C O B A L T N E W S

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The Cobalt Development Institute is registered at 167 High Street, Guildford, Surrey, GU1 3AJ.

COMMENT

THE annual conference of the CDI took place in Shanghai on the 9th/10th May and was the most successful yet in terms of the number of attendees. The audience heard a range of excellent papers from important players in the cobalt market and these presentations ranged from discussing the dynamics of the market to political risk management and from project updates to market regulation.

The outlook for cobalt demand remained very good, particularly in the chemicals sector (for batteries) and we learned that nearby it was expected that the cobalt market would likely be volatile by virtue of low stocks and restrictions on the availability of raw materials, but that in the longer term this should stabilise as new production came on stream. Of course we were reminded that relatively high prices can give rise to substitution!

One couldn't escape the fact that the fundamentals for cobalt had changed compared to the year before and there was a buzz of excitement throughout the conference.

Apart from the high quality of papers presented, *THE* Cobalt Conference provides probably the best forum for networking in this sector as well as finding out who is who and what the next developments are. Next year's conference is in Toronto and at that time we will be able to see how the market has unfolded, but the CDI would be interested to hear from anyone who believes they can contribute to the proceedings with a paper. If you would like to participate at this premier cobalt event next year please contact me at the numbers shown on the CDI website.

THE Cobalt Conference 2007 Shanghai

The annual conference of the Cobalt Development Institute (CDI) was held on the 9th and 10th May 2007 in the Jing An Hilton in Shanghai. This conference is the only one dedicated to cobalt and proved exceptionally popular as we welcomed almost 300 registered delegates representing twenty-nine countries and six continents, with more than 20% of the attendees coming from China. This made Shanghai the most popular CDI Conference ever, and reflected the interest and optimism in the market for the special metal.

The Conference was opened by David Weight, the CDI's new General Manager, who introduced the equally new Chairman Mr. Steve Dunmead of OMG Inc. Steve opened by thanking the CDI's Isabelle Porri for arranging the Conference and thanked the speakers for their participation.

Steve also paid tribute to the former Chairman, Mr. Pierre Van de Bruaene, who had so effectively guided the CDI for the past two years.

The Conference was advised that 2007 is the 50th anniversary of the CDI and Steve looked at some of the issues that the cobalt industry will be facing in the future, such as:

- REACH
- Globalisation of REACH-like regulations
- Significant growth in new applications such as catalysts and HEV's
- The prospect of industry consolidation
- Massive growth in cobalt demand in China
- Revitalisation of the cobalt infrastructure in DRC

Future success of the CDI, he explained, also depended on the active involvement of members which would allow the CDI to offer greater service to the industry.

David Weight then kicked off the conference by outlining the CDI's 50 years of almost continuous service to the cobalt industry from its early years in the 1950's as the 'Cobalt Information Centre' based in Brussels and patronised by Union Minière and later Gécamines. After a short period of obscurity in the 1970's the organisation was reformed 1982 as the Cobalt Development Institute where Gécamines and Zambia Consolidated Copper Mines were the key players. Today the Institute is a non-profit organisation for primary and secondary producers, for converters and recyclers, for users and traders of cobalt and for the scientific community. It exists to promote the use and knowledge of cobalt in all forms and to support the sustainable development and use of cobalt, cobalt compounds and products.

David explained that the main activities of the CDI were:

- Product stewardship
- Pro-active scientific work to better understand how to use cobalt products in a safe way (HS&E)
- Bringing together the opinions of the members in regulatory matters
- Lobbying on health, safety and environmental matters
- Statistics
- Information – Website/WBMS/Abstracts/Monograph
- REACH!

For the future the aims were summarised as follows:

- To encourage a more representative mix of Members i.e. producers and end users
- Development of a better geographical spread of members
- More Detailed Statistics
- Improved Data/Science
- REACH Consortia Management

It was then announced that the CDI was to perform a REACH management role on behalf of the cobalt industry to help implement the new REACH regulations which come into force on the 1st June 2007. David explained that the CDI will be providing management and technical services to the cobalt industry REACH within a newly formed Division. The CDI REACH Task Force has spent the past year working on this important issue and has already made considerable progress. The CDI will work with the cobalt industry to:

- Provide Secretariat and Technical Services
- Manage Cobalt Consortia – ***At least three Consortia identified for cobalt substances***
- Develop Consortium Membership Agreement – ***Working draft already completed***
- Give Technical Input – ***Have identified substances & uses***
- Assist with Data – ***Establishing/refining data gaps (REACH Task Force has been working with the CDI's considerable bank of research and data)***

- Assist with formation of Consortia Steering Groups (management) and Working Groups (technical) – ***Preliminary work done and pre-Consortia groups to be formed before month end.***
- Contact downstream user groups to work on exposure scenarios – ***Already in communication with: EPMA; MTA; ECMA; CPMA; Re-Charge; Driers Group; Magnets Association…..***
- Encourage anyone in the industry affected by REACH to consider joining (producers/importers) or working with the Consortia (downstream users) – ***Identified as the optimum way to approach the regulations.***

The main challenges were identified as being:

- Data gap analysis
- Substances/Uses all identified and agreed
- Developing/implementing accurate exposure scenario's with relevant and workable RMMs
- Covering all downstream uses
- Covering all end of life routes
- Consumer products must cover foreseeable uses in exposure scenarios to environment
- Key will be communication up and down supply chain and ensuring that the necessary data is developed

In conclusion David stated that "**although REACH is primarily a EU producer/importer responsibility, it will be essential to establish effective communication and data exchange with downstream users."**

Presentations

A diverse range of papers was presented to the Conference covering strategic issues through to managing risks.

Peter Searle of CRU Strategies opened the conference with Mary Chi with a keynote presentation looking at the 'Strategic Issues for Cobalt'. They showed how cobalt demand has grown at a compound annual average growth rate of 6.6% over the past 10-years with significantly higher actual rates in the more recent years as a result of the increased demand for chemicals in China. Growth in the cobalt market has been affected by constrained supply it was noted, and therefore prices have risen. In particular it was observed that concentrate supply from the DRC had declined in 2006 and there was some doubt about whether there would be sufficient availability to meet demand in the short to medium term. It was noted that China and Asia together could become larger than the current market! Hence the CRU believed price volatility would remain for the foreseeable future, but that in the longer term cobalt units from Greenfield nickel projects and increased DRC supplies could see the Long Run Marginal Costs (LRMC) close to US$14/lb from 2010. In summary the CRU observed:

- Favourable changes to fundamentals on the supply side
- Recent changes in the DRC-China link will affect the short-term outlook for Chinese raw material supply
- Demand from rechargeable batteries, superalloys and polyester will remain robust, but growth rates may be affected by high prices
- Very little additional production will come onstream before 2009
- Increases in freight costs and capital costs of new projects indicate that LRMC will be around US$14/lb after 2010 when significant new production should be coming into the market

We also heard a Chinese cobalt processors view of the local market from Mr. Li Xiaodong, Vice President of Zhejiang Huayou Cobalt Nickel Materials. He showed how the Chinese market was heavily reliant upon imported concentrate and intermediate because domestic production could only supply about 2% of needs. The Chinese cobalt supply structure for 2006 is summarised in Fig.1.

It was explained that there was a surplus capacity of some 40% in Chinese cobalt processing plants and that only 70% of the installed capacity of Chinese producers was being utilised.

Mr. Li went on to say that they expected consolidation within the Chinese market in order to keep pace with the ever more stringent requirements of the continuously increasing Chinese demand. Cur-

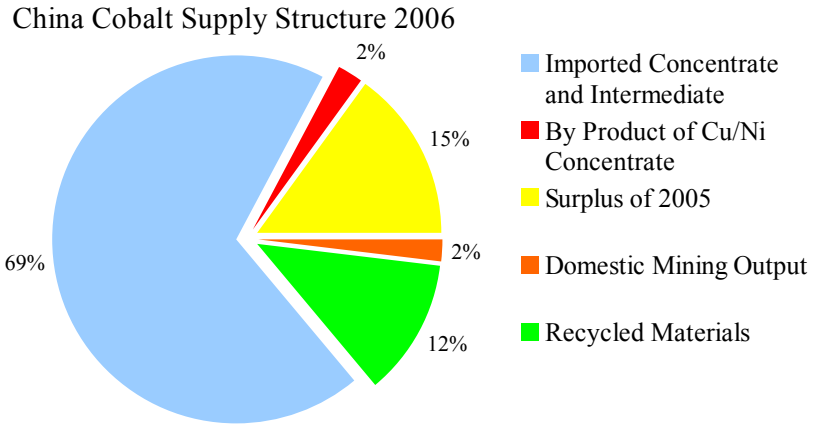


Figure 1

rently there are 120 companies with a capacity of 25,000tpy and it was expected that in 2-3 years there would be 5-10 integrated companies in the higher operating capacity rate of around 20,000tpy.

Huayou believed that future cobalt price would be under pressure as a result of the new copper-cobalt production capacity and tailings projects scheduled for 2009 together with the nickel laterite projects which are also expected to come on stream by 2009.

On the products side Mr. Ha-Young Lee of Samsung SDI Energy Division, gave a review of battery developments for Samsung. Batteries make up some 11% of the Samsung revenues and after early development of Ni-MH batteries Samsung is now a leader in the cylindrical, prismatic and polymer Li-ion batteries where the market has gone from strength to strength, showing a CAGR volume growth of 18.6% since 2004. After giving a detailed insight into battery development, Mr. Lee explained that the Li-ion battery market is growing fast and new applications such as power tools and hybrid electric vehicles (HEV) will contribute to this growth. He added that high and volatile cobalt prices would lead to substitution of cobalt, particularly as NCM and LMO batteries are cheaper alternatives to LiCoO2, and could lead to stagnation of cobalt use.

Sustainable development is heavily dependent upon efficient recycling and Ghislain Van Damme of Umicore (Recycling Solutions) explained his company's approach to recycling cobalt containing rechargeable portable and EV/HEV batteries with the VAL'EAS® technology. The demand for these types of power units is expected to increase considerably in the future, driven by concerns over CO_2 emissions and volatile organic compounds (VOC). The Umicore process is designed to address these concerns by offering environmentally sound recycling with zero waste and VOC free gas emissions.
The VAL'EAS® process has 5-steps (after worldwide collection of used batteries):

Step 1. Smelting + energetic valorisation (Hofors, Sweden)
Steps 2 & 3. Refining and purification of metals (Olen, Belgium)
Step 4. Oxidation of cobalt chloride in cobalt oxide (Olen)
Step 5. Production of lithium metal oxide for new batteries (South Korea)

The process, the conference was told, has been adapted so that it represents the Best Available Technology for recycling of used batteries or ultra-capacitors and offers full compliance with the New European Battery Directive.

Sam Rasmussen of Tenke Fungurume Mining gave a detailed description of this exciting project in the DRC The project is majority owned by Phelps Dodge (now Freeport) with Tenke Mining (Lundin Group) providing funding and Gécamines providing technical support. He explained that Tenke Fungurume is a US$650M project with initial operations expected to produce 115,000tpy copper cathode and 8,000tpy cobalt metal. Production is expected during the final quarter of 2008/first quarter 2009 and the operation has an expected life of 40-years, employing 1,100 permanent personnel plus up to 5,000 indirect jobs as well as providing other sustainable development projects.

In a change from the usual format the conference received a paper on the management of political risk from Melissa Chai, the Regional Director of insurance brokers Jardine Lloyd Thompson Asia Pte Ltd. In her presentation, Melissa reviewed the perception of risk and outlined recent political risk events such as Venezuelan privatisation of oil and mining assets and events in the DRC. She highlighted the political trends in political risk such as the greater willingness of Governments in emerging markets to renege, ignore or repudiate agreements and commented on new sources of risk such as local/central Government and development agencies as well as inter-regional conflict.

In managing political risk Melissa explained the process involved (Fig. 2).

She also outlined some basic rules for considering political risk insurance:

- **Insurance will not fix a bad deal or contract.**
- **Be aware that PRI may not be the right product – full credit or performance protection may be necessary.**
- **Get advice early and with sufficient depth to contemplate the full range of possible solutions.**
- **Define perils clearly.**
- **Start early, analyze the risk develop strategy.**
- **Understand the value of different risk participants.**

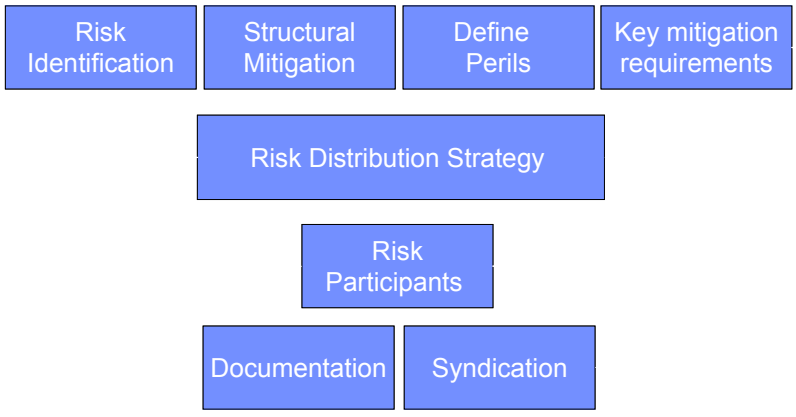


Figure 2

- **Work as a partner but control the process.**
- **Actively manage and sell the risk - move away from "Insurance Buying" mentality.**

Ricardo Valls, the President of Nichromet Extraction Inc, talked about the Geosol Izabal Guatemalan laterite project, the new source of nickel and cobalt in America. In a detailed geological presentation Ricardo explained how the nickel lateritic region of Guatemala was bigger than the laterite region being developed in Cuba. The Geosol Izabal represents an immature wet laterite profile, but the most striking difference between this and other wet laterites is the presence of up to 30% magnetite, which carries nickel grades of 1.2% to 2% as nickel sulphide and about 0.2% cobalt. We look forward to hearing of the further successful development of this exiting new project in Central America.

As attendees at the Conference were reminded by David Weight in the opening remarks, the new REACH regulations enter into force on the 1st June 2007 and will have profound effects on the EU non-ferrous metal industry. Dr. Tom Brock of the CDI gave a paper outlining the HS&E obligations of manufacturers, importers and downstream users of cobalt substances. The timeline for the introduction of this regulation was also explained in some depth, but essentially it is as follows:

- Entry into Force: **1st June 2007**
- Pre-Registration: Completed by end **2008**
- First Authorisation List: **By 2009**
- Registration: >1000t; CMRs (1&2); R50/R53 (>100t): **end 2010**
- Registration: >100t: **end 2013**
- Registration: >1t: **end 2018**

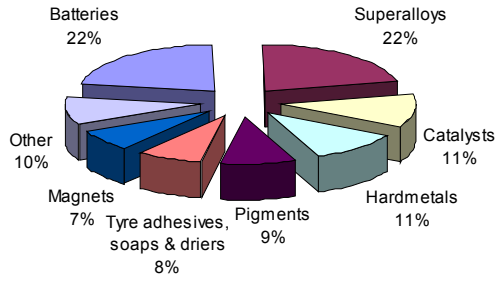
It was explained that information needed to be exchanged up and down the whole supply chain for this legislation to be implemented properly and for ease of reference we have produced the paper as an article in this cobalt news so that it can be used as reference.

Robert Baylis, a Senior Analyst at Roskill Information Services provided a detailed look at cobalt demand and end-uses. He explained that demand had increased from 39,000t in 2001 to 56,000t in 2006 and showed the breakdown of end uses in Fig. 3.

It was noted that battery consumption in that period had by increased 26%; Catalyst consumption by 13% and magnet consumption by 2%.

Some 58% of superalloy consumption takes place in the USA and is mainly destined for the aerospace sector. Increasing passenger air travel, defence procurement and more gas-fired power stations have seen demand improve significantly in 2006 compared to 2004/5.

Battery production has grown consistently since 2001, and in 2006 Japan has lost its dominance to Korea and China. Until the end of the 1990s NiCd and NiMH batteries dominated, but now we see the Li-ion cells eclipsing these battery types.



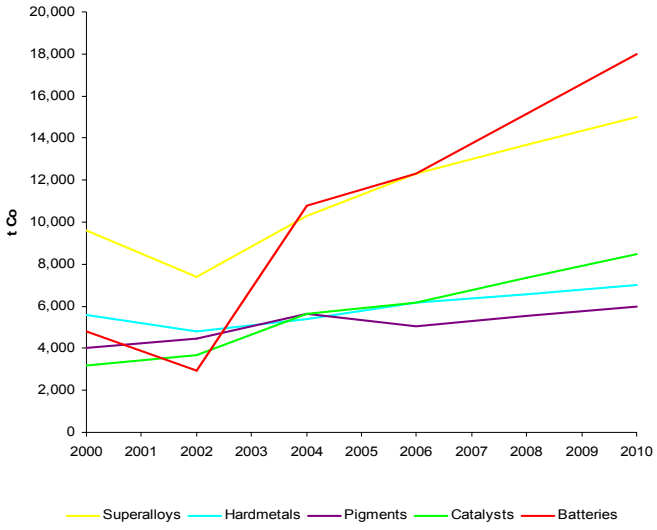
Source: Roskill estimates

Figure 3

Robert reminded us that traditionally cobalt is used as a binder material for cemented carbides with China leading the way in demand for cutting tools, mining tools, hard wearing parts and brazed tools, followed by the USA and Japan.

It was explained that catalysts are becoming more important for environmental and industrial processes (particularly oil) and for textiles. Oxidation in the presence of cobalt salts (acetate, octoate, and naphthenate) is important in the production of PTA catalyst and some 3,000tpy cobalt is used within the PTA market for the production of textiles, particularly in the Asia/Pacific region, where China is the largest producer (32%). Oil refining and hydrotreating in the oil industry consume some 1,500tpy cobalt, though catalysts are regenerated several times and then recycled.

China also ranks highly in the pigments sector of the cobalt market we were told where cobalt is used as pigment and decolouriser in ceramics and glass. This is mainly in the form of oxide and carbonate.



Source: Roskill estimates

Figure 4

Robert outlined the growth in magnets where the sector is enjoying something of a resurgence as a result of Chinese demand which now represents almost half the market share, having posted an increase of 14% between 2004 and 2005.

Roskill have a positive outlook for cobalt demand growth across the end-use spectrum, but particularly for rechargeable batteries, driven by Chinese demand as shown in Fig. 4.

Another interesting cobalt development is Formation Capital Corporation's hydrometallurgical project in Northern Idaho which is expected to come on stream late in 2008 producing high purity aerospace grade cobalt metal. Scott Bending, President of Formation Capital, took the conference through the details of the project explaining the unique and innovative processes that had been developed to extract silver, gold, copper and cobalt at the Big Creek facility. He added that the current facility was being expanded to refine high purity cobalt metal. The feasibility study is to be completed in June 2007 and mine permitting is well advanced. Formation Capital are aiming at a cobalt production of about 1,600tpy. Scott stressed the strong project economics and the fact that the USA is a primary cobalt consumer with no domestic supply! The underground mine is expected to have a life greater than 10 years and the whole operation is situated in a pro-mining region in need of economic stimulation.

A most interesting paper was prepared by Mr. Shao Baixuan, Chairman, Zhejiang Galico Cobalt and Nickel Materials Co. Ltd and Ms Xu Aidong, Chief Analyst Ni/Co, Beijing Antaike Information Development Co. Mr. Baixuan has over 25-years experience in the market sector and he gave us his thoughts and observations on the Chinese market.

During the 1990s, Chinese cobalt production was very modest, being in the 400–1000tpy range, mostly arising as JNMC by-products and this was balanced by consumption of some 800–1000tpy. However, a high development rate became apparent at the turn of the century and between 2000 and 2006 the average growth rate for cobalt was 19.7% making China the second largest consumer at 11,700tpy in 2006. Internal cobalt smelting capacity, it was noted, is far ahead of actual consumption and because the Chinese market moved into surplus of supply the price for cobalt declined leading to lower local prices and hence a demand for a broad range of cobalt raw material. However, the raw material shortage resulting from DRC restrictions on cobalt exports will cause refined cobalt production in China to drop to 9,000t in 2007 it was suggested and will remain at this level for 2-3 years. Mr Baixuan believed that developing economies rich in resources will try and apply stricter controls to exported material and therefore the Chinese industry should take very active measures to resolve this situation. Conversely, Mr Baixuan considered that those developing economies with large resources should recognise the importance of China as an economic driving force in order to develop win-win cooperation agreements. He also believed that primary processing of cobalt would move more towards Africa which will force the Chinese industry to adjust its established way of working.

Emphasising the ever tightening global regulation, John Atherton, Program Director, International Council on Mining and Metals (ICMM), presented a paper to the Conference outlining the implications of the Globally Harmonised System (GHS) for Classification and Labelling (C&L) of substances. The drive for this system started at the UN conference in Rio in 1992 where it was hoped to have a harmonised system available by 2000 if feasible. Its purpose is to:

- Enhance the protection of human health and the environment by the provision of an internationally comprehensible system for hazard communication.
- Reduce the need for testing and evaluation of chemicals
- Facilitate international trade in chemicals whose hazards have been properly assessed on an international basis

This, he advised, presented many challenges to the metals industry:

- How to characterise raw materials
- How to deal with variability
- Variation of classification between different systems
- How to deal with massive forms compared to finely divided forms (e.g. powders)
- How to handle alloys

The GHS is a non-binding international recommendation and has been the subject of international projects for several years. The OECD is the focal point for the development of harmonised health and environmental hazard criteria, but within the EU the Commission is set to implement the GHS in time for C&L in the new REACH regulations.

John outlined the global implementation status of the GHS and his analysis showed that it was quite advanced. He explained that the ICMM was providing implementation support and would be providing guidance notes for member companies in the second quarter of 2007. Their next steps would be to provide comments to other jurisdictions; guidance notes for implementation in the mining/metals industry; input for REACH RIPs 3.3 and 3.6 and tracking of GHS globally.

Remaining on the regulatory theme, Ghislain Van Damme of Umicore spoke on behalf of Recharge, the international rechargeable battery association, about the new EU legislative and regulatory agenda on batteries. He explained that the new

Battery Directive (2006/66/EC) published on the 26th September 2006 sought to establish rules:

- On the placing on the market of batteries and accumulators (B&A)
- On the prohibition on the placing on the market of B&A containing certain hazardous substances.
- For collection, recycling and disposal of waste B&A to supplement community legislation on waste
- To promote a high level of collection and recycling of waste B&A

Responsibilities would therefore fall on manufacturers, pack assemblers, OEMs, private label owners and any entity selling directly to the end-user market from another country.

Ghislain went through the process envisaged indicating the environmental fee that would arise – this was expected to be between 3 & 5% of retail price. He also explained the labelling requirements and indicated where bottlenecks may occur, for example, harmonisation for the implementation date of the Directive in all Member States and the possibility for double charging between WEEE and Waste Battery Collection Schemes.

ReCharge believes that the EU directive promoting the collection and recycling of spent batteries; materials recovery and better waste management are two long-term objectives that should be achieved by the new regulation.

Other new pieces of legislation or regulation aim at a better knowledge and control of the flow of chemicals placed on the EU market. They will add some burden on the EU industry. ReCharge's role is to anticipate and impact on the development of those new regulatory and legislative tools in the best interests of the battery industry.

The broad range of papers presented at this year's conference gave a good insight into the current and future cobalt market. It is apparent that for the short to medium term the market can expect a period of volatility because of constraints on the availability of raw material, and significant new supplies are not available until 2008/9. Activity on the demand side remains bright, particularly in the chemicals sector for Li-ion rechargeable batteries and particularly in China, though most sectors are looking at growth. Obviously high, volatile prices mean that substitution becomes a risk for cobalt and we heard one or two comments in the papers about this.

So, the overall impression from *THE* Conference was one of optimism for cobalt for the next few years but we look forward to reviewing the situation at the same time next year to see how developments have unfolded.

Full copies of the conference proceedings can be purchased from the CDI at a cost of £150.00 Sterling. Please contact Isabelle Porri for further details.

THE Cobalt Conference 2008

14/15 May – Toronto, Canada

Next year's conference will be held at the Sheraton Centre Toronto on 14/15 May 2008. It will follow the same format as this year's. Detailed schedule and information will be posted on our website in the next few weeks.

Call for Papers

We are always looking for good quality, topical papers for our conference. We already have a few speakers confirmed for 2008 but the programme is not yet complete. If you'd like to make a presentation, please contact David Weight at david.weight@thecdi.com.

Registration for REACH: Outline of the HS&E Obligations of Manufacturers, Importers and Downstream Users of Cobalt Substances

With REACH having become a reality on the 1st June 2007, the CDI Toxicologist, Tom Brock gave an outline of the obligations of the main players affected by this regulation at *THE* Cobalt Conference and we reproduce the main aspects of his paper hereunder. It is designed more as a checklist than an article and covers the essentials of the REACH regulations for manufacturers, importers, downstream users and distributors of cobalt substances. For further details on REACH please browse the CDI website at www.thecdi.com.

Subjects covered:

1. Some Definitions (from REACH Article 3)
2. Timing
3. The Legislation (As pertinent to Registration)
4. Health, Safety, Environment "ingredients" needed to meet a stakeholder's obligations for Registration.

1. REACH Terms

- Substance: A chemical element and its compounds in the natural state or obtained by any manufacturing process, including any additive necessary to preserve its stability and any impurity deriving from the process used, but excluding any solvent which may be separated without affecting the stability of the substance or changing its composition.
- Preparation: A mixture or solution composed of two or more substances.
- Article: An object which during production is given a special shape, surface, or design which determines its function to a greater degree than does its chemical composition.
- Intermediate: A substance that is manufactured for and is consumed in or used for chemical processing in order to be transformed into another substance (non-isolated, on-site isolated, and transported isolated).
- Import: Physical introduction in to the territory of the Community. An "Importer" is any natural or legal person established within the Community which is responsible for import.
- Manufacture: Production or extraction of substances in the natural state. A "Manufacturer" is any natural or legal person established within the Community who manufactures a substance within the Community.
- Downstream User: Any natural or legal person established within the Community other than the manufacturer or importer, who uses a substance, either on its own or in a preparation, in the course of his industrial or professional activities. A distributor or consumer is not a Downstream User.
- Use: Any processing, formulation, consumption, storage, keeping, treatment, filling into containers, transfer from 1 container to another, mixing, production of an article or any other utilization.
- Exposure Scenario: The set of conditions, including operational conditions and risk management measures that describe how the substance is manufactured or used during its life cycle and how the manufacturer or importer controls, or recommends downstream users to control, exposures to humans and the environment.
- CMR: Carcinogenic, Mutagenic, Reproductive toxicity (human health hazards).
- PBT: Persistent, Bio-accumulative, Toxic (environmental health hazards).

2. REACH Timing

- Entry into Force: 1June 2007
- Pre-registration: Completed by end 2008.

- First Authorization List: By 2009.
- Registration: >1000t, CMR's (1&2), R50/53 (>100t): end 2010
- Registration: > 100t end 2013
- Registration: > 1t end 2018

3. The REACH Legislation

- Regulation (EC) 1907/2006: Registration, Evaluation, Authorization and Restriction of Chemicals
- Title II: Registration
- Title IV: Information in the Supply Chain
- Title V: Downstream Users (DUs)
- Annex I: Chemical Safety Reports (CSRs)
- Annex II: Safety Data Sheets (SDS)
- Annex VI-XI: Information Requirements (tonnage)
- Annex XII: Provisions for DUs

Registration for Manufacturers/Importers (M/Is)

- Includes Substances, Preparations, Articles, and some Intermediates (on-site isolated/ transp. isolated).
- For each substance, a single Technical Dossier is submitted even when multiple M/I's are involved (e.g. "1 substance 1 registration"; by "lead registrant").
- A chemical safety assessment will be performed and a Chemical Safety Report (CSR) completed for all substances subject to registration in quantities of 10t or more per year per registrant

The Technical Dossier for a substance includes:

- Identity of the Manufacturer(s) / Importer(s).
- Identity of the substance.
- Information on all registrant's manufacture /use
- Hazard classification and labelling (includes self-classification).
- Guidance on safe use of substance (risk management measures).
- Study summaries of information requested by Annex's VII-XI (Relevance).
- Robust study summaries of the information derived from Annex's VII-XI (Reliability).
- An indication of as to which of the information submitted has been reviewed by an assessor chosen by the M/I and having appropriate experience.
- Proposals for testing.
- For substances in quantities of 1-10t, exposure information as specified in Annex VI (Sec. 6)
- A request/justification as to which information the M/I does not want placed on the Internet.

The Chemical Safety Report (CSR) will document the chemical safety assessment for substances produced at 10t or more. A chemical safety assessment will include:

- Human health hazard assessment.
- Physicochemical hazard assessment.
- Environmental hazard assessment.
- Persistent, Bioaccumulative, Toxic (PBT) and very Persistent (vP) & very Bioaccumulative (vB).

If the registrant concludes from the assessment that the substance meets criteria for classification as dangerous (67/548 EEC) or is PBT or vPvB, the chemical safety assessment is extended to include (for all identified uses):

- Exposure assessment including generating exposure scenarios (or identification of relevant use and exposure categories) and exposure estimation.
- Risk characterization.

All potential Registrants (M/Is), Downstream Users (DU), and third parties will participate in a Substance Information Exchange Forum (SIEF):

- To facilitate for the purposes of registration the exchange of information between potential registrants thereby avoiding duplication of studies.
- Agree classification and labelling (C&L) where there is a difference in C&L between registrants.
- REACH Title III deals with data sharing.

Information in the Supply Chain

- The supplier (M/I,DU, Distributor) of a substance or preparation shall provide the recipient with a Safety Data Sheet (SDS) if:
- The substance or preparation meets the criteria for classification as dangerous or
- PBT/ vPvB
- Substance of concern for other hazards.
- REACH Annex II deals with SDS. SDSs contain: Chemical Safety Report information, Exposure Scenarios, Risk Management Measures (RMM) for Exposure Reduction.
- *Communicate Down the Supply Chain*: Each

actor (M/I, DU, Distributor) in the supply chain communicates to the downstream user whom he supplies with a substance

- *Communicate Up the Supply Chain:* A downstream user communicates to the actor in the supply chain who has supplied him with a substance.
- The SDS is the tool of communication.

Obligations of Downstream Users for Registration

- A DU (or distributor) may provide information to assist in Registration.
- Downstream Users of Dangerous Substances must :
  - Inform their suppliers of their or their customers' use(s) so the supplier can prepare exposure scenarios for that use, including identification of appropriate risk management measures (RMM), or….
  - Keep the use(s) confidential and prepare the exposure scenarios and identify appropriate RMM for these uses themselves and….
- Apply as a minimum the identified RMM for their own use and to recommend the identified RMM to their customers together with other information in safety data sheet (SDS) for the substance. Note: DU may be required to prepare an SDS or Exposure Scenario & annex to existing SDS.
- Report their uses to the European Chemicals Agency if they use substances in quantities of 1 tonne or more per year outside the conditions of an exposure scenario supplied to them in the SDS, including, if necessary, any proposals for testing.
- All DU to provide feedback to their suppliers if they do not agree with information supplied to them.
- Keep information available for a period of at least ten years

4. The HS&E "Ingredients" for Registration of Cobalt Substances

- Specific data on physicochemical properties of substance Annex VII-X
- Specific data on toxicological properties of substance –Tonnage Driven, Annex VII-X.
- Specific data on ecotoxicological properties of substance- Tonnage Driven Annex VII-X.
- Specific data on manufacturing and use of substance.
- Specific data on human and environmental exposure to the substance & exposure reduction practices.
- The Scientific and Technical Information will be used to:
  - Prepare Chemical Safety Reports
  - Prepare Safety Data Sheets
  - Develop Exposure Scenarios
  - Develop Risk Management Measures
  - Carry Out Risk Characterization

Summary

- **Definitions** (Find them in REACH Article 3)
- **Timing** (REACH entry into force 1 June 2007)
- **The legislation**
  - One substance-One registration
  - Manufacturers, Importers, and Downstream Users all participate in Registration.
  - Information must be communicated up and down the supply chain. M/Is and DUs (under specific circumstances) must conduct Chemical Safety Assessments and prepare SDSs and CSRs.
- **HS&E Ingredients for Registration**
  - Physicochemical, Tox, and Ecotox data requirements are tonnage driven.
  - M/Is and DUs must provide detailed information on substance manufacturing processes and all uses.
  - M/Is and DUs must provide detailed exposure information (Environment and Human).
- **M/Is and DUs must provide detailed exposure reduction measures for humans and the environment (Risk Management Measures).**
- **The CDI have the technical and management expertise to guide cobalt stakeholders in the REACH Registration process**

The conference proceedings are available to purchase from the CDI at a cost of £150.00. For more details, please contact Isabelle Porri.

Powder Metallurgy Superalloys

Though a little dated, the foregoing article is nonetheless a good introduction to the application of powder metallurgy in superalloys which continues to be one of the major uses for cobalt. We intend to develop the powder metallurgy series and bring the readership right up to date with developments over the forthcoming issues of the Cobalt News.

History

Nickel-base powder metallurgy (PM) superalloys have been in the hot sections of jet engine aircraft for over twenty five years. They provide improved strength, creep resistance, creep fatigue, and better low cycle fatigue properties at higher temperatures than conventional superalloys. Fracture mechanics, with its emphasis on defect size and crack growth rate, is a major design criterion for their application, and the concern about ways to both define and limit the defects that are inherent in PM products continues.

Tight process control limits during processing after atomisation deal very successfully with non-metallic defects. Contamination has been minimised or eliminated through handling in clean room environments, often using vacuum or inert gas screening and loading. To quote one user of PM, `Powder is not the problem. Process control is the key.' Nearly all engine manufacturers agree that PM superalloys will give improved high temperature performance.

Reports have recognised that fatigue life of superalloys was limited by defects, but improved alloys were likely to come from PM. In a 1995 report, the US National Materials Advisory Board stated 'turbine engine applications account for approximately 90 percent of the market for superalloys', and it is probable that 100% of applications are in gas turbine engines.

Processing

PM superalloys were initially used as near net shapes in the as-HIP and heat treated condition using coarse powder as the starting material. Although there has been alloy development over the past twenty years, two process changes represent more significant advances in the PM superalloy technology; a shift initiated by Pratt & Whitney to 'gatorising' or isothermal forging, and the use of finer powder.

All PM superalloys today use powder with a maximum particle size no greater than 106 microns, and in many cases with a maximum size as small as 44 microns. These two changes were performance driven - start with smaller non-metallic defects (finer powder) whose size distribution is tight, or make those defects that are present less vulnerable to fracture initiation and growth (isothermal forging). Atomisation improvements have enabled the powder manufacturer to improve the yield of fine powder with little or no sacrifice in cost, and the low cycle fatigue properties of isothermally forged products are superior to as-HIP product. The fine-grained structure in extruded billets for isothermal forging enables them to be inspected using high sensitivity ultrasonic testing to detect what small defects may be present.

Although the vast majority of PM parts in today's engines are isothermally forged, as-HIP parts are still being used especially in those applications where creep strength is the sole design criterion. A third change that appears more frequently in current specifications is a switch to supersolvus heat treatment to increased grain size and damage tolerance. The PM superalloys now in service are all nickel base and gamma prime hardened, table 1.

Table 1. Composition of some PM superalloys

	Alloy					
Element	Rene 95	Rene 88 DT	Astrolloy	MERL 76	IN-100	N-18
C	0.06	0.03	0.02	0.02	0.02	0.02
Cr	13	16	14.5	12.4	12.5	11.5
Co	7	13	16.5	18.5	18.5	15.7
Mo	3.5	4.0	5.0	3.2	3.2	6.5
W	3.5	4.0	-	-	-	-
Ti	2.5	3.7	3.5	5.0	4.4	4.35
Al	3.5	2.0	4.0	4.3	5.0	4.35
B	0.007	0.015	0.03	0.02	0.02	0.02
Zr	0.005	0.03	0.06	0.05	0.06	0.03
Other	Nb 3.5	Nb 0.7	-	Nb 1.65	V 0.8	Hf 0.5

The volume percent of gamma prime varies up to 64% in MERL 76, but lower percentages in the two most recent alloys, N-18 and Rene 88DT suggesting that the optimum may have been exceeded.

The engine manufacturers using components derived from PM technology include Pratt and Whitney, General Electric, MTU, SNECMA, International Aerospace, CFM International, IHI and Allied Signal. PM parts range from a low of about 1.4kg (3.1bs) for cooling plates on the T 700 to a high of 640kg (14001bs) for the compressor disk on the GE 90.

Most of the PM superalloy parts in engines were chosen because of the performance that each one could deliver. While this used to be the sole criterion for alloy selection, the cost factor is now a major factor with many manufacturers.

Alloy Development

Alloy development also continues, especially in conjunction with NASA's program on the Mach 2.4 High Speed Civil Transport, and the IHPTET Program where higher temperature capabilities as well as longer times at T3max, are sought. Because two of the immediate goals of IHPTET are an 80% increase in power to weight ratio and a 30% reduction in specific fuel consumption, the use of titanium aluminides is virtually mandated. Interest in alpha-2 alloys has waned because of their temperature limitations, but work continues on monolithic gamma as well as gamma metal matrix composites.

A Ti-48Al-2Nb-2Cr centrifugal compressor diffuser has already been made as a replacement for IN718 with a 45% weight saving. This success has led to incorporating the gamma TiAl diffuser into a future Joint Technology Advanced Gas Generator (JTAGG). Orthorhombic aluminide may prove to be the biggest player in this field.

The specific strength advantages of these materials may push some superalloys out of compressor components, and their high temperature properties may have similar results in other engine parts. Aluminide production applications, which will cut superalloy usage, are still a short way off and changes involving cost reduction and alloy development may affect the scenario for PM superalloy usage quite quickly.

The reasons for alloy development are not new. The push to increase the operating speed and temperature of turbine disks at both the rim and the bore continues. There is work going on independently at Pratt & Whitney, General Electric, Rolls Royce, and SNECMA to develop a new disk alloy or an improved process that will allow rim temperatures to be between 700 and 750°C.

Criteria for development at these temperatures continue to be crack growth tolerance, low cycle fatigue, creep resistance, creep fatigue, and a resistance to environmental attack. Bore temperatures of the turbine disk will also increase and the major criterion there will be elevated temperature strength. Three of the companies involved explicitly state that any new alloy will be powder.
New alloys are also likely to be revisions of existing alloys for these incremental improvements. GE holds patents which modify compositions of existing alloys using tantalum as a major alloying element, and in some cases substitute it completely for tungsten.

Processing

Process changes to improve performance of existing or modified alloys continue. Using finer powder satisfies the demand for improved reliability in civil aircraft. Supersolvus heat treatment to increase grain size has proved a reliable means to improve fatigue life and in the case of N-18 has resulted in only a 5% decrease in tensile strength.

With a single alloy for the disk, selective heat treatment is a process that must be considered. The result is a part with varying grain size from the rim to the bore and a gradation of properties within the same material. The use by Pratt & Whitney of IN-100 `integrally bladed rotors' in the 6th, 7th, 8th, and 9th compressor stages of the F-119 engine is a very specific example where properties are controlled by the process. The first flight of this engine which will power the F-22 advanced fighter was scheduled for early 1996. Compressor blades do not see the high temperatures of those in the turbine section, so this process may be limited to the compressor section. Use of integrally bladed rotors means a thinner, lower weight rim, but this process will probably be limited to military engines since commercial operators would probably prefer to replace a single blade than a whole disk.

Another processing route for higher operating temperatures is the dual alloy approach in which the blade and ring assembly is bonded to the hub of a disk. This enables the use of the cast blade alloy in the hottest section of the disk where creep could cause failure. Depending on temperature requirements, the hub could be a PM alloy. There may also be work being done on the concept of a triple alloy, comprising one for the blades, a second for the rim, and the third for the hub.

Requirements for the NASA High Speed Civil Transport originally focused on the combustor and the exhaust nozzle, but now include air foils which will be cast, the fan container disk and the turbine disk. It is the latter that poses the biggest challenge. Although the rim temperature will be approximately 700°C, it will stay hot for 2 to 3 hours to present

engines maximum temperature for only a few minutes during takeoff.

It has also been reported that there will be no temperature gradient between the rim and hub, so it is likely that process innovations and new alloys will be the solution. Because the maximum temperature is only 700°C, this disk will stay nickel based and will be a PM superalloy. NASA's objective is to have all the technology available by 2003 so that a commercial decision can be made to have a plane built by 2005.

Cost Reduction

There are three cost improvement processes which may have an early effect on PM superalloy usage. Two of these are very similar. These are atomisation deposition (Spraycast X), and electroslag remelting as a source for spray forming. The third is the replacement of VIM-VAR superalloys with PM as-HIP superalloys.

Spraycast X, developed by Howmet for Pratt & Whitney, is a lower cost method to producing superalloy rings. It provides a direct one step conversion of vacuum melted superalloy to semifinished rings. The production of rings from billet material is compared with that of material from Spraycast. Economically, it appears advantageous, but grain size control presents challenges. At present, P&W is not considering this process as a replacement for IN-100. Its purpose is to replace cast and wrought alloys as a cost reduction.

General Electric envisions its patented process, using the ESR furnace in conjunction with the cold induction guiding nozzle, as a means to manufacture preforms which will be isothermally forged to replace some of its PM superalloy hardware. Whether it can produce the quality necessary to replace parts currently made from powder remains to be seen. Because the product that solidifies on the preform is approximately half liquid and half solid, the necessary grain size control may prove to be a very formidable problem in the development work and could eventually limit the use of this process.

A third cost reduction process is one that Allied Signal used when they first used PM Astroloy in the disks on their APUs. The cost analysis, in which the final component cost was the raw material cost plus fabrication, showed that the uniform fine grained PM product machined much better than wrought Astroloy, and lowered the total cost.

The company's experience has been very good over a ten year time period. In response to the question `Why use as-HIP?', the reply was `It is better to know your worst defect and be prepared to deal with it. Know the size of the ceramic defect and deal with this from a design standpoint using fracture mechanics to get defect tolerance. There is then no need to worry about unforeseen forging defects.'

Another very large user of as-HIP PM superalloys is the Russian aerospace industry, all of whose PM superalloys are as-HIP They have fifteen years experience with this product and are happy with as-HIP hardware. It is possible that these experiences may re-open the evaluation of as-HIP hardware as a cost reduction.
Another cost reduction potential, the use of nitrogen instead of argon as the inert gas during atomisation, will probably not succeed. There is a long history of success with argon, and perhaps the only way that nitrogen will be used is with spray deposition to ensure that there is no porosity in the product.

PM Growth

PM superalloys, which were termed `a troubled adolescent' have now fully matured. Growth in the near future will depend on the success of the Boeing 777, since there are significant amounts of powder in both the P&W and GE engines for this aircraft. The GE 90 alone has six PM parts with a total weight of 2100kg (47001bs).

Two other areas for growth are the market for lower thrust engines, where demand for increased efficiencies may bring PM superalloys into play, and land based turbines for power generation. This industry may borrow the technology from the aerospace field.

Key Properties

Compared to conventionally produced superalloys, PM superalloys provide:

- Improved strength
- Improved creep resistance
- Improved creep fatigue
- Better low cycle fatigue properties

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