

# **The Environmental Challenge : The Approach Adopted for the Manufacture of Chromium Metal and Ferrotitanium**

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## **1. ABSTRACT**

Purchasers are increasingly concerned that goods and services have been produced in an environmentally responsible manner. Similarly, many banks and other financial institutions will only provide services to companies which can demonstrate that their operations are being carried out in a manner which pays due regard to the environment. It is therefore crucial that manufacturers operate in accordance with good environmental practice.

There is no doubt that countries throughout the world are realising the need to protect the environment and this has resulted in many countries enacting regulations for this purpose.

The European Union recently introduced new legislation [EU Directive 96/61/EU] on Integrated Pollution Prevention and Control [IPPC]. The legislation required all European Member States to implement National legislation by 30 October 1999. IPPC is a new pollution permitting system that applies mostly to manufacturing companies but waste management, energy production and some farming activities are also included.

London & Scandinavian Metallurgical Co Limited [LSM], based in the United Kingdom, is a major producer of ferrous and non-ferrous metals and alloys. The Company is part of the Metallurg Group, whose Head Office is in New York.

Over the past few years LSM has built new manufacturing facilities to improve productivity and meet the environmental

challenge. Two plants were built to produce ferro titanium and chromium metal at a cost of \$1 million and \$4.8 million respectively.

Fundamental to the new permitting system is that when a company selects, or changes, its manufacturing processes it is required to reduce, or prevent, environmental impacts using the 'best available techniques'. This paper describes how these two state of the art plants meet the anticipated requirements of the new European Directive.

## **2. INTRODUCTION**

London & Scandinavian Metallurgical Co Limited [LSM] was established in 1938 and has had a manufacturing base at Rotherham in the United Kingdom since 1947. It is part of the Metallurg Group which is a leader in the production and marketing of high quality ferrous and non-ferrous metal alloys and specialist metal products. Principal markets include the aluminium, iron and steel, titanium and superalloy industries.

The world is ever changing and this paper describes how LSM has successfully risen to the challenge of meeting the rightly ever more stringent environmental standards, specifically for the production of chromium metal and ferrotitanium.

## **3. THE PRODUCTS**

### Chromium Metal

LSM produces chromium metal much of which is supplied to the superalloy industry. The process is the reduction of chromium oxide by aluminium powder.

### Ferrotitanium

LSM sells ferrotitanium to the steel industry worldwide where it is has several uses

including interstitial free steels and the stabilisation of stainless steel. The process used at LSM is scrap based and the raw materials can be in many forms such as turnings, sheets and heavy sections. Blends are prepared and charged into a dedicated purpose built induction furnace.

#### 4. THE REGULATIONS

Environmental law has grown rapidly over the last decade. Much of the legislation applies to the manufacturing industry as emissions, by-products and waste produced during manufacturing processes have the potential to pollute the environment. The **Environmental Protection Act 1990** (EPA) introduced integrated pollution control (IPC), which stipulates that it is an offence to operate a "prescribed process" without authorisation from the Environment Agency (EA) in England and Wales, or the Scottish Environment Protection Agency (SEPA) in Scotland.

Manufacturers are responsible for operating the processes that come under IPC, and therefore play an important role in gaining authorisation.

If authorisation is granted, it will probably be subject to a series of conditions covering how the process is operated, and what monitoring must be carried out.

IPC was changed when EC Directive 96/61 on Integrated Pollution Prevention and Control (IPPC) became law after being approved by the United Kingdom Parliament in July 2000. All new installations must comply with IPPC. Existing installations which come under the IPPC Directive are allowed a transitional period until 30 October 2007 in which to comply.

The IPPC Directive was based on the UK system of IPC, although there are a number of important differences, including:

- many more installations will come under IPPC than currently come under IPC.
- IPPC takes into account more environmental impacts than IPC, i.e. the condition of the site when

an installation closes, energy efficiency, waste reduction, noise, vibration, heat, consumption of raw materials and accident prevention.

- IPPC applies to installations, whereas IPC applies to processes.

It should be noted that some of the new installations for IPPC will come under the control of the local authority (LA) rather than the EA.

The purpose of the IPPC Directive is to achieve integrated prevention and control of pollution leading to a high level of protection of the environment as a whole.

More specifically, it provides for a permitting system for certain categories of industrial installations requiring both operators and regulators to take an integrated, overall look at the polluting and consuming potential of the installation. The overall aim of such an integrated approach must be to improve the management and control of industrial processes so as to ensure a high level of protection for the environment as a whole. Central to this approach is the general principle that operators should take all appropriate preventative measures against pollution, in particular through the application of best available techniques enabling them to improve their environmental performance.

The term "best available techniques" (BAT) is defined as "the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole". This definition is clarified as follows:

"techniques" includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned;

“available” techniques are those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator;

“best” means most effective in achieving a high general level of protection of the environment as a whole.

LSM has always been in the forefront of environmental best practice and has therefore co-operated fully with the European Commission in putting forward such “best available techniques”. Our expertise has therefore been given freely to the Commission and is now described.

### 5. LSM's APPROACH

#### Chromium metal production:-

The following description gives details of the new plant installed for the production of Chromium metal. The plant was built to replace an existing Chromium Metal production plant, which had been in operation for more than 40 years. The plant was commissioned in 1997.

*i] Raw Materials Storage:-* Raw materials such as chromic oxide and aluminium powder as well as various oxidising and conditioning agents are stored at one end of the building in separate areas to prevent cross-contamination. The oxidising agents are stored in a secure compound to avoid the risk of fire.

*ii] Weighing Operation:-* The Chromic Oxide bags are attached to discharge stations situated above weighing hoppers mounted on load cells at floor level. Screw feeders transfer the raw materials into the weighing hoppers.

The weighing bin for each batch sits on an electrically driven bogie, which travels on a rail track situated in a pit beneath each discharge point. The various raw materials are automatically dispensed into the

weighing bin. This process and the positioning of the bin on the track are computer controlled.

*iii] Mixing Operation:-* The weighing bin is transferred to a separate enclosed room where the contents are mixed in a rotating blender.

*iv] Firing Operation:-* A firing pot is located inside one of several firing chambers situated below ground level. Travelling fume extraction hoods are moved forward to cover the firing pot and to connect with the main extraction ducting.

After the reaction fume has subsided, a reduced extraction volume is provided to each chamber containing a cooling pot.

#### Main Environmental Benefits:-

**The Main filter plant:-** Firing can only take place in one chamber at a time due to a system of interlocks on the travelling hoods and firing feed conveyor.

During the firing process when large amounts of fume are generated for a relatively short period of time, the extraction volume is at its maximum. During this period a lower ventilation volume is available at the other remaining chambers [one or more of which may contain a pot which is cooling but emitting little fume].

When no firing is taking place, the fume plant is automatically shut down to the lower extraction rate in order to minimise the energy consumption of the filter unit.

The filter plant comprises 4 compartments, with 132 filter bags per compartment. The cleaning cycle is fully automated with each chamber cleaned ‘off-line’ in turn by means of a reverse air pulse system.

A monitoring and recording system is installed on the fume plant to continuously monitor particular emissions. This comprises of a probe mounted in the exhaust stack and a combined control unit/microprocessor based data-logger. Emissions from the stack are continually monitored and any deviation above a pre-set level will signal an alarm.

The fume plant operates with a total particulate emission level below 5 mg/Nm<sup>3</sup>.

**Emissions to air:-** Total particulate emissions are below 5 mg/Nm<sup>3</sup> where the part of chromium and its compounds is less than 1-2mg/Nm<sup>3</sup>.

**Emissions to water [sewer]:-** The only liquid emission is from the water quenching tanks.

**Emissions to land:-** Waste fume dusts from the process are taken to a licensed landfill site. The quantity of fume dust generated depends upon the quantity of chromium metal being produced.

**Operational data:-** The plant uses the following utilities:

|             |                                                                               |
|-------------|-------------------------------------------------------------------------------|
| Electricity | - 139 kWh/tonne of Cr metal                                                   |
| Gas         | - 6 m <sup>3</sup> /tonne [calorific value of gas is 39.2 MJ/m <sup>3</sup> ] |
| Water       | - 2 m <sup>3</sup> /tonne                                                     |

**Cross media effects:-** The nature of the operation is such that most of the releases are to air rather than to either of the other two environmental media.

For most applications, the metals industry has generally standardised on a bag filter plant to control airborne emissions. A bag filter plant [i.e. a dry system] was chosen for this application, as it would provide good filtration with the lowest environmental impact.

Wet scrubbing systems were considered, but rejected. A wet type of abatement such as a Venturi scrubber would result in a sludge waste, which would be more difficult and costly to dispose of, and would contain a significant proportion of water. The plume from the main stack would also be wet and not so well dispersed.

**Economics:-** The total cost of the project was in the order of about \$4.8m included in which were the following:

|                                      |         |
|--------------------------------------|---------|
| Weighing Station                     | \$0.65m |
| Firing Chambers/Feeders              | \$0.27m |
| Cooling Conveyor/<br>Stripping Booth | \$0.33m |
| Pot Preparation                      | \$0.23m |
| Main Fume Plant                      | \$0.60m |
| Building and Civil Work              | \$1.73m |

**Applicability:-** The above presented technique is as a whole applicable to a new plant, but can be applied to existing plants.

### Ferrotitanium

The following describes the approach adopted by LSM for the production of ferrotitanium. Importantly, details of the techniques used to minimise the environmental effects of degreasing titanium swarf are given. The plant was originally commissioned in 1993.

The production of ferrotitanium is achieved by melting ferrous scrap and titanium scrap in an electric induction melting furnace. The alloying process is slag free.

Ferrous units are purchased to a specification in the form of mild steel solids. Titanium scrap is delivered to site in container trucks. The feedstock includes lump scrap metal castings, wrought products and turnings (swarf) from machining processes. Upon receipt, materials are checked to ensure that they are not contaminated with radioactive materials. Large lumps of scrap are reduced in size. Swarf is chipped using a swarf pulveriser and then fed through a centrifuge to remove oil and moisture.

The titanium swarf is degreased in a rotary dryer, where the oil-bearing gases are led through a cyclone to remove dust and carry over. These gases then pass through an afterburner. Combustion gases/fumes are either re-circulated through the drier or are ducted to a second cyclone. After passing through the cyclone, sorbent (sodium bicarbonate) is introduced to neutralise the gas stream. Finally the gas passes through a ceramic filter before being discharged to the atmosphere via stack.

Furnace charges are calculated based on the analysis of the raw materials. The materials

are weighed into pans and fed into an electric induction melting furnace. A chute system is used to feed in materials during the melting operation. When melting is complete, the molten metal is tapped into an ingot mould and a stream sample is taken for analysis. After cooling, the ingot is transferred to other operations such as breaking, crushing and grinding to achieve the required product size.

#### **Degreasing of Titanium Swarf for the Production of Ferrotitanium**

The degreasing system removes oil and water from titanium turnings so that they can be safely melted in an electric induction furnace.

Swarf is degreased in a rotary drier (installed 1993) which is designed to distribute the swarf through a flow of combustion gases recycled from an afterburner. Material is fed into the degreaser by a belt conveyor, and after degreasing is collected in hoppers prior to melting.

Ducting carries the oil-bearing gases away from the dryer and through a cyclone to remove dust and carry over. These gases then pass through the afterburner, which is heated by a gas-fired burner. The Afterburner has been designed to allow complete combustion of the oil vapour [i.e. destruction of volatile organic compounds by thermal oxidation]. Combustion gases/fumes are either re-circulated through the drier or are ducted to a second cyclone. Dampers control the proportion of gas recycled. From the cyclone the gas stream enters the filtration plant (installed 1998). A sorbent material [sodium bicarbonate powder] is injected into the ducting prior to the filter unit to neutralise any acidic gases that may be present and prevent corrosion damage to the filtration plant.

Maximum temperature of gases entering the filter plant is 350°C. The filter is rated at approximately 7000 Nm<sup>3</sup>/h [at 350°C] and contains 576 ceramic filters. The filters are tubular and manufactured from calcium silicate or alumina silicate. The cleaning cycle is fully automated and cleaning is achieved by means of a reverse air pulse system. Particulate emissions from the stack are continuously monitored and any

deviation above a pre-set level will signal an alarm. The fume plant operates with particulate emission levels below 5 mg/Nm<sup>3</sup>.

#### **Main environmental benefits:**

##### **Emissions to air:**

Particulate - below 5 mg/Nm<sup>3</sup>  
Volatile organic compounds [VOC's] destroyed in the afterburner

VOC's are well below the permit level of 20 mg/Nm<sup>3</sup>

**Emissions to water:** - None

##### **Emissions to land:**

Waste fume dusts from the process are taken to a licensed landfill site. The quantity of fume dust generated will depend on the quantity and quality of swarf being processed.

**Operational data:** The plant uses the following utilities:

**Gas** the amount of gas consumed varies widely depending upon the density of the material being processed and the amount of oil and moisture contamination present. The average consumption is typically 374m<sup>3</sup>/tonne of swarf processed.

**Electricity** the plant is not independently metered. However, it is calculated that electricity consumption is typically 180 kWh/tonne of swarf processed.

**Water** None used.

**Cross media effects:-** The nature of the operation is such that the releases are to air, rather than to either of the other two environmental media.

For most applications the metals industry has generally standardised on a bag filter plant to control airborne emissions. However, for this application a ceramic filter was chosen due to the high temperature of the waste gas stream. The ceramic filter also provided good filtration with the lowest environmental impact.

Wet scrubbing systems were considered, but rejected. A wet type of arrestment such as a Venturi scrubber would result in a sludge waste that would be more difficult and costly to dispose of, and would contain a significant proportion of water. The plume from the main stack would also be wet and not so well dispersed.

**Economics: Project Costs**

The rotary drier and afterburner was installed in 1993.

The cost in 1998 would be in the order of

|                                                                        |         |
|------------------------------------------------------------------------|---------|
|                                                                        | \$0.56m |
| Cyclone, ducting [ceramic filter] filtration plant [installed in 1998] | \$0.45m |
| Estimated overall project cost                                         | \$1.0m  |

**Applicability:-** New and existing plants.

## 6. CONCLUSION

It can be seen that LSM has invested heavily to ensure that the production of chromium metal and ferrotitanium meets the ever stringent environmental needs of society today.

It is crucial that the modern alloy producer is exceedingly responsible and meets the environmental expectations of customers, financial institutions and national governments. LSM has achieved this and will continue to do so.