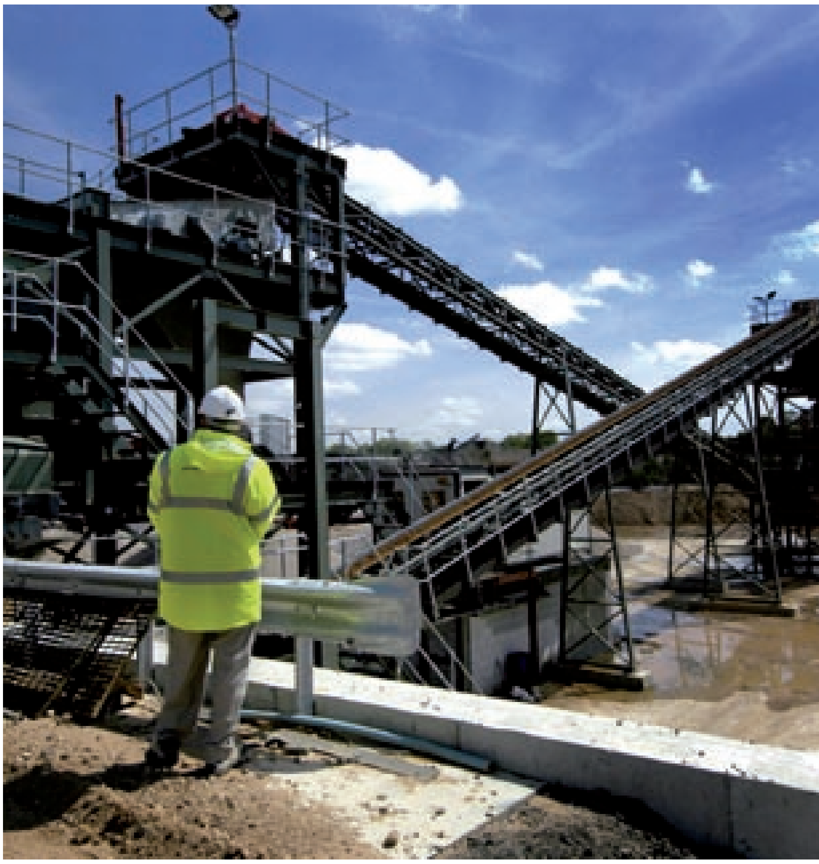
Introduction

Virtually everyone connected with quarrying will know of the **goodquarry.com** website. It has become a well used source of information on a wide range of topical issues ranging from biodiversity to water, air pollution to planning and much more. Now there is a brand new section on Production and Process Technology, written by the British Geological Survey. It contains all kinds of useful information on crushing, screening, washing, etc. including industry case studies. It also has numerous 'Key Findings' which give useful information on the process under discussion. The section concludes with a summary of good practice in each of the technologies mentioned below.

Overview

The aggregates industry produces about 204 Mt per year of crushed rock and sand and gravel from over 1500 quarries throughout the UK, plus offshore dredging. Production and processing technology is a key factor in the overall operation. The four main stages in quarrying are preparation by removal of overburden, extraction, processing and finally restoration or reuse.

The methods and equipment used depend primarily on the type of deposit and the source rock being worked. The key factor is whether the material requires crushing before further processing, or just washing and separation. In all cases the overall aim is to use the minimum input (energy, water, manpower, equipment, capital etc) to produce the maximum output of saleable product with the minimum waste and environmental effect.



Sand and gravel washing plant

Extraction

Following removal of overburden by dragline or hydraulic excavator, hard rock aggregates generally require careful blasting to break the rock into small fragments (usually less than 1m across). Excavators load haulage trucks to carry the blasted rock to the primary crusher; alternatively conveyors may be used. Sand and gravel is either worked in wet or dry conditions. Dry working is the most efficient in terms of maximising extraction and it also enables more selective extraction. Where deposits exceed 5 m, dragline excavators are extensively employed; these are robust and efficient at feeding conveyor systems. Where deposits are thinner or more consolidated, hydraulic backhoes are used. Some very unconsolidated deposits, such as dune sands or some glacial deposits may be excavated directly from the face by wheeled front-end loaders. Marine sand and gravel is worked by trail dredging where a suction pipe is pulled across the seabed at slow speed using a specialised dredger. The product, which generally has a very low fines content, is then offloaded at wharves for additional treatment before dispatch.

Crushed rock aggregate quarries tend to be larger, deeper and longer lasting than sand and gravel pits and involve large investments and outputs typically in the range 100,000 to 5 million tonnes per annum (tpa). Sand and gravel pits are usually shallow, sometimes only five or six metres deep. Operations are likely to be shorter term and typically produce 10,000 to 1 million tonnes per annum (tpa), with most in the range 100,000 – 300,000 tpa.

Panorama of limestone quarry

Production & Process Technology

Crushing

Crushing in hard rock quarries is generally carried out in stages (primary, secondary, tertiary etc) using a variety of types of crusher, including jaw, cone and gyratory crushers. The key factors of crusher performance include the throughput per hour, product sizes and shapes, capital cost, amount of fines produced, power consumption, rate of wear of parts and environmental issues (noise and vibration). These govern the choice of crushers for any operation.

The **goodquarry.com** website now has concise and current information on crushing technology and operation such as that summarised in the table below. Case studies from industry on the effects of changes in crushing equipment or practice can be found in the Quarry Fines and Waste section of the website.

Key findings listed on the website include:

Cone crushers rely on a full chamber ('choke' feed) to give the best results. Failure to 'choke feed' results in lower quarry fines production but also reduced capacity, poor product shape and uneven crusher liner wear.

Jaw crushers are mainly used in primary crushing where the amount of fines produced is typically less than 5%.

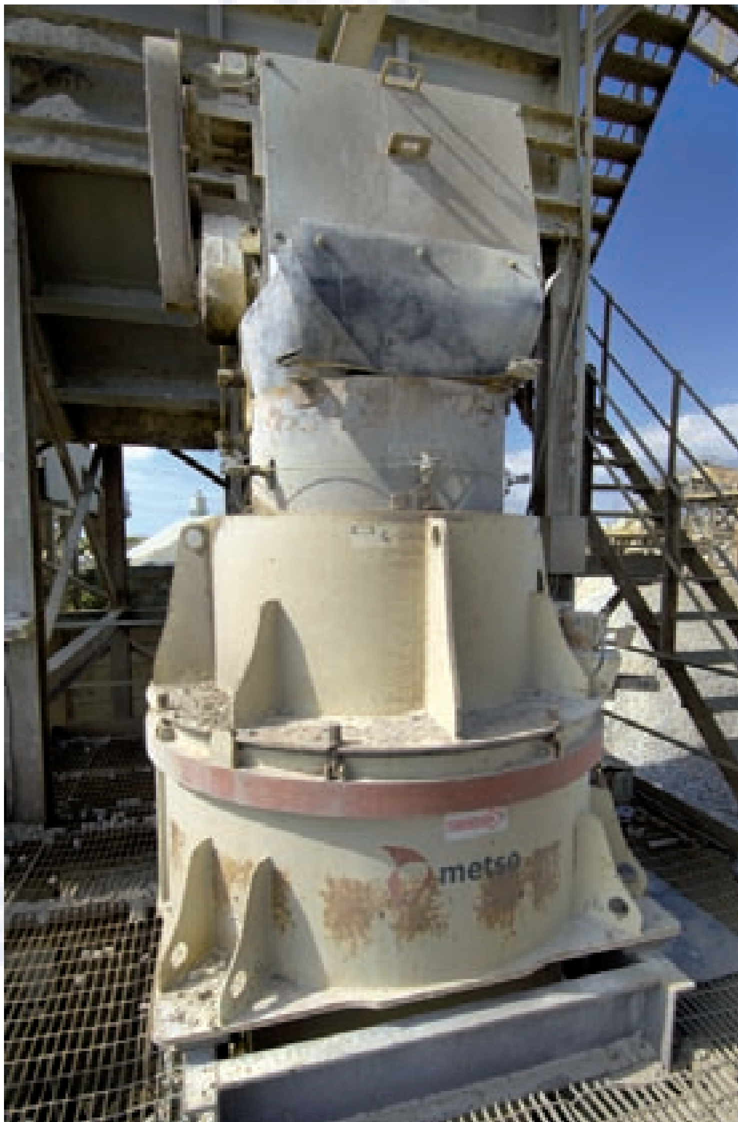
Cone crushers are mainly used in secondary and tertiary roles.

Impact crushers tend to be used where shape is a critical requirement and the feed material is not very abrasive. The quality of these products makes them ideal for use in some highly specified roadstone and concrete aggregate applications.

Stage	Crusher type	Maximum size mm	Fines %
Primary		1000	10-20 1-7
Secondary		250	4-5 30
Tertiary		100	5-30 20-40
Type: Gyratory Cone Jaw Impact			

Primary Gyratory Crusher

Cone crusher at sand and gravel plant



Washing

Washing is used to remove unwanted silt, clay and dust adhering to the rock fragments and sand particles. It is also used to classify or separate materials by variations in their size, shape or density. A variety of equipment is used, including hydrocyclones, scrubber barrels, log washers and sand screws, depending on the material and the intensity of washing required. The water content of the product is then reduced or removed by settling, filter presses or drying.

The **goodquarry.com** website describes the different types of washing equipment and has a series of 'Key Findings' relating to their use. For example the section for thickeners and belt presses has the Key Finding of

Installing a thickener generally reduces the need for four or five silt lagoons down to one lagoon. Installing a filter press may eliminate the need for a lagoon at all.

There is also a comparison of belt and press filter systems.

Classifying and screening

Classifying and screening is used to separate particles into different size fractions. Screening uses a mesh with holes of set size for the required product. Static and dynamic classifiers can also be used to separate material by air currents or by centrifugal force in a cyclone. There is information on all these processes on the **goodquarry.com** website. Key findings relating to classifying and screening include:

The most likely use of air classification in the UK quarrying industry will be for the removal of material finer than 63 microns from fine aggregate of quarry fines to produce manufactured sand. This is already the case in some quarrying operations in the USA.

Drying

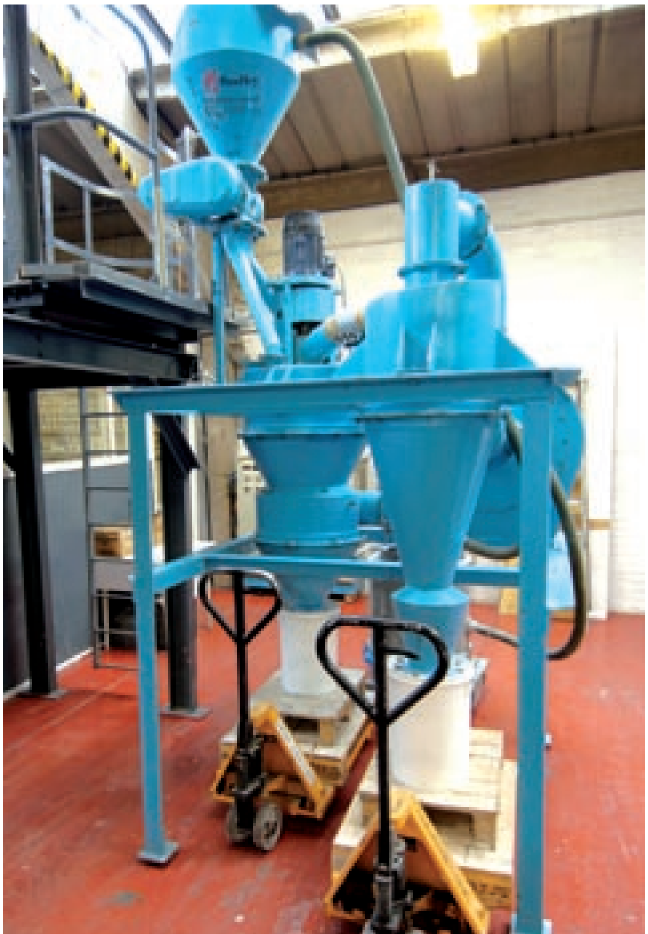
Drying is sometimes carried out to facilitate further processing of feed material, to improve the handling of products and reduce the transportation costs. However, it is an energy-intensive, expensive, operation due to the high latent heat of vaporisation of water and the inherent inefficiency of using hot air as a drying medium.

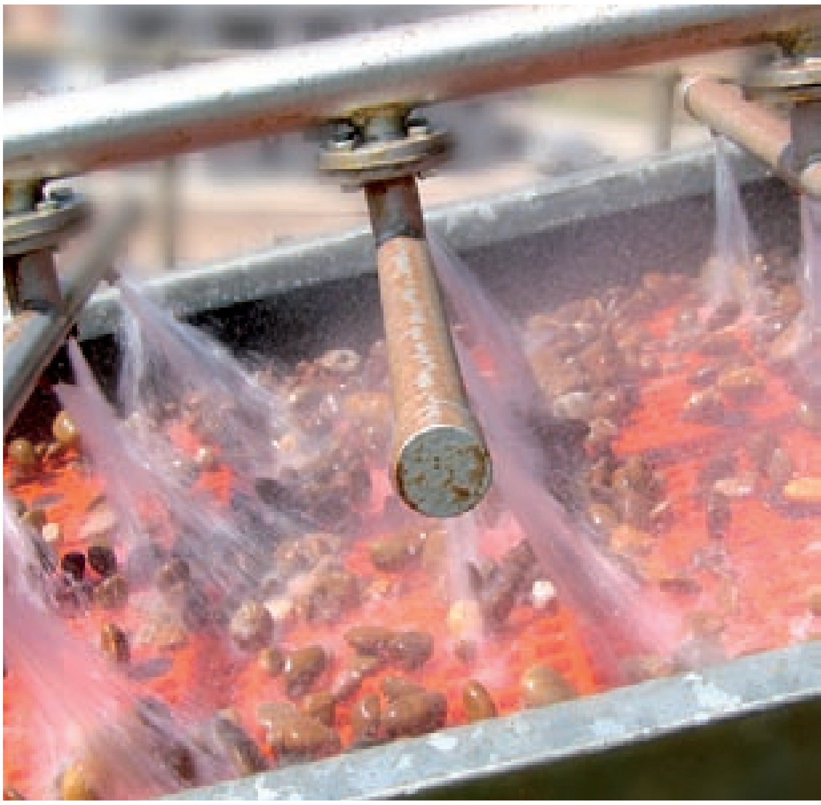
The **goodquarry.com** website discusses the use of the most commonly used types (rotary dryers and fluidised bed dryers). These are primarily used to dry asphalt plant raw material.

Key findings include:

Systems for recovery of heat are used in kilns but not with dryers; this leads to poor thermal efficiency and a perception that drying is a prohibitively expensive option.

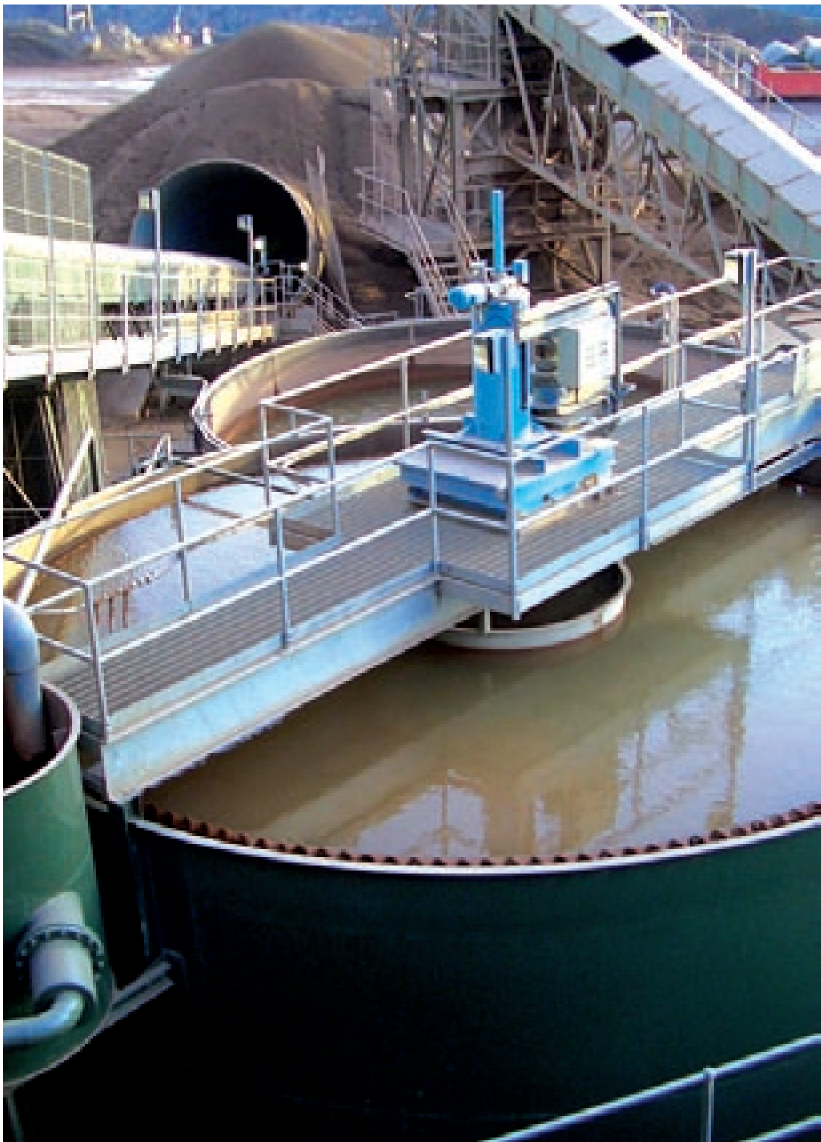
Pilot-scale air classifier





Wash jets over wet screen

Washing plant thickener



Quarry Fines & Waste

Summary

goodquarry.com contains much useful information for both operators and mineral planning authorities on the subject of quarry fines and waste which is summarised below.

Mineral Planning Authorities

Good practice means that MPAs should consider the need to agree or specify planning conditions relating to:

- The location of waste heaps
- Controlling of leachate and run-off
- The height and shape of waste heaps
- Surface treatment, e.g. vegetation
- Progressive restoration
- The duration of temporary heaps.

Operators

Good practice means that operators should try to:

- Minimise the production of waste
- Find a use for waste, e.g. landscaping
- Site waste heaps within workings
- Use waste for progressive restoration
- Site waste heaps having regard to potential effects upon:
    - *The landscape*
    - *Groundwater*
    - *Surface watercourses*
    - *The flood regime.*
- Encase contaminated waste so that it cannot escape. Store top- and sub-soil and overburden with a view to ultimate restoration.
- Use wastes positively. If they cannot be hidden then they should be landscaped and vegetated as soon as possible.

Growing trial in quarry fines

Limestone quarry fines under cover

Quarry filled with waste and fines

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