The aim of this project was to develop a cost-effective briquetting system for recycling process residues and rock mineral wool offcuts back through a cupola melting furnace.

The production process for rock mineral wool insulation products generates a number of residue streams with different physical characteristics. Together these add up to a significant proportion of the raw materials input to the process. Previously, recycling of the residue had not been viable because of the abrasive nature of the different materials streams and specific processing constraints and it had been disposed of to landfill. Much of the material is low density, bulky and costly to send to landfill.

The primary objective of this project was to develop a system capable of converting the various abrasive secondary streams into suitable briquettes within several minutes and with acceptable levels of wear and cost. A series of development trials investigated an extensive range of conditioning equipment, inorganic and organic binder systems and numerous forms of briquetting presses. Wear problems proved to be a major difficulty but these were overcome using a novel forming method. A satisfactory system was developed to offer cost-effective, fast formation of briquettes, without heat and with good briquette strength.

The benefits of the new briquetting system include:

- **Reduction of landfill disposal and CO₂ emissions**
- **Estimated eventual savings of around £80 000/year on raw material, energy and landfill disposal costs**
- **A cost-effective solution to a difficult processing problem**
- **Potential application for the technology in other smelting processes**
Background

Rock mineral wool is a spun, mineral-wool product commonly used for domestic insulation and widely employed in industrial and horticultural applications.

Rock mineral wool is made by heating a mixture of basalt rock and coke fuel with various slags and mineral fluxes at a temperature in excess of 1,550°C in a cupola furnace. The melt is run from the cupola on to one or more rapidly rotating metal wheels and fibreised - an air blast produces a controlled veil of fibre and small particles of unfibreised melt (known as shot). The fibre is sprayed with an organic binder solution before being formed into various thicknesses and widths of mat for fabrication into slab, roll or other insulation products.

The conversion efficiency of the process is relatively poor due to a number of inherent process constraints - typically residues from wet fibrous filters, defective product and recovered shot. A further process residue arises in the ‘hell-hole’, where glassy solids accumulate underneath the cupola. These streams are illustrated in the process schematic in Fig 1. In 1993, when the project was begun, over 50,000 tonnes/year of rock were processed at the Owens-Corning Queensferry plant. The melt value of the residues, when combined with the cost of disposal to landfill, resulted in a total effective loss of around £400,000/year.

There are several environmental issues surrounding the process. In addition to the amount of process residues disposed of to landfill, and the associated use of transport, the process also involves quarrying, the transport of raw materials, significant energy use and the emission of CO₂ from the cupola.

These economic and environmental pressures prompted an evaluation of the recycling of rock mineral wool process residues. However, this material could not simply be returned to the cupola because raw materials must be introduced as fist-sized lumps to maintain good gas flow through the cupola bed. This ensures good heat transfer from the burning coke. If fibrous or finely divided rock mineral wool were to be fed straight into the cupola it would result in reduced airflow through the bed, leading to temperature reduction and melt solidification. Additionally, gas flows through the system would also carry fibre into the bag filters, causing blockages, overpressure, and a risk of fibre release to atmosphere through overpressure relief.

Briquetting input raw materials and even some process residues is a recognised method of introducing feedstock into a cupola, but methods generally rely on the use of cement binders. These require long cure times necessitating a large number of moulds, making the process very capital, space and labour intensive.

This project to find an alternative method of making briquettes was funded by the Department of the Environment under the Environmental Technology Innovation Scheme (ETIS). The Scheme, which is now closed, provided grant assistance for pre-competitive industrial research in the environmental field and has been superseded by the Future Practice element of the Environmental Technology Best Practice Programme. More information can be obtained from the Environmental Helpline on 0800 585794.

Project Aims

The purpose of this project was to develop the technology for a cost-effective system for the conversion of rock mineral wool process residues into briquettes (or extrusions) of a similar size and, ideally, hardness to the normal feedstock. The aim was to develop an innovative method that would reduce briquette production time from days to a few minutes and thus allow efficient recycling back to the cupola. Wear to plant due to the abrasive nature of the feed materials also had to be overcome.

Additional aims included reducing demand for raw materials (and associated transport), reducing the need for landfill, and lowering energy and CO₂ emissions due to reduced raw material melting.

The Project

Material handling

Initial briquetting/extrusion forming trials showed that the input materials had to have a consistent, homogeneous texture before they could be briquetted properly. The widely differing characteristics of the different streams - glass shot, solidified glass melt and fibre matting - presented a severe challenge in terms of reducing these materials to a consistent material form.

It was found that common types of attrition machine were, in most cases, unable to cope with all these material types. For example, a hammer mill reduced lumps of solidified melt to the required grading with ease but needed a long residence time to break up the fibre skeins, producing excessive wear even on hardened hammers. A compromise but effective solution was finally achieved by developing a briquetting press that was less sensitive to feed...
material condition. This allowed the use of a simpler, inexpensive shredding machine that produced an acceptable product material with reasonable levels of equipment wear and energy use.

Using this simpler, versatile equipment it was found that a wide range of additional materials could also be processed including filtered wet fibrous waste, dry powder recovered from bag filters and even glasswool offcuts from other factories within the Company.

Briquette development
Various types of briquette-forming equipment were trialled, ranging from simple hydraulic presses, through roller equipment, extruders and brick presses, to experimental roll compactors. The main difficulty throughout was that as soon as pressure high enough to enable the briquettes to hold together (‘green’ strength) was achieved, the abrasive nature of the glassy materials produced unacceptable wear rates on the forming equipment. On occasion, even hardened steel components were worn away in a matter of hours.

The technical viability of producing briquettes in an on-line process had thus been proved within the ETIS project but the high wear rates encountered at that stage rendered the process economically unattractive and the formal project was closed as a technical but not a commercial success. However, the interest generated within the project and the continuing need for a solution prompted further work on the development to start some 12 months later.

Following a range of inconclusive initial trials, a technical breakthrough enabled rapid progress to be made on a number of fronts. It was found that the inclusion of relatively small amounts of selected materials had the effect of increasing the as-made hardness of the briquettes and accelerating the cure process. The green strength of the briquettes produced as a result improved considerably such that a briquette could be dropped from four metres onto concrete without damage.

These trials showed that excellent briquettes could be made using simple hydraulic pressing equipment. The fact that lower pressures could be used as a result of the modified briquette composition prompted the use of a roller briquetting system that had earlier been rejected because of the high maintenance costs arising from wear. While the capital cost of the roller equipment is substantially higher than that of a hydraulic press, the output is typically ten times greater. In a further development (now patented), the roller press manufacturer introduced a modification to the press operation which further reduces wear whilst maintaining briquette quality.

Different residue streams

Plant trials
A full-scale plant trial involving 3.5 tonnes of residue briquettes introduced to the cupola over a period of several hours has demonstrated the final stage of recycling. This involved recycling of briquettes at up to 20% of the stone charge, and showed no significant change in the cupola melt characteristics.
Environmental Benefits

An intention of the project was to avoid any increase in stack emissions released from the cupola as a result of recycling. This need to minimise emissions largely governed the selection of binders used. The lower requirement for limestone flux and coke to smelt virgin raw material will result in a net reduction in CO₂ emissions of approximately 500 tonnes/year.

The introduction of this technology at the Owens-Corning Queensferry plant is expected to reduce the requirement for landfill disposal by approximately 5000 tonnes/year initially, with the potential to reduce this further as the technology is developed.

Cost Savings

The cost of landfill disposal is increasing rapidly. At 1998 prices it averages around £30/tonne for the types of material being considered within this project - a considerable proportion being of very low density. Taken together with savings on raw materials, material handling and energy, the overall saving on current costs of the recycling process is about £38/tonne, excluding landfill tax.

The current economics result in a briquette recycling system which is cost neutral for low to medium volumes of briquette production, but which rapidly becomes cost positive as volumes increase or as landfill disposal or raw material costs inflate.

Additional Benefits

In addition to the potential cost economies, there are a number of other benefits associated with the developed technology.

Cupola recycling reduces the requirement for raw material quarrying and associated transportation. In the case of Queensferry, the latter will equate initially to approximately 8000 tonnes of stone and 90000 lorry miles per year.

Availability of a reasonably low-cost briquetting facility offers the option to modify the melt composition by adding small amounts of other minerals to the batch before briquetting. This option is often difficult to achieve in a cupola fed with raw stone. If a marginal costing approach is adopted, it becomes possible to consider the use of a wide range of waste raw material, eg quarry fines, as feedstock, which makes the whole process less dependent on the quality of its raw materials.

Potential Users

The greatest potential is for cupola operations but this need not be restricted to the manufacture of insulation wool. Further potential exists in the foundry and metal smelting industries where similar recycling problems occur.

Increasingly, briquetting is being used as a recycling route in many industries. Several aspects of the technology developed here are likely to have much wider applications.

Development Status

A construction project for a briquette recycling plant at Queensferry has been completed recently. Consideration is also being given to the construction of a second briquetting plant within the Owens-Corning Corporation.

The engineering/recycling consultancy is also extending aspects of the briquetting process developed within the project for application in other recycling fields.