Technical Note:

Reduction of waste from fabrication processes

by J. Bongardt*

Synopsis

Ecologically acceptable techniques are described for the handling of waste materials from the fabrication industry. New production methods and the recycling of sludges from grinding and other waste materials are suggested.

Introduction

Traditionally, waste from industrial production was discarded. Nowadays waste material recycling and by-product reuse are demanded. The manufacturing enterprises in cooperation with environmental firms have developed new concepts to reduce waste in fabrication processes. An internal waste management policy within the production process in addition to changing the fabrication process are acceptable ways to reduce waste, decrease costs and guarantee the product's quality.

Reduction of waste by alternative processing

One method for reducing residues and wastes is to increase the material yield by improving well-known fabrication methods. For example, improved methods of precision casting, precision forging, laser welding and electrophoretic coating are now being employed. Another method is to decrease the output of waste by using more efficient waste-reducing methods of processing.

In the surface hardening of steel, toxic residues are produced from the traditional salt bath used for nitriding. These residues incur high disposal costs.

A work-piece surface of similar quality can be made by gas cyaniding. The development of high pressure nitriding gives the advantage of short processing time and the grinding/finishing step is not required by virtue of the high dimensional accuracy achieved by controlled gas quenching. This treatment method has been successfully applied in the fabrication of fuel injection nozzles.

In another case wear-resisting parts are flush quenched by pressure spraying instead of boronizing. By using this alternative, the costly disposal of fluoroboric acid in residual substances becomes unnecessary. (Incidentally, the carrier substance for boronizing can be recovered.)

Laser treatment of surfaces does not produce waste, but the laser beams may cause damage to personnel. The hardness of a laser track is influenced by the material and can be controlled over a wide hardening range by the treatment rate. Under the conditions of complex dynamic loading conditions the hardness and residual stress promise a long life of these products as shown in Figure 1. This technology is used for hardening piston rings and crankshafts.

In addition to the reduction of waste by alternative methods for surface hardening, another possibility of reducing waste is the adaptation of heat treatment in the fabrication process to the application of different machining methods.

The traditional way to machine rings of chromium-alloyed steel is schematically demonstrated in Figure 2. The formed unworked piece is machined in the first step by a hard metal tool without a cooling lubricant. The dry chips from this turning process can be used in

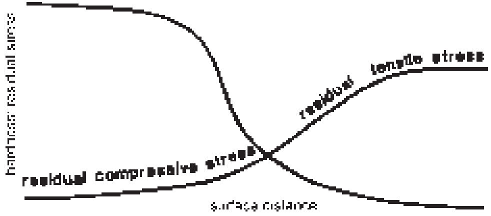

Figure 1—Hardness and residual stress in a laser-treated skin (schematically)

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the form of briquettes for remelting in steel production without any problems. After traditional heat treatment with oil quenching and reheat drawing of the temper, the working part is finished by grinding. The use of a cooling lubricant oil for grinding necessitates washing the work-piece.

The result of the grinding process is that the skin of the work-piece has residual machining stress. The stress is caused by the cutting forces and the thermal conditions. It can be influenced by the cutting speed, the feed rate and the cooling lubricant. In the case of the tensile stress in the skin, the life of the work-piece will be reduced in service.

An additional shot-peening step has a favourable effect. It leads to a compressive residual stress combined with a long life, as proved by Schreiber[1].

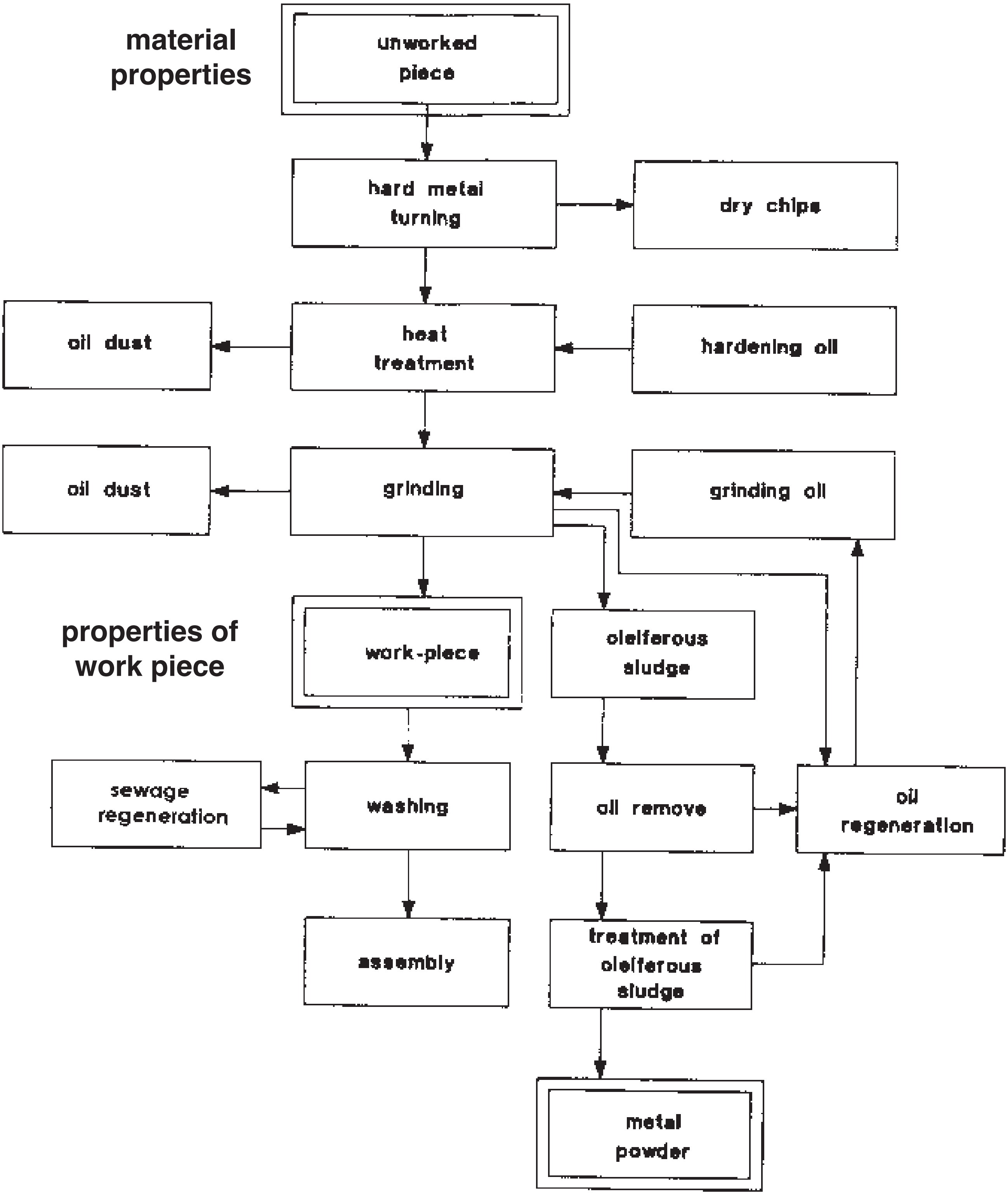

Figure 2—Production process 1 for chromium alloyed steel rings (schematically)

The contaminated sewage water, the oleiferous grinding sludge and the used hardening oil are the undesired by-products of the fabrication process. In the past these waste products were disposed of in a simple way by physico-chemical treatment or by incineration. Oleiferous sludge derived from low-alloyed steel production processes can also be fed into the rotary kilns of cement production plants.

Figure 3 represents, schematically, a simplified variant of a conventional production process. The turning of hardened steel with a CBN-tool needs more machining time, caused by lower machinability rating and feed rates. However, the handling costs are reduced.

Clean chips are the residue of dry turning. They can be fed to an electrical furnace for remelting. Dry turning does not create additional costs for the treatment of the cooling lubricant and its recycling.

The machining with a cooling lubricant emulsion allows higher productivity, but makes purification of the cooling lubricant necessary for reuse. The wet chips also have to be cleaned for recycling or for disposal.

The properties of the skin of work-pieces machined with cooling lubricant and dry-turned, respectively, were investigated by the author[2]. The results are demonstrated in Figure 4 and Figure 5. The surface hardness of the wet-turned work-piece is higher than that of the dry-turned. In both cases a long life-time of the work-pieces follows from the residual machining stress in the skin.

An alternative fabrication method could be the dry machining of the soft unworked piece, initially with a hard metal tool and in a second step with a CBN-tool, followed by laser treatment as shown in Figure 6. By this tooling combination no hardening oil and no lubricant is required. An additional advantage are low handling costs due to the fact that for all the operating steps the work-piece needs only one mounting in only one complex machine.

Recycling of residues and waste treatment

Residues and waste, e.g. sewage water, contaminated chips and sludge, are the undesired by-products in the process of

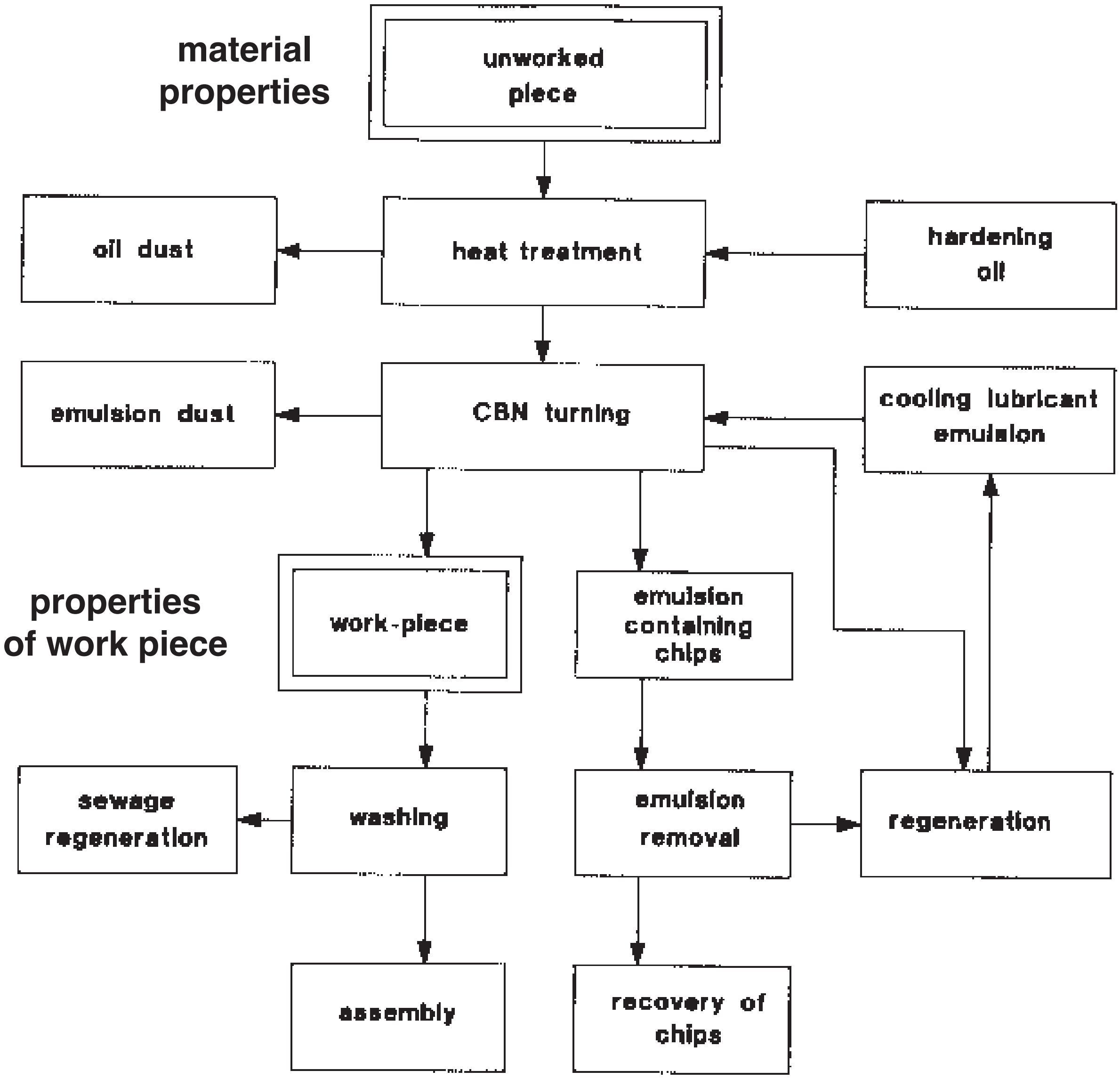

Figure 3—Production process 2 (schematically)

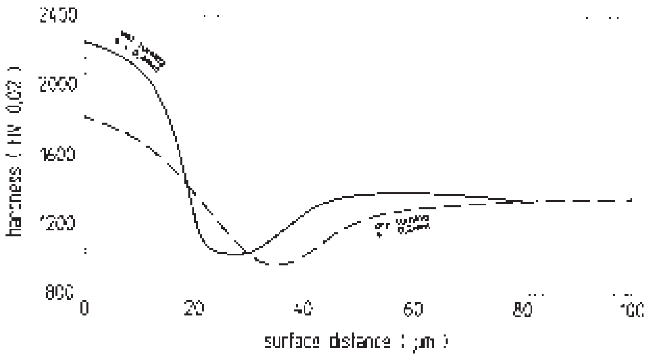

Figure 4—Hardness of CBN-turned surface

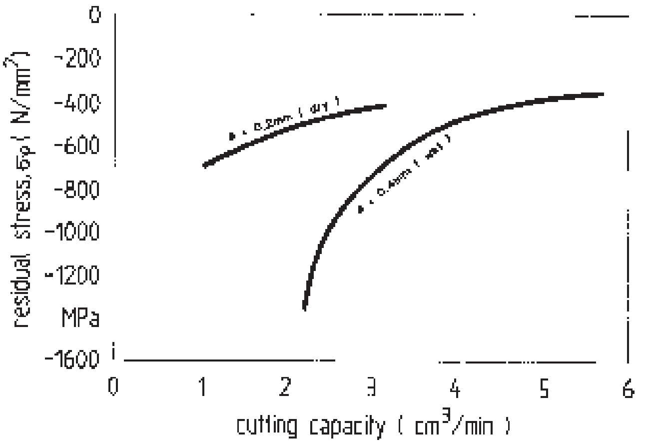

Figure 5—Residual stress of CBN-turned steel

metal machining. In the machining of automotive components approximately 18% of costs result from the use of conventional cooling lubricants. The conclusion is that the cooling lubricants (which allow a high machining rate), should be recycled for a long period to reduce costs. The costs for procurement and disposal of cooling lubricants and the impact of recycling them were investigated by Kißler³. The results are demonstrated in Figure 7.

The recycling of oil-contaminated chips is also a possible method for an environmentally friendly production process. The washing process, especially when used for non-ferrous alloys, delivers clean chips, which are briquetted for remelting. The washing liquid is also recycled in a circuit as shown in Figure 8. The resulting mud and the oil are incinerated.

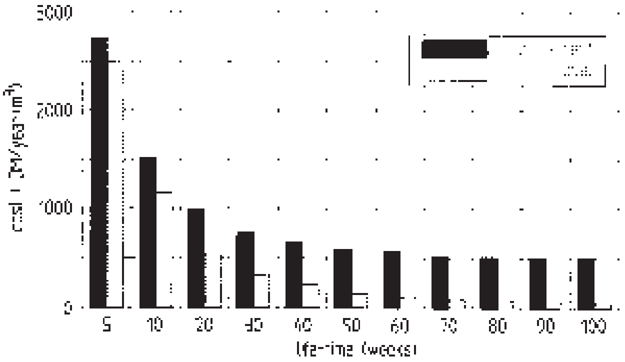

Figure 7—Costs for the procurement and disposal of lubricants depending on the life time

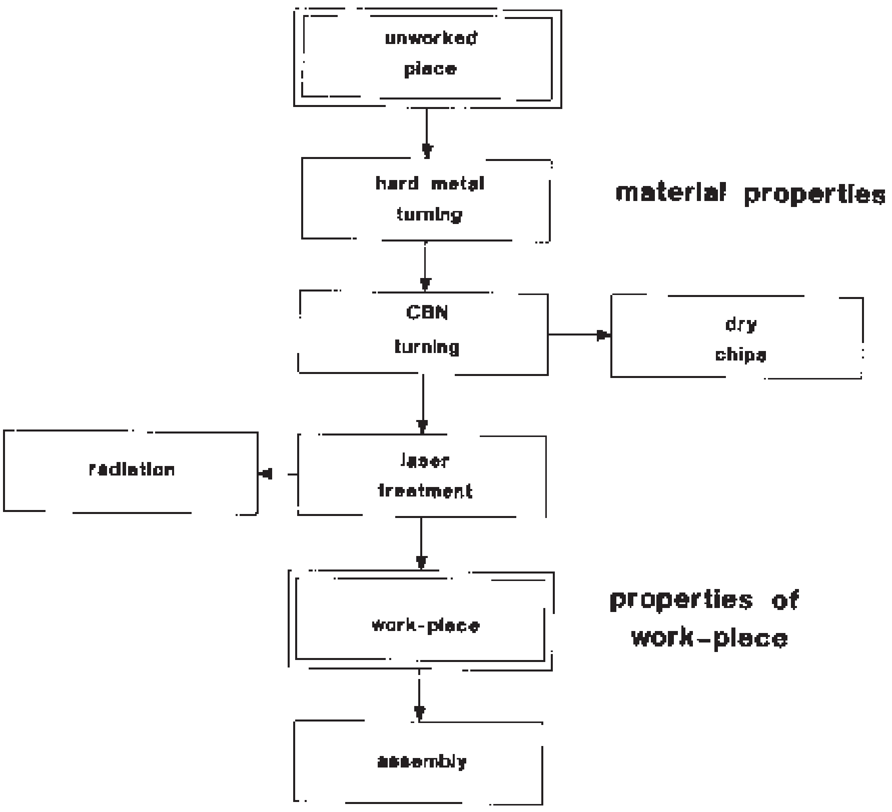

Figure 6—Production process 3 (schematically)

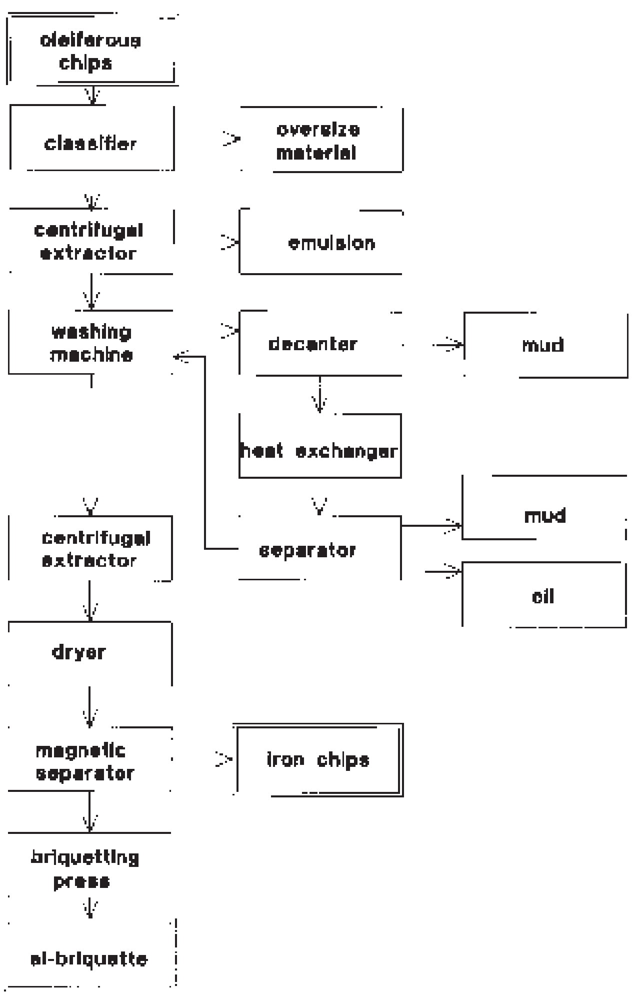

Figure 8—Washing of non-ferrous metal chips

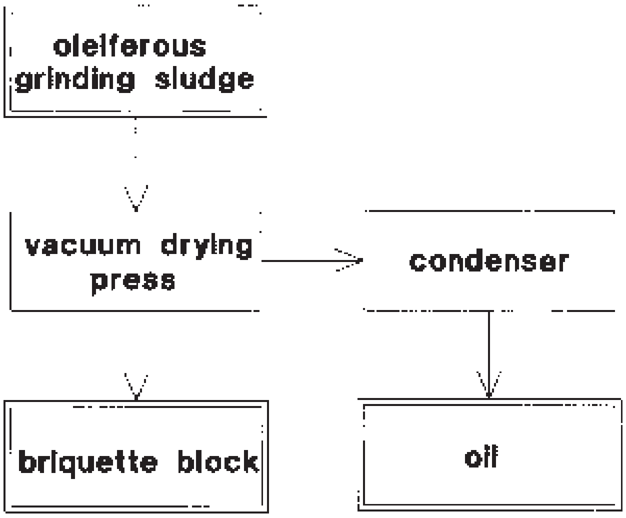

Figure 9—Vacuum treatment of oleiferous grinding sludge

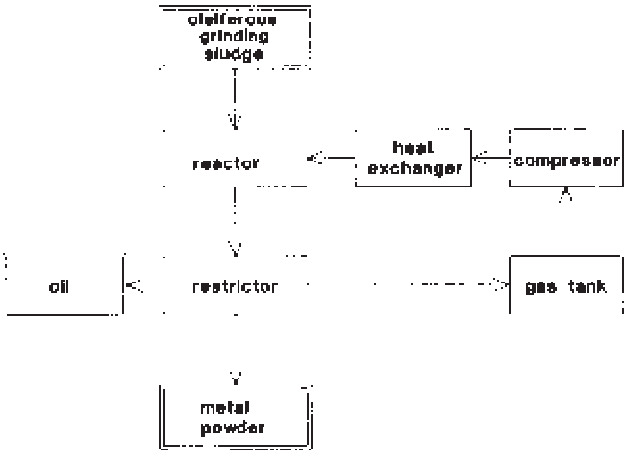

Figure 10—Gas extraction of oleiferous grinding sludge

The discard of oleiferous chips and grinding sludge is costly and restricted by their maximum oil content of 3%. Their remelting in a cupola demands an oil content of less than 10% and less than 1% in an electric furnace. An oil content of 1% can be achieved by heating the sludge at a temperature of 500°C in a drum dryer and then burning the oil fume in a recuperator. Also, the limit of 1% oil can be guaranteed by recycling the oleiferous sludge in a vacuum drum heated indirectly or heated by electrical resistance in a special vacuum chamber at a temperature of up to 250°C. The vacuum process is schematically demonstrated in Figure 9.

The output of this process, namely the metal powder briquetted blocks, is reused for steel production. After regeneration the oil is fed to the machining system.

The best quality of regenerated oil is reached by a treatment of the oleiferous sludge with supercritical CO_2-gas. The process is illustrated in Figure 10, but the equipment for this process is the most expensive when compared with other methods.

Conclusions

Reducing waste in fabrication means decreasing costs and improving ecology. The benefits in waste reduction are increased material yield, the application of new production methods with a low output of waste and the recycling of cooling lubricant and other process by-products. However, the application of new production methods to minimize waste output demands a comprehensive knowledge of material properties and machining methods to guarantee high-quality products.

To solve the many problems it is necessary to intensify the cooperation between manufacturing industry and waste management firms.

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Honours for three inventors who made a global impact*

Three people whose technology developments have had a global influence on the minerals industry have been honoured by The Australasian Institute of Mining and Metallurgy.

Their awards are welcome recognition of the role played by scientists and technologists in the nation's success as a mineral exporter, said Institute President, John Ralph.

They also demonstrate that the export of mineral technology is an important by-product of our mining success, Mr Ralph said.

The awards are to:

John Floyd, of Dandenong, Victoria, was the creator of the Ausmelt smelting process which has greatly improved the productive and environmental efficiency of smelting, in the USA, France, Germany, India, Korea, Zimbabwe and Namibia as well as Australia. He receives The AusIMM President's Award.

Charles Warman of North Sydney initially developed and then progressively refined and manufactured slurry pumps which were first used around Australia and are now used globally. He receives The Institute Medal.

Ian Devereux of Manukau City, New Zealand, developed and manufactures mineral sampling equipment which has been adopted internationally. He receives the Mineral Industry Operating Technique Award.

Announcing the awards, John Ralph said they illustrated that success in the minerals industry owed almost as much to a nation's intellectual resources as to its physical assets.

'Each of these awards has been made to people who achieved world class technological excellence in three very different areas of the industry', he said. 'Each underscores the export value of locally-developed minerals technology.' ◆

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Iscor world leader in mineral and metal industry*

'Iscor is without a doubt a world player in the mineral and metal industry.' This is the message Mr Hans Smith, Executive Chairman of Iscor Ltd and Honorary Professor of the Department of Material Science and Metallurgical Engineering at the University of Pretoria delivered recently to the Pretoria branch of the South African Institute of Mining and Metallurgy (SAIMM).

'The potential of Iscor, processor of mainly iron ore, coal, ingot steel and rust-resistant steel to expand is enormous. Particularly as regards quality, the world leaders can come and learn from us.' According to Mr Smith, growth is not measured in volume only, but particularly in value.

In the area of technology, Iscor is also one of the leaders. A case in point is the Corex and Ifcon processes. For instance, Iscor opened the first Corex plant in the world. 'These processes are unique and the quality of the products is excellent,' says Mr Smith. ◆

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Acta Metallurgica Gold Medal award*

The 1997 Acta Metallurgica Gold Medal has been awarded to Sir Peter Hirsch, Emeritus Professor of Metallurgy at Oxford University. The medal is an international award, established in 1974 to recognize outstanding ability and leadership in materials research. It is awarded annually by Acta Metallurgica, Inc. with financial support from Elsevier Science Ltd. Professor Hirsch has conducted research of enormous scientific signficance and technological impact, and taught a generation of students who are now in academic and industrial positions throughout the world.

Professor Hirsch was nominated by The Institute of Materials, and was selected for the award by a distinguished international panel of judges. The medal will be presented to him on April 15, 1997 at the Institute of Materials Council Dinner in London. ◆

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