DONCASTER PROJECT — A U.K. WASTE RECLAMATION PLANT: NEW PRODUCTS FROM DOMESTIC WASTE

P. HOOK
South Yorkshire County Council, Environment Department
Barnsley, South Yorkshire, England

ABSTRACT

The paper briefly describes the United Kingdom organization of solid waste disposal, the processes and products of the Doncaster Reclamation Plant at Doncaster, South Yorkshire, U.K.

Also covered, is the experience gained in applying the concept of treating domestic consumer waste by the utilization of the reclaimed materials in industrial outlets, and to obtain overall economical costs to the Statutory Disposal Authority.

The apparent shortcomings of such outlets and the inability to increase such returns for the products, in spite of high quality Standards, is defined.

In a selected difficult product — glass rich ore — new utilization of this material by creation of unique products is developed and costed, therefore giving the waste adequate financial return, besides considerable further opportunities and outlets.

ORGANISATION OF WASTE DISPOSAL IN ENGLAND

In 1974, the local government organisations within the United Kingdom were completely altered.

The following only applies to the England area, where a two-tier system was created to form District Councils at one-tier, with larger County Council Authorities making the second. However, where these cover the densely populated areas the responsibilities split between the two-tiers are further altered, and the authorities classed as Metropolitan Authorities. South Yorkshire County Council is one such Metropolitan County Council, while Doncaster a district within it, is a Metropolitan District Council.

The statutory waste function is divided between the two-tiers, in that the responsibility of the collection of household wastes is the District Councils', while the disposal of the material is the statutory function of the County. The County Council is also responsible for the satisfactory disposal of 'industrial' waste, monitoring of private landfill sites and plants, and the strategic planning of the waste disposal function in the County's own geographical area.

DONCASTER — SOUTH YORKSHIRE

Doncaster Metropolitan District is typical of medium sized conurbations within the United Kingdom being 225 sq miles (581 x 10^4m^2), and a population of 286,500 people. Approximately 210,000 people reside within the main town area — Doncaster — situated to one end of the District area.

The main industries are coal-mining and quarrying in the primary sector while the manufacturing sector covers metal, mechanical engineering, chem-
icals, glass, textiles, paper, vehicles and other metal goods. The town is surrounded by agricultural areas, but is probably best known for its racecourse, and the British Classic run there – St. Leger.

Doncaster M.D.C. is one of four such Metropolitan Districts – the others being Rotherham, Sheffield and Barnsley – which together create the Metropolitan County of South Yorkshire. The County has an area of 602 sq miles (1560 x 10^6 m^2) and a population of 1,301,300 people.

The allocation of local authority functions between the District and the County, besides the waste collection and disposal is as follows:

<table>
<thead>
<tr>
<th>Metropolitan District Council</th>
<th>Metropolitan County Council</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>Transportation</td>
</tr>
<tr>
<td>Youth Employment</td>
<td>Highways</td>
</tr>
<tr>
<td>Housing</td>
<td>Police</td>
</tr>
<tr>
<td>Environmental Health</td>
<td>Fire</td>
</tr>
<tr>
<td>Planning (Local)</td>
<td>Planning (Structure &amp; Strategic)</td>
</tr>
<tr>
<td></td>
<td>Consumer Protection</td>
</tr>
</tbody>
</table>

**WASTES FROM THE DONCASTER AREA**

The total annual waste collected within the district and handled by the County Council is:

<table>
<thead>
<tr>
<th>Material</th>
<th>Tons (kg) per Annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic &amp; Civic Amenity Waste</td>
<td>78,700 (70 x 10^6)</td>
</tr>
<tr>
<td>Trade &amp; Inert Wastes</td>
<td>108,670 (97 x 10^6)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>187,370 (167 x 10^6)</td>
</tr>
</tbody>
</table>

NOTE: Civic Amenity Waste is derived from "Dumpit" sites which is a local waste disposal point provided for members of the public to deposit unwanted bulky household wastes. It is then taken to a landfill site for disposal, by the County Council.

The County Council’s methods of waste disposal in the District’s area:

The Treatment Plant – the Doncaster Plant – is presently treating 1008 tons (0.9 x 10^6 kg) per 5 day week from approximately 250,000 people. This is approximately 56,000 tons (50 x 10^6 kg) per annum (Table 1).

**TABLE 1 TYPICAL ANALYSIS OF HOUSEHOLD WASTES INTO THE DONCASTER PLANT**

<table>
<thead>
<tr>
<th>Material</th>
<th>Percent Weight</th>
<th>Percent Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>24</td>
<td>49</td>
</tr>
<tr>
<td>Plastic</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Textiles</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Unclassified</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Vegetables and Putrescibles</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td>Fines (below 15 mm)</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Ferrous Metal</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Glass</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Nonferrous Metal</td>
<td>Trace</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*Moisture content of total material as received approximately 30 percent.

**BACKGROUND TO THE DONCASTER PLANT PROJECT**

In 1974, the central landfill site within the Doncaster area was scheduled to be completely filled in 3 years, and in the decisions required for its replacement, the County Council were faced by the following restraints:

1. Doncaster is situated on aquifers, so possible landfill sites created by the sand and gravel extraction industry were not usable.
2. The capital investment for a chosen option should be reasonable.

Also, a Policy decision was taken that all waste disposal investments made should include material recovery and resource utilization if possible, while the lowest overall economics must be obtained from such investment.

At the same time the Department of Environment (Central Government) with Warren Spring Laboratory (a Department of Industry Research
Establishment) were developing at research scale, mechanical processes for the sorting of household wastes, which were total energy efficient, and capable of economically retrieving the material resources within the wastes.

Therefore, in 1976 a joint project between South Yorkshire County Council Department of Environment, Warren Spring Laboratory carried the pilot processes and further development into a design and construct contract with a specialist contractor, Motherwell Bridge Tacol, to create a working plant, at Doncaster in 1979.

The "ideals" of the plant were as follows:
1. The processes should use simple and known technology, capable of being duplicated elsewhere in the United Kingdom.
2. The overall economics of the plant should be less than that of a simple transfer station installation, transportation and placing into sanitary landfill sites 13 miles (15 \times 10^3\text{m}) distant. In the United Kingdom, therefore, this equates to a total waste disposal cost of $13-19/ton (\$0.015-0.020/kg) (1978), which the Plant at Doncaster should not exceed.

**DONCASTER PLANT — BRIEF DETAILS**

The plant is situated within a typical industrial estate covering 7.5 acres (3 \times 10^3\text{m}^2) in a total site development of 89 acres (36 \times 10^3\text{m}^2). The site is reasonably adjacent to the centroid of Doncaster conurbation, thus minimising the secondary costs of collection by the District Council.

The choice of site was made to demonstrate that it was possible to carry out waste treatment processes adjacent to central town development, besides the economical possibilities of using the recovered materials in immediate adjacent areas.

The capital costs of the plants (1979 (Base Year):

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>$190,000</td>
</tr>
<tr>
<td>Building, Services and Site Development</td>
<td>$2,185,000</td>
</tr>
<tr>
<td>Processes — Special Development, Procurement and Development</td>
<td>$1,083,000</td>
</tr>
<tr>
<td>Processes — Provision and Installation</td>
<td>$2,660,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$6,118,000</strong></td>
</tr>
</tbody>
</table>

An outline flowsheet of the processes (Appendix 1) is used in the following brief description. Throughout, the concept of minimum energy input is incorporated within the processes.
Primary Recovery Circuit — This system is common to all material passing through the plant

Secondary Recovery Circuit — The material within these circuits relate and upgrade the particular end-product.

**PROCESS DESCRIPTION**

Domestic refuse is delivered by the collection vehicles of the Doncaster Council, by tipping onto a level floor, within an enclosed reception hall, at the front of the process.

The primary recovery circuit is fed by a front-end loading shovel on to a plate conveyor of variable speed which evens the flow to a design 11.25 ton/hr (10,000 kg/hr). Provision has been made for installation of a bag-opener at the end of the plate conveyor to allow for possible future changes in the incoming waste.

The wastes are fed into a rotating screen, where it is sorted into fixed sizing (0-40 mm, 40-200 mm, over 200 mm) which were predetermined by experimental work at Warren Spring Laboratory. The purpose of the sizing is to concentrate particular materials as a feedstock to the secondary circuits, and the screening range has been chosen to satisfy this requirement, as well as to clean materials which are to be subsequently recovered.

The fine fraction (less than 40 mm) is removed and fed to a secondary vibrating screen, which eliminates dirt, ashes and creates a mixture suitable for processing in the glass recovery circuit. The ash-like (-15 mm) material separated at this stage is suitable for use in green open-space areas at a depth below that of 75 mm.

The middle fraction (40 mm – 200 mm) from the rotating screen contains newspapers, plastics, tins, large organics and complete bottles. These are processed to produce ultimately, the fuel besides subsidiary feedstock for the secondary glass circuit, and magnetically obtained ferrous products.

The coarse fraction (greater than 200 mm) from the rotating screen contains large papers and boards, large metal objects and textiles. The last is obtained by a moving rail ragger sweeping the inside areas of the tromel in the highest part of the rotating screen. The paper, metal and textiles can be separated using a laser controlled blower, a metal detector and a high fraction drum respectively.

These three fractions leaving the primary recovery circuit provide the feedstock to the Secondary Recovery Circuits.

A typical Materials Balance is given in Appendix II.

The secondary recovery circuits are:

The fines fraction, after screening at 15 mm, and when joined by a sized feed from the air classifier, is rich in glass. Gravity concentration on modified stoners produce a putrescible rich material while density separation and optical sorting produce a mixed color cullet acceptable to industry.

The middle fraction, after the removal of the ferrous metals, is fed into an air classifier which separates heavy from light materials. The heavies contain some glass and these will, eventually, be screened to provide additional feed to the glass recovery circuits. The lights which is the combustible materials — papers, plastics and some textiles, are processed through a shredder, drier and pellet mill to provide a marketable solid fuel. The ferrous metals are baled for further use by the foundry industry.

The coarse fraction, provides a massive metal byproduct which allows textiles and larger papers to be identified, and separated. These are attractive to the paper industry and soft rags outlet as research products.

**PRODUCTS OF SECONDARY RECOVERY CIRCUITS**

<table>
<thead>
<tr>
<th>Products</th>
<th>Recoverable Proportion by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>4-6</td>
</tr>
<tr>
<td>Fuel</td>
<td>25</td>
</tr>
<tr>
<td>Fe Metal</td>
<td>7</td>
</tr>
<tr>
<td>Paper Fibre</td>
<td>4</td>
</tr>
<tr>
<td>Fines</td>
<td>10-18</td>
</tr>
<tr>
<td>Putrescibles</td>
<td>25-20</td>
</tr>
<tr>
<td>Textiles</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>30-85 percent</td>
</tr>
</tbody>
</table>

**GLASS**

Specification of material obtained. Size 15 - 40 mm

Contamination by H₂O NIL, — Fe = 0.01 percent Max., — Organics = 0.05 percent

Nonmagnetic = 0.01 percent, — solids = 0.05 percent
## APPENDIX II DONCASTER PLANT – MATERIALS BALANCE

<table>
<thead>
<tr>
<th>Fraction Size</th>
<th>Apparent Assay (percent wt)</th>
<th>Distribution (percent wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent Fraction Size Weight Classification</td>
<td>Pa</td>
</tr>
<tr>
<td>Fines &lt;40 mm</td>
<td>40 Fines 13 5 1 1 1 4 75</td>
<td>2 3 3 34 40 3 19 7 57 87</td>
</tr>
<tr>
<td>7 Magnetics</td>
<td>6 1 1 1 1 92 1</td>
<td>2 2 2 1 1 87 1</td>
</tr>
<tr>
<td>Middle +40 mm</td>
<td>10 Air Classifier 1 2 1 45 17 3 3 10 11 8</td>
<td>1 4 1 29 37 4 47 57 40 2</td>
</tr>
<tr>
<td>50 Heavies</td>
<td>-200 mm 4 -38 mm 4 1 26 11 1 4 1 56</td>
<td>1 1 6 9 1 1 9 1 6</td>
</tr>
<tr>
<td>29 Lights</td>
<td>57 11 8 15 2 1 1 1 5</td>
<td>66 74 77 28 14 2 31 22 1 4</td>
</tr>
<tr>
<td>Coarse +200 mm</td>
<td>10 Oversize 75 7 5 5 1 2 1 1 3</td>
<td>30 18 18 3 1 3 2 5 1 1</td>
</tr>
<tr>
<td>Total 100</td>
<td>25 4 3 16 5 7 1 2 3 35</td>
<td>100 100 100 100 100 100 100 100 100 100</td>
</tr>
</tbody>
</table>

Pa = Paper
PI = Plastics
Tx = Textiles
Pu = Putrescibles
Gi = Glass
Fe = Ferrous Metal
NFM = Nonferrous Metal
MC = Miscellaneous as Mainly Wood
MNC = Miscellaneous as Mainly Ash/Cinder
Fi = Fines
Color — Mixed 85 percent White/5-10 percent Green/5-10 percent Amber
OUTLET — Colored glass container industry.
Value of material = $27-30/ton ($0.03-0.034/kg) (1980)

FUEL
Specification of material obtained. Size — Dimension 28 mm
Moisture 17 percent, Ash 14 percent, S. 0.3 percent, Cl. 0.9 percent
Calorific Value 18,000 MJ/kg basic materials, papers, plastics and textiles.
OUTLET — Industrial users with existing solid fuel outlets using No. 1 Industrial Coal for process and heating energy.
Value of material = $30-37/ton ($0.034-0.041/kg) (1980)

METAL (Fe)
Specification of material obtained. 95 percent wt. metal. Steel and tinplate 95 percent, Aluminum 5 percent baled to 300 mm cubes x 50 kg.
OUTLET — Foundries and de-tinning industry.
Value of material = $12-17/ton ($0.013-0.019/kg) (1980)

PAPER FIBRE
Capable of being upgraded by merchants to higher grades for fibre recovery.
OUTLET — Waste Paper Industry. Value of material = $13-17/ton ($0.015-0.019/kg) (1980) (experimental)

FINES
Utilization within open spaces and fill areas.
OUTLET — Local Authority. Value of material = $6.2-10.5/ton ($0.007-0.011/kg) (1980)

PUTRESCIBLES AND ORGANICS
Utilization on surfaces of industrial spoil heaps.
OUTLET — Local Authority reclamation schemes.
Value of material = $3.32-6.65/ton ($0.003-0.007/kg) (1980)

IMMEDIATE EXTENSIONS TO PRODUCTS
NONFERROUS METALS
The basic work has been carried out for the obtaining of these materials within the glass circuit. Copper and aluminum rich ores obtained.
OUTLET — Merchants. Value of material nominal but covering marginal costs.

FUTURE EXTENSIONS
PUTRESCIBLES AND ORGANICS
Research work carried out shows that the anaerobic digestion of the material including a high contamination of paper, gives the possibility of economical treatment, with methane-rich gas and a marketable solid humus-rich material. The parameters which would indicate a substantial economic return by sale of gas is 10-15 day retention, yield 0.4m3/kg at 50 percent total solids.
OUTLET — Adjacent industries using natural gas for manufacturing processes.
REFERENCES — U.K. natural gas price = $0.55/ft3 ($0.015/m3) (1980)
Gross calorific value = 1092 kg/ft3 (38 x 103 kg/m3)

TIN CANS
The present market outlet to foundries is a diminishing base in the U.K., and does not allow the alternatives and market returns of the separate materials — tin, high grade steel and aluminum to be obtained.
A system of cryogenics treatment at Doncaster’s low output would seem to show good returns based on the following parameters:
Al / Sn : Fe : at 3-5 percent: 97-95 percent.
Market value of Grade 4 steel $84-101/ton ($0.095-0.114/kg) (1980). The specification for the de-tinning action at this grade, is without Al: at 3 percent contamination. Market value of tin $11,850/ton ($13.3/kg) (1980). Market value of Aluminum Scrap $1,000/ton ($1.14/kg) (1980).
OUTLET — Tin-Steel Container Industry.
Aluminum with Ferrous Contamination — high grade steel industry.
Ferrous with low level Tin Contamination — steel scrap special steel industry.

ENERGY BALANCE FOR PROCESSES
It is useless to demonstrate the fuel possibilities of the treatment to waste materials, if more energy is absorbed into the process than can be potentially available in the created fuel. In the Doncaster concept the following:
TABLE 3

<table>
<thead>
<tr>
<th>Process</th>
<th>Electrical Energy Input (kwh) Processing Fuel at 2.6 ton/hr (3,000 kg/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
</tr>
<tr>
<td></td>
<td>180</td>
</tr>
</tbody>
</table>

INTERIM APPRAISAL OF PROJECT

At this point therefore, it might be possible to show that one possible method of "economically" achieving the disposal of domestic wastes could be the utilization of the recovered materials as "feedstock" within existing industries, but a critical survey of the previous sections to this paper must give the following reservations:

1. The original wastes will consistently arise from the conurbations, but the outlets, and more particularly, the rates obtained for the feedstock, is industrially based. All industry is cyclic, cannot be otherwise in free markets, and usually on a 5 year basis.

2. The rate, and demand for the feedstock will continually rely on the industry's own situation, which has no connection to the Local Authority costs, ability to create the feedstock.

3. The quality level of the feedstock, and therefore the rate given by industry for the material will always be relative to its own original basic resource — in the United Kingdom this is the relevant "virgin" material feedstock.

Within these apparent economical shortcomings, it is necessary to consider the original concept and the development of the systems being investigated by the team in the 1974-1979 time period.

1. In 1974, within the United Kingdom, the splitting of the disposal from the collection of wastes, meant that new Engineers with other discipline experience became involved, where as before, the basic approach was "collection" only.

2. The approach of these new Engineers was of treating the materials which occurred within all wastes to a stable condition, i.e., no further costs incurred by society. This rather than the prevailing simplistic overall deposit of often, quite complex materials — is at the best — a compromise, cosmetic type of "disposal".

3. This approach also suggested, that in the treatment of the waste materials, the utilization of the material could be one of the satisfactory alternatives. However, while this could be the possible recycling or reclamation to industry, each and every material must be identified for its own opportunities without preconceived ideas.

4. The materials must be accepted as a "man-made feedstock" and not as might have been originally suggested, an easy and cheap resource to existing industry. This identification of a man-made resource was further justified when the work into potential utilization of the products began, and recovered material with consistent unnatural contamination was being obtained.

5. No one single material within the consumer wastes would be sufficiently valuable to cover all the costs of the other resources. The higher the price, quality obtained, the more opportunity of return, outlets and utilization would be available. Indeed, the highest possible price must be obtained for all products, if good and consistent overall economics were to be obtained.

Therefore, for this maximum return to occur, two methods are available:

1. The reduction of the costs of creating the product — PRODUCTION COSTS

2. The increase in the market price obtained for the product — SELLING PRICE

Logical survey of the cost ranges involved in (1) and (2) above show that (2) has the greatest potential, but even in 1974, there was considerable experiences of failure within the U.K. to economically recycle domestic waste derived material, i.e., inked papers and incinerated metal bales.

Was the fault in the Local Authority themselves in not obtaining the best possible price, or that they were not skilled in marketing their produce? This is possible, since in the U.K., Local Authorities are a monopoly, without skills or organization in obtaining successful marketing of "products", but the failure probably lies in the established markets into which they were attempting to sell the material.

U.K. INDUSTRIES AND RECLAMATION MATERIALS STANDARDS

Historically, the industries or the United Kingdom are completely based, and with very little
modern process investment, upon the virgin "feed-
stock", easily obtained by the original British
Empire organization.

Each industry has its own corresponding
reclamation organization with no cross-connection
of feedstock occurring at the merchant level, i.e.,
papers stay within paper, plastic to plastics. As ex-
pected, their approach is very rigid, while con-
tamination materials and levels, markets and prices
are completely integrated into their own particular
basic feedstock and industry.

PAPERS
The U.K. paper industry covers the full range of
products using 100 percent virgin pulps, tissues,
newsprint, krafts and boards. The industry is
rapidly diminishing, and specialize in high grade
special papers, while the board industry is in very
great difficulties.

WASTE GRADES
The waste grades are (4) – Computer stationery
$185/ton ($0.20/kg) (1981)
(7) – New kraft lined corrugated $25/ton
($0.3/kg) (1981)
(9) Mixed waste paper and colored card $8/ton
($0.02/kg) (1981)
(10) All other types $8/ton ($0.02/kg) (1981)

METALS
The U.K. metal industry covers specialized steels,
mild steels and foundry products. The state
monopoly British Steel Corporation now concen-
trates on special steels, as foreign competition has
diminished the other steel production to very
small outputs.

WASTE GRADES
The waste grades are (OA) – Heavy structural and
plate $40/ton ($0.04/kg) (1981)
(4C/4D) – new steel short bales $40/ton
($0.04/kg) (1981)
(10) – light cast iron $28/ton ($0.03/kg) (1981)
(7A) – short steel turnings $23/ton ($0.02/kg)
(1981)
(Light iron) – $23/ton ($0.02/kg) (1981)
(Destructor scrap) – $10/ton ($0.01/kg) (1981)

FUELS
The energy prices range is shown to give the al-
ternatives against which a fuel product might be
assessed by a customer (Table 4).

OTHERS
To the above outlets, can be added the industries
of nonferrous, plastics and textiles. While the re-
claimed product will often be as “rich” as the con-
tventional feedstocks in wanted material, because
of the nature, rather than the amount, of the con-
tamination:

1. No economical cleaning of the material will
raise the grade.
2. The price obtained will always be down-
graded against the virgin material grade, and pos-
sible further price reduction is required as an in-
centive for use.

GLASS INDUSTRY
The glass industry, has, besides the shortcom-
ings applying to the other outlets described above,
its own unique limitation when being used for any
foreign reclaimed feedstock.

In the U.K. the glass industry is generally mak-
ing “containers” with the glass efficiently made on
site from separate and raw material feedstocks in-
troduced into the start of the process. Readymade
glass is therefore a “foreign” material to the con-
tainer manufacturer.

The U.K. industry produces a full range of
glass containers from clear to colored, but in view

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Unit</th>
<th>Average Price per Unit $</th>
<th>Gross Calorific Value per Unit</th>
<th>Average Price per Gross kWh $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Date – October 1980</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grid Electricity</td>
<td>kWh</td>
<td>0.289</td>
<td>38.1 MJ</td>
<td>0.055</td>
</tr>
<tr>
<td>Fuel Oil (Light)</td>
<td>Litre</td>
<td>0.210</td>
<td>41.1 MJ</td>
<td>0.018</td>
</tr>
<tr>
<td>Fuel Oil (Medium)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Coke</td>
<td>1000 kg</td>
<td>159.6</td>
<td>27,900 MJ</td>
<td>0.020</td>
</tr>
<tr>
<td>Fuel Oil (Heavy)</td>
<td>Litre</td>
<td>0.210</td>
<td>41.1 MJ</td>
<td>0.018</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>m³</td>
<td>0.015</td>
<td>28,180 MJ</td>
<td>0.010</td>
</tr>
<tr>
<td>Coal</td>
<td>1000 kg</td>
<td>84.55</td>
<td>84.55</td>
<td>0.010</td>
</tr>
</tbody>
</table>
of increased competition is specializing at the higher standard and grade, clear container outlets.

Eighty-five percent of the containers made in the U.K. are clear, and the remainder split between brown—brewery trade—and an increasing green—wine industry.

Prime costs of the raw materials for glass is cheap, plentiful and cannot be assessed as a diminishing resource.

The value of cullet—premade glass—will therefore be very low, and if clarity is required, the contamination of color in an otherwise similar material, means that no marketing of the reclaimed product would enable a higher price to be obtained.

Typical U.K. Prices Obtained 1980 Base—Delivered to Glass Manufacturer

<table>
<thead>
<tr>
<th>Product Description</th>
<th>Price (1980)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Glass Cullet to Specification</td>
<td>$27/ton</td>
</tr>
<tr>
<td>Clear Glass Cullet (No color contamination)</td>
<td>$30/ton</td>
</tr>
<tr>
<td></td>
<td>($0.03/kg)</td>
</tr>
<tr>
<td></td>
<td>($0.034/kg)</td>
</tr>
</tbody>
</table>

It was accepted at the outset of the Doncaster Project, that the processes and products must be aimed at existing outlets to get instant returns, and providing high quality standards in the materials was adopted, outlets for the fuel, metal and glass could be obtained.

However, any limitation of markets for the products in the fuel and metal outlets, would be much more difficult in the glass, even if a standard, consistent quality product was achieved. The glass outlet appeared to be a different matter, but within the limited manpower resources available, it was decided that the glass product should be investigated for other uses. If successful, the approach would be applicable to all other materials being derived from the processes.

**DESCRIPTION OF SECONDARY GLASS CIRCUIT — APPENDIX III**

The secondary glass circuit is fed from the -40 mm material obtained by the rotating screen in the Primary Recovery Circuit. This material contains putrescibles, glass, stones and fine materials below 15 mm. Assay (APPENDIX II).

The secondary screens remove the below 15 mm using standard vibrating inclined plates and creating an increasing glass rich feed to the modified stoners.

The stoners use an inclined vibrating screen with an upward current of air to remove putrescibles and other light materials.

Further cleaning, including the removal of light ash, is carried out in the rising current separator using water as its medium.

**APPENDIX III OUTLINE FLOWSHEET — SECONDARY TREATMENT CIRCUIT GLASS**

(Note For Clarity Reject Collection Systems are not Shown)
This feedstock is now 85 percent rich in glass, with the remaining contaminants being stones, ceramics, coal and other opaque but hard materials.

Optical sorting is achieved by use of light source and light sensitive cell which examines each particle for transparency, rejecting by means of an air jet the opaque materials, to leave a mixed — color broken glass material — cullet.

The processes, although simple in concept and material separation, is complicated to existing U.K. solid waste processes. It requires a high level of operative skill and understanding to enable satisfactory running to be obtained. Experience, has shown that the improvement of replacing the stoners, and a simple conveying system between the separator and the optics will give a smoother operation and lower operating skills requirement.

The cost of the processes is high in capital terms and the production costs are critical to the standard of products being maintained under continuous output.

### Capital Costs (1980 Base Year)

<table>
<thead>
<tr>
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<th>$</th>
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<tbody>
<tr>
<td>Optical Sorters</td>
<td>133,000</td>
</tr>
<tr>
<td>Conveying Systems</td>
<td>114,000</td>
</tr>
<tr>
<td>Rising Current Separators</td>
<td>95,000</td>
</tr>
<tr>
<td>Destoners</td>
<td>114,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>456,000</strong></td>
</tr>
</tbody>
</table>

**PRODUCTS OF THE CIRCUIT**

The original calculations showed that at best, the cost of the cullet, would be equivalent to market prices obtainable for mixed glass cullet in the United Kingdom, but this assumed:

1. Fifty percent rejection of material presented to the optic sorters to make the required standard.
2. No costs had been made for the fact that the glass material could not be utilized elsewhere in other product streams, without prejudicing that products utilization.

Examination of the process between the rising current separator and the optical sorter showed that the feedstock had excellent ‘aggregate’ qualities. At this point therefore 50 percent savings of marginal capital outlay could be made, and a theoretical doubling of the material quality available for utilization.

In the U.K. situation, there was no possibility of use as an aggregate against the natural stone resource as the market value is low, and especially, the outlets are controlled by British Standard Specifications and Code of Practices which discriminates against non-natural materials.

However this satisfied the first criteria, of reducing the production costs of the feedstock, was it possible to increase the market value of the feedstock?

**NEW PRODUCT**

There is no particular difficulty in making the obvious use of the materials into decorative traffic surfaces, but what was interesting was that it soon became apparent that the characteristics of the glass, together with the other hard materials, produce surfaces and textures which cannot be matched by any natural occurring materials. These surfaces are light reflective for safety aspects and outdoor applications, where aggressive, but decorative, surfaces are required.

Secondly, it was also realized that the value of the aggregates, when used in such applications, is not related to the materials within, but to the utility of the product when solid in the market outlets.

Finally, the use of the material in this way, plus refinement, showed that many new outlets, alternatives and combinations became possible to allow a national and realistic economic return to be made.

**THE PROCESS (APPENDIX IV)**

The material, therefore, was used into floor tile applications and the process required is on conventional lines, using either a resin or cement filler, depending upon which particular market outlet is being utilized.

The aggregate requirements are crushed to the required size, and in the pilot method, use of 85 percent by weight of aggregate to 15 percent by weight filler. The use of the expensive resin — against cement — can be justified for the market alternatives which became available.

The mixing is carried out in existing types of mixers, but it is necessary to pretreat the aggregates to allow adhesion between filler and aggregates. Coloring of the aggregate is also achievable at this stage.

Filling of the mould is carried out using vibration. After stripping and curing, the surfaces can
be polished to whatever degree of smoothness is required. This also has the effect of allowing the glass aggregate the ability to show its unique ability in light reflection, etc.

The colouring of the filler allows overall color effect to be obtained, or as particularly desired, when used in a larger area or specialist application.

**ECONOMICS**

The capital investment of such a process line, and using new equipment has been costed at $66,500 (1980).

Assuming that the original cost of the final glass cullet was $0.03/kg and this is the price of production to the Local Authority, then the outlet return is nil, but the Local Authority could claim the theoretical alternative cost of disposal.

However, if the feedstock is removed after the rising current separator, the total amount of the material is raised by 50 percent, a capital saving of 56 percent made, and energy costs of the process are reduced to 35 percent of the original. This gives a production cost of $13.5/ton ($0.015/kg) if labour and other revenue costs are assumed unchanged.

The price of the aggregates in the tiles, if it is assumed a full market price is obtained, allowing for all capital repayment, revenue costs including labour, plant, and profits at industry level requirements, can be equated to $30.42 ($0.03-0.04/kg).

The market returns of such a plant, at a comparatively small throughput of 300,000 ft² (28,000 m²) per year, show that if the product is placed into competition with conventional floor paving only, it is considerably cheaper. However, in this case, it is being underpriced, since some market research showed that it can be priced above such other existing items, due to its attractive and unique appearance.

It is also felt by the use of the material in the alternative applications where safety values could be applied, that the prime cost of the material could be further raised.

Statutory limitations of the Local Authorities in the U.K. prevent them investing “risk” capital in such an industrial application, so we are at the present time attempting to obtain an entrepreneur to start and develop such an industry.

**THE FUTURE OF SUCH NEW PRODUCTS AND MATERIALS**

Therefore, in a difficult material such as glass, which shared only limited possibilities in the return to its “industry”, it is possible to show that by a change of the attitude of mind, new outlets and possibilities exist.

It would seem that similar opportunities exist in the plastic with paper, papers with plastics, organics, textiles, fuels and possibly metal combinations, while it is interesting that many of the new developing countries of the World already show
the utilization of such products in their alternative value.

While the economics used in this paper are direct Local Authority costs, with the reduction of these statutory costs of the treatment of waste, reducing the cost to society, it can also be argued that with such positive uses of waste products to create industry, considerable secondary savings become applicable.

An industry based upon these materials creates new jobs and wealth, besides an enlarged base for opportunities of further development. It will occur within central conurbation areas of population — called in the United Kingdom inner cities — where great problems exist, including poor job opportunities. These secondary but positive costs will make waste treatments, rather than disposal, very cheap to society.

CONCLUSIONS

1. A realization that treatment of waste is now required rather than 'disposal' will enable many new economical opportunities to be developed for this purpose.

2. The materials to be treated can be utilized, and therefore obtain satisfactory treatment, but it will need new attitudes and some technology to be able to utilize the potentials of these materials.

3. It is also possible to appreciate that as natural resources do get used and contaminated, then the products and reuse of them must accommodate the limitations of materials within.

4. Finally, the treatment of waste will cost money to the society that created it, but these costs can be made economical, reasonable and acceptable.

NOTE: Throughout this paper the exchange rate used £1 = $1.90.

ACKNOWLEDGMENTS

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