports (cobalt content)	3,700
Cobalt consumption	12,000
Balance	+ 3,126 tonnes

5. China's Position in the Global Cobalt Industry

- In 2005, China will become the world's largest refined cobalt producing country
- Its increase in consumption is the main reason for the global increase in cobalt demand over the past two years
- China's cobalt industry relies heavily in imported raw materials. In order to maintain cobalt production, it has had to rely on large imports of concentrates from the DRC
- In order to maintain its production, China will face increased competition for feed materials and have to become more active in international markets

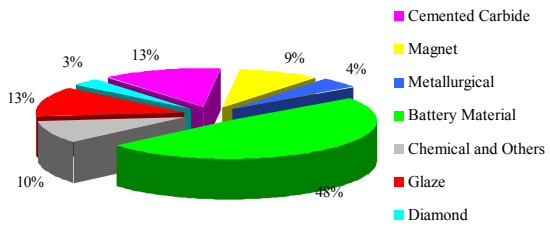

Fig. 8 – China Cobalt Consumption Fields

- In order to maintain its competitiveness, various Chinese organisations have entered into arrangements for participation in a number of overseas projects. These are summarised in Figure 9.

Company	Partner	Share	Mine	Invest.	Capacity	schedule	Current
CNMC	Yunnan Province	2:8	Lubumbashi	$11m			2005Q2 Started Construction
China Minmetalss	Cuba	49%	las Camariocas		4000t/y Sintered Ni	2009	Building
JNMC			Sally Malay		Ni/Cu/Co Concentrate	2004	Running
MMC	Highlands Pacific	85%	Ramu	$65m	3200t/y		Sign Agreement
Wanbao	**Comide**	**51%**	**Likasi, Feza**		**Co Alloy 4000t/y**	**2005 May**	**Trail Production**
COVEC	DRC MKM	71%&29%	Kalumbwe-Myunga	$39m	926t/y		初步协议
An Unnamed Company	Haviha	10%	AUS Mutooroo		1000-2000t/y		Feasibility Study

Fig. 9 – China Overseas Projects

This paper is based on that presented by Mr. Zhai Yang of Beijing Antaike Information Development Co. at the 2005 China International Nickel and Cobalt Industry Forum in Xiamen, China 23-25 November 2005. Further information can be obtained from Mr. Zhai Yang at soocoo@263.net.

Cobalt on the Web

With the proliferation of internet usage it seems appropriate for the CDI to spend some time on Google and probe the dark corners of the web to discover what is out there for those interested in cobalt.

As anyone who has typed 'cobalt' into a search engine will know the results are both numerous (11,800,000) and diverse, including restaurants, computer sites, internet marketing, heavy duty dance floor sales and a few concentrating on the metal and its compounds. It is this final group of sites I will concentrate on in this article!

For those interested in cobalt a good place to start is the Cobalt Development Institute's own website (www.thecdi.com) which contains information on uses of cobalt, recent abstracts and patents relating to cobalt, production statistics and information on the health, safety and environmental aspects of working with cobalt and its compounds. The members' area of the website also contains links to the members' websites.

For information on the production and use of cobalt there are more specialist sites for the web user to view, including the USGS's Cobalt site (http://minerals.usgs.gov/minerals/pubs/commodity/cobalt/) which is updated monthly. For how this production is used, sites such as SPIN (Substances in Preparations in Nordic Countries, http://www.spin2000.net/spin.html) is also useful. Using SPIN online, one can identify a compound and see for what product usage it was used in the Nordic countries over the last few years and in what tonnage.

Alloys composition and material properties can be found by elemental search (with minimum and maximum elemental composition percentage) at http://www.matweb.com/search/SearchComp.asp with over one thousand cobalt containing alloys listed, this appears a useful resource for those concerned with alloys. A premium service is also available for this website.

News relating to the latest happenings in the world of cobalt can be delivered to your inbox through a timed google alert (http://www.google.co.uk/alerts?hl=en) or news sites such as infomine.com (http://www.infomine.com/commodities/cobalt.asp) and metalbulletin.com. For news on the latest happenings in Europe with regard to policies, committee discussions and announcements http://www.euractiv.com/ is an excellent resource. Although a Non Ferrous Metal overview of policies which could affect the industry can be found at the Eurometaux website (http://www.eurometaux.org).

Basic Chemical information on cobalt can be found at a number of sites, one of the more comprehensive is http://environmentalchemistry.com/yogi/periodic/Co.html and a list of such sites is found at the open directory project (http://dmoz.org/Science/Chemistry/Elements/Cobalt/).

For those interested in the health and safety aspects of cobalt there are a number of websites which deal with the subject, these include the ATSDR (Agency for Toxic Substances and Disease Registry) website in the United States of America (http://www.atsdr.cdc.gov/tfacts33.html, this site includes Adobe downloads of the toxicological profiles) Toxnet (Toxicology Data Network, http://toxnet.nlm.nih.gov/) and the UK Health and Safety Executive (http://www.hse.gov.uk/pubns/msa17.htm). Whilst there are other sites which provide information these examples have been provided as the content is peer reviewed and generally reliable.

For those interested in the classification and labelling of cobalt compounds within the European Union, the best place to start a search is the ECB (European Chemicals Bureau) classification and labelling website (http://ecb.jrc.it/classification-labelling/) by using the "search classlab" tab at the top of the page or the "ESIS" (European chemical Substance Information System) tab on the left of the page one should be able to find the information you require. The N-Class database based in the Nordic countries (http://apps.kemi.se/nclass/default.asp) is also a good resource for this subject too. Although, with the implementation of the Global Harmonised System looming in the next couple of years then the UNECE website on GHS should probably be examined to (http://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html).

DISCLAIMER: The CDI is not responsible for the content or views of external websites, the websites listed above are in no way endorsed or sponsored by the Cobalt Development Institute they are only provided for the relevant and practical information of the reader.