An executive summary

The TORBED* process reactor technologies are novel but well proven generic gas/solid contacting techniques used for processing materials and are protected by a portfolio of Patents and Trade Marks throughout the industrialised economies of the world. They were invented and developed as techniques to revolutionise the processing of minerals, foods, chemicals and wastes.

The TORBED reactors provide unique benefits in precise, rapid, smaller scale and lower cost solutions to industrial materials processing problems with operating temperatures ranging from cryogenic to greater than 1,600°C (2,900°F). The reactors will handle almost any shape of feed solids, including micron-sized powders, sludges and slurries. The low pressure drop across these new reactors facilitates easy process gas recirculation allowing reducing, oxidising and neutral atmospheres to be maintained at high temperatures.

Installation of the first commercial prototypes took place in 1986. Now TORBED reactors are in commercial use with some 100 or more plants in Europe, North America, South Africa, New Zealand, Australia, China, India and Japan for applications as diverse as fat free “frying” of snacks, toxic waste destruction and materials recycling.

The New Zealand Aluminium Smelter at Tiwai, South Island New Zealand, installed and successfully commissioned the largest TORBED reactor built to date at six metres (20ft) diameter early in 1994. This prototype was successfully tested for dry scrubbing exhaust gases from the smelting operations. The application was put into operation in 1996 with twelve 6 metre diameter TORBED reactors installed at Tiwai scrubbing 1,000 m^3/s of exhaust gases and a further six 6 metre TORBED reactors were installed at Bell Bay in Tasmania in 1997. These smelters are part owned by Comalco Aluminium Ltd of Australia who are also using TORBED reactors for thermal destruction of their cyanide and carbon laden waste at a rate of 10,000 tonnes per year in their smelting plant on Boyne Island, Australia.

TORBED reactors are commercially in use and continually being developed for:

- gasification/combustion of agricultural residues
- waste combustion/calcination of paper sludges and fillers
- catalyst processing
- high temperature calcination
- dry gas scrubbing
- cereal processing
- sulphide ore roasting
- soil, rock and sediment remediation
- ash treatment
- chemical reactions

and many other novel processes.

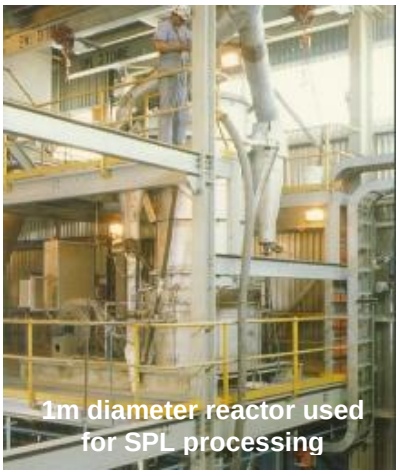
Pilot plant facilities are available for test, development and demonstration purposes in Canada and Europe. Both these pilot plants are fully staffed with analytical facilities available. These pilot plants utilise 400 mm diameter TORBED reactors complete with feed and product discharge arrangements.

It is our policy to grant licences for exploitation of the TORBED reactors to organisations that can demonstrate a proven ability to address a particular market or application. Descriptions of some of the non-confidential uses of the process are listed in the following brief application notes.

Industrial Applications

Combustion

The ability of TORBED reactors to handle wide variations in feed shape, size and quality is being applied to the controlled combustion of a variety of materials including carbon, shredded wood waste, organics and hydrocarbons.



1m diameter reactor used for SPL processing

One such application that relies on the absolute precision of the TORBED reactor is the **processing of Spent Pot Lining (SPL)** from the aluminium smelting industry. The refractory lined "pots" in which aluminium is smelted are removed from service when they have reached the end of their useful life and the spent refractory lining and carbon cathode are broken up and removed from the pot as Spent Pot Lining (SPL) so that a new lining and carbon cathode can be installed. The material that is removed is often classified as a toxic waste.

SPL contains a mixture of refractory, carbon and other contaminants including fluxes and cyanide. Comalco Aluminium Ltd of Australia commenced a development programme in 1987 to process SPL to produce a waste stream that is non hazardous. In order to thermally dissociate the cyanide in the SPL, processing of the material was attempted in various calcination devices including a rotary kiln, fluidised bed and transport reactor without success. A TORBED reactor proved to be successful. In 1990, a plant capable of processing 3,000 tonnes per year of SPL was commissioned. The process has proved to be as effective as predicted and by the end of 1994, the plant capacity was increased to 10,000 tonnes per year. This is a well-proven industrial application of the TORBED technology.

1.5m diameter reactor for wood waste combustion

The TORBED technology was identified as being one capable of satisfying the need for the **controlled combustion of shredded wood waste**. Pilot trials were successfully completed and two 5MWt combustors were installed in 1999 in the Netherlands. These reactors must also handle tramp feed materials including door handles, hinges, nails and other metal and incombustible materials.

Removal of volatiles from solids

In 1993, a pilot plant capable of processing 150 kg/h of oil-contaminated solids was fully tested at BP's Sunbury laboratories. A consortium of oil and gas exploration companies then funded the further development of the TORBED reactor as a **transportable de-oiling plant** for eventual off shore use. This plant demonstrated the capability of stripping hydrocarbons from solids in a controllable manner.

When **recycling machine shop ("swarf") and other metal wastes such as mill scale**, it is a problem when these contain cutting oil and a coolant since the wastes

cannot be added directly to a remelting process without serious disruption of the molten metal from the steam and explosive vapours that are generated. Rotary kilns have been used in the past to evaporate the oil and water from these wastes providing a clean feed stream to the remelting process.

Because the feed stream has a widely varying quantity of cutting oil and water, the process needs very close control to prevent combustion of the oil in the drying process. A TORBED reactor has been demonstrated to provide up to 8 times more throughput of clean dry metal per unit of energy input than rotary kiln techniques. The quality of the metal was found to be consistent and of higher purity with minimal oxidation.

The TORBED process has been in full-scale production since 1989 processing up to 3 tonnes per hour of swarf containing anything up to 20% by weight cutting oil and water.

In the summer of 2000, a 1.8m diameter reactor was commissioned for the **devolatilisation of up to 20 t/h of old asphalt coated road stone.**

The plant was opened formally in September 2000. The plant is designed to volatilise old asphalt (laden with PAHs) so that the road stone can be recoated and reused. The volatiles produced in the process are thermally oxidised directly in the upper part of the TORBED reactor.


1.8m diameter reactor used to devolatilise old road stone

Mineral Processing

The ability of the TORBED reactors to carry out precise calcination and heat/mass transfer processes has allowed the development of unique process plants. The first mineral processing application was the **calcination of vermiculite.**

Vermiculite is a naturally occurring mineral. When crushed, graded and fed into a hot furnace (1,200 ^{o}C or 2,200°F), the vermiculite expands or exfoliates to produce a lightweight particle that is then used as an insulating and fire retardant fill. The process requires a very rapid heat transfer to the particles to promote as large an increase in particle size as possible to give low densities. Historically, vertical shaft and rotary kilns have been used to exfoliate vermiculite.


High temperature mineral processor

The TORBED reactor has shown itself to have unique capabilities in this application in producing higher quality, lighter and more consistent product with lower energy consumption. High heat and mass transfer and precision of control with the TORBED reactors have provided these advantages. Most important, the TORBED process provides more saleable product per unit of raw material fed i.e., a higher yield.

The TORBED process is in successful operation in 11 major production plants in Europe and Japan. Throughputs vary according to raw material grading but typically range from 1-5 tonnes per hour.

The ability of TORBED reactors to carry out flash processing of fine powders with particle retention times of often less than 50 milliseconds has led to the development of novel products and processes. This ability has been developed at pilot scale (up to 300 kg/h) and was put into commercial operation during 1998.

Industrial Applications

A 1m diameter high temperature “fuel injected” TORBED reactor was commissioned in 1998 to **calcine industrial minerals at temperatures up to 1,600°C**. The use of direct injection techniques whereby natural gas is mixed and combusted directly in the process chamber base allows intense high temperature calcination reactions to be undertaken.

Catalyst processing

Extrudates/pellets that support catalytic material need a high free surface area. The higher the surface area, generally the more effective is the catalyst. Most catalyst support materials are calcined at high temperature to "fire" or "set" the support structure. This calcination is a critical phase in the production process.

The TORBED reactor has been demonstrated to produce exceptionally high surface area and uniquely structured particles when used to carry out the calcination process. Several pilot trials have now been successfully concluded and commercial plant has been in continuous operation for more than 4 years.

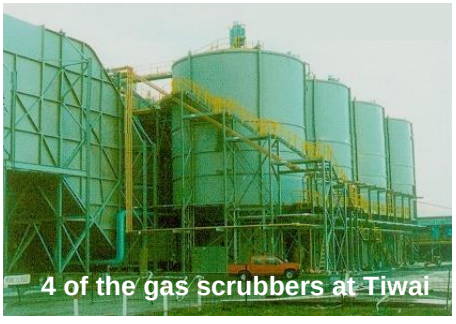
A pilot plant used for catalyst processing

Gas scrubbing

The extract ductwork that draws fumes away from the smelting pots in an aluminium smelting plant contains levels of contaminants that need to be removed from the exhaust before discharge to atmosphere. The TORBED process is used as a reactor to contact alumina with the exhaust gas stream to adsorb the pollutants prior to discharge. A TORBED reactor can be employed in a single or two-stage assembly providing unique adsorption properties.

The low pressure drop across TORBED reactors is important because the volumes of gases to be processed are high at 200,000 nm^3/h (117,500 acfm) per TORBED reactor and the particle size range that is used in the reactor is small and substantially un-graded.

After construction of a 5000mm prototype in 1993, a 6000mm (20 ft) diameter two-stage reactor was installed and commissioned in early 1994. The results were sufficiently favourable that New Zealand Aluminium Smelters Ltd decided to proceed with an expenditure of NZ$94m (£30m) on a new scrubbing plant based on thirteen 6000mm (20 ft) diameter TORBED reactors. These were installed in 1995/6 and the plant is achieving the best world standards. A further 6 such units were commissioned at Comalco’s Bell Bay smelter in Tasmania in 1997.



4 of the gas scrubbers at Tiwai

Food processing

In the snack food industry, most products available are either fried or "cooker extruded" before being dusted with oil and flavours. A trend toward lower fat and healthier eating snacks has allowed the development of new low fat products, particularly based on expanded "half pellet" products.

Industrial Applications

Spice pasteurisation plant supplied by TORBED Services Ltd

The TORBED process has shown itself to have unique capabilities in this application in producing higher quality, lighter and more consistent product with lower energy consumption. Indeed, some shapes of product can only be air expanded in a TORBED reactor. High heat and mass transfer and precision of control with the TORBED reactors have provided these advantages. The installation is quiet and compact.

The TORBED process is in successful operation in several major production plants in Europe, Australasia, the Americas and the Middle East. Throughputs vary but typically range from 50-500 kg per hour.

Traditionally spices have been pasteurised by steam or radiation. The former technique has limitations in terms of product quality and ultimate levels of pasteurisation. It has been found by extensive trials on a range of spices that much lower residual contamination can be achieved using the TORBED reactor with hot air as the process medium.

The TORBED process has shown itself to have unique capabilities in these applications in producing higher quality, more consistent product at low energy consumption with low residual contamination levels. The process can rapidly be changed for different products and characteristics. The installation is quiet and compact. Pilot trials have been successfully carried out and full-scale production plant is in operation processing 300 - 400 kg/h of spices. Many other precision roasting, drying and bloating processes are in commercial use.

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