To address environmental protection, efforts are made to reintroduce the high volume of RAP material into the materials cycle and to reuse a very high ratio. Since the 1970s, an effort has been made to recycle an increasing volume of reclaimed asphalt while continuously optimising the energy-intensive process of asphalt production.

Innovative further developments can lead to economically and ecologically practical energy savings and a reduction of CO₂ emissions. Any temperature lowering by 10 °C, for example, which is technically feasible and produces acceptable quality, halves the respective emissions.

As a competent partner, BENNINGHOVEN offers a wide range of products in the area of recycling additive systems. Whether hot or cold processing, everything takes place under the premise of the highest possible quality for the asphaltic mixture.

In addition, the recycling components are adapted and integrated for the retrofitting of existing systems according to individual customer requirements. According to individual demands or any normative and state requirements, customers can choose between hot and cold feed systems. This strengthens the environmental concept and achieves low CO₂ emissions as well as reduced use of resources.

As an innovative company, BENNINGHOVEN already meets tomorrow’s standards and ensures careful use of resources. BENNINGHOVEN is the solution for economical, flexible and environmentally friendly production of asphalt.
Recycling legislation and common sense demand that as much as possible of the precious resource “reclaimed asphalt” is reused.

The highest theoretical additive volume of used asphalt mainly depends on its grading curve, or, in other words, on its ingredients with regard to volume, size and composition. It therefore has to be one of the objectives to reconcile the grading curve of the crushed asphalt as much as possible with the grading curve of the final asphalt product.

Representation of the different screened volumes after crushing the reclaimed asphalt. This is the dry grading curve, i.e. the 16-22 mm material can also contain conglomerates.
This gentle grinding technology is the perfect precondition for nearly 100% re-use of the RAP material.

Another significant benefit of this grinding technology is the substantially reduced generation of fine particles – the crucial advantage which prevents blockage of the transport paths and the parallel drum as much as possible.

Fine particles can substantially impede the function or the efficiency of the parallel drum and even cause it to fail (see images on the right).

**BENNINGHOVEN’S PERFECT GRANULARITY.**

The BENNINGHOVEN granulator gently separates the reclaimed asphalt into its individual components – without destroying the original grain structure.
GRANULATOR
DESIGN AND FUNCTION

// DESIGN OF THE GRANULATOR
1 Power unit
2 Primary granulator
3 Pre-grinding of large slabs with reciprocating tampers
4 Primary granulator - milling shaft, grain size: 0-70 mm
5 Magnetic separator
6 Screen, 2-level screen
7 Stockpile conveyor 1, grain size 0-8 mm
8 Stockpile conveyor 2, grain size: 8-22 mm (0-22 through conglomerates)
9 Secondary granulator, variable grain size adjustable: 0-22 mm
10 Return of oversize aggregate

// CRUSHING STAGE 1/2
The granulator is loaded with reclaimed asphalt by a wheel loader - as a one-person operation. During the first crushing stage, the asphalt slabs are broken into smaller pieces and pressed down onto the milling shaft. During the upwards motion, the reciprocating tampers prevent bridge formation in the hopper. The milling shaft achieves an output of 0-70 mm in the second grinding stage.

// CRUSHING STAGE 3
Before the broken material is conveyed to the screen, any contained iron parts are removed by a magnetic separator. After fractioning through the screen, the oversize aggregate from crushing stage 3 is fed to the secondary granulator. The result of stage 3 is variable - analogue to the screen used - and is fed back to the screen through the oversize aggregate return (output free from oversize aggregate).
The granulator allows gentle grinding without destroying the original grain structure. This virtually produces no additional fine particles or dust, providing ideal preconditions for feeding RAP into the asphalt mixing plant (up to 90 %+x).

Low wear, operating and follow-up costs ensure maximum efficiency. This is also supported by the direct loading with a wheel loader as only one person is required which means low personnel costs.

The granulator is available as a stationary or as a mobile model. The mobile version is equipped with a 4-axle semi-trailer and ready for operation within 30 minutes.

The granulator features an upstream magnetic separator and has an output of up to 200 t/h, it is resistant to iron and only generates low levels of dust and noise.

A self-regulating control is integrated for independent operation of the system. This does not require the constant presence of an operator which minimises operating costs significantly.

The system is operated via a touch panel display and features a user-friendly and clear structure. For process optimisation, the frequency converter technology integrates a continuously adjustable speed control for the milling shaft. The continuous, self-regulating material feed ensures maximum throughput. A radio remote control can be optionally integrated.

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**TECHNICAL DATA GRANULATOR**

<table>
<thead>
<tr>
<th>Model</th>
<th>MBRG 2000</th>
<th>SBRG 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Mobile</td>
<td>Stationary</td>
</tr>
<tr>
<td>Screening</td>
<td>2-level screen</td>
<td>2-level screen</td>
</tr>
<tr>
<td>Output (max., t/h)</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Dimensions (L x W x H, mm)</td>
<td>18,000 x 2,980 x 4,000</td>
<td>Project-specific</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>54,500</td>
<td>Project-specific</td>
</tr>
<tr>
<td>Power unit (kW)</td>
<td>283</td>
<td>Mains supply, project-specific</td>
</tr>
<tr>
<td>Average drive power (kW)</td>
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<td>125</td>
</tr>
<tr>
<td>Width of feed hopper (mm)</td>
<td>4,350</td>
<td>4,350</td>
</tr>
<tr>
<td>Depth of feed hopper (mm)</td>
<td>1,450</td>
<td>1,450</td>
</tr>
<tr>
<td>Loading height (mm)</td>
<td>3,600</td>
<td>3,600</td>
</tr>
<tr>
<td>Capacity (m³)</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Slab height (edge length mm)</td>
<td>1,800</td>
<td>1,800</td>
</tr>
</tbody>
</table>

**Pre-granulator**

| Shaft length (milling shaft mm) | 2,150 | 2,150 |
| Milking teeth                  | 140   | 140   |

**Secondary granulator (2 shafts)**

| Shaft length (mm) | 1,200 | 1,200 |
| Lug shells        | 84    | 84    |
The RAP material content in asphalt production keeps on increasing. As with white material, it is therefore necessary to add the starting material precisely according to the recipe.

Sorting of the reclaimed fractions is the prerequisite for flexible, exact additive volumes according to recipe with regard to quality and size. The following applies here: the better the storage, the higher the compliance with the recipe for producing asphalt without compromising on quality.

To consistently pursue the environmental concept for the re-use of resources, dry or covered storage of the RAP material should be ensured.

This is because a higher moisture level of the material requires a higher energy input for drying or heating the RAP material in preparation for the optimum mixing process. One additional per cent of moisture in the starting material already requires one additional litre of heating oil for each ton of asphaltic mixture. This can add up to as much as 2000 litres of heating oil in one day – almost the annual consumption of a home owner.

In addition to this, a low moisture level is gentle on the system. Less moisture in the RAP material means less water expansion in the mixer. Vapour shocks release forces which could damage the periphery of the plant.

1 additional % of moisture in the virgin material = 1 l more heating oil per 1 t of asphaltic mixture
OVERVIEW OF RECYCLING SYSTEMS

COLD RECYCLING SYSTEMS

>> MIDDLE RING DOSING SYSTEM

>> DOSING SYSTEM INTO THE MIXER

>> MULTIVARIABLE DOSING SYSTEM
OVERVIEW OF RECYCLING SYSTEMS

HOT RECYCLING SYSTEMS

>> PARALLEL DRUM

>> PARALLEL DRUM IN COUNTERFLOW WITH HOT GAS GENERATOR

>> RPP - RECYCLING PRIORITY PLANT
The middle ring dosing system allows up to 25% of RAP material to be added and is suitable for stationary plants, but especially for mobile asphalt mixing plants (MBA). Retrofitting on existing systems from all manufacturers is possible without problems.

For the middle ring dosing system, large quantities of recycling material are used. The material is introduced into the inside of the dryer drum via a belt and a ring elevator, mixed with the white material and heated gently.

To avoid caking in the drum and in the chutes, BENNINGHOVEN has designed a special solution.

The RAP material is coated by adding all resulting coarse fillers via the pre-separator. This ensures that the RAP material does not stick and is additionally protected against flame impact.
With the dosing system into the mixer, up to 30 % RAP material can be added depending on composition, quality and moisture of the recycling material. Retrofitting on existing systems from all manufacturers is possible without problems.

DOSING SYSTEM INTO THE MIXER

For the dosing system into the mixer, large quantities of recycling material are implemented. The recycling material is conveyed from the feed hopper directly to the mixing tower via an inclined conveyor or alternatively with a space-saving RAP elevator.

Dosing is carried out by belt scales so that a precisely defined recycling volume is fed to the mixer via a chute. The resulting water vapour is routed to the filter dedusting through generously sized insulated pipes.
Multivariable dosing system allows the addition of up to 40 % RAP material – the highest possible ratio for cold recycling.

The recycling material is conveyed directly from the feed hopper to the mixing tower via an inclined conveyor or alternatively with a space-saving RAP elevator. A clearly defined recycling volume is fed to the mixer in small quantities. Highly precise weighing technology allows very exact dosing. Gentle, time-based addition prevents strong vapour shocks during water expansion which is gentle on material and components. Up to 40 % RAP material can be added depending on its composition, quality and moisture content. In addition, the production of hydraulically bound base and cold asphalt is also possible.
Up to 70% recycling material can be added with the parallel drum. The parallel flow drum system is a proven solution for hot feed recycling systems.

Parallel flow recycling drums are in operation worldwide today in all sizes and capacity levels. This technology has proven successful over decades and has undergone continuous further development by the plant manufacturers.

The parallel flow method allows processing of up to 70% recycling material. This is achieved through a parallel flow drum system which is equipped with a burner which was specially developed for this purpose.

The design of the fixtures which prevent direct flame contact with the recycling material and allow effective heating is of particular importance for this method. The recycling material is dosed through a weighing system and fed to the mixer via a heated and insulated chute.
HOT RECYCLING SYSTEM

RPP – RECYCLING PRIORITY PLANT

Up to 80% recycling material can be added with the RPP – Recycling Priority Plant. The main component RAP material is the determining factor in the plant design. The mixer is positioned precisely vertical underneath the parallel drum.

The recycling material takes the straight and simple path through the entire system, avoiding deflections of the recycling material which could result in clogging and sticking or caking.
HOT RECYCLING SYSTEM
HOT GAS GENERATOR

Indirect heating of the material lowers the total energy required for the operation of the plant. This energy efficient process supports the positive total energy balance of the plant.

Use of a hot gas generator means that emissions are clearly below the standard range and therefore particularly environmentally friendly. BENNINGHOVEN is leading in compliance with the current standard.

The parallel drum in counterflow with a hot gas generator represents economic added value as the ratio of added recycling material can be significantly increased – up to 90+x % depending on quality.

The challenge is to heat the recycling material to the optimum processing temperature of 160 °C while keeping emissions in the standard range and not burning the contained bitumen – especially as ever stricter standards and limit values will apply in future.

The burner automatically moves forwards and backwards on its chassis, depending on the operating condition. Afterwards a partitioning element moves in or out. This procedure was developed especially to prevent damage to the components inside the burner after shutting off the firing.

Due to the chimney effect and the associated rising hot air from the RAP dryer drum, the burner would not be protected without this partitioning. When the burner is restarted, the partition moves out and the entire unit moves back into the operating position.
### System Meets Plant

#### Overview

The systems can be combined with each other or used and linked in for specific volumes according to the customer order – large quantities by parallel drum, smaller quantities via cold feed (as an example).

#### Combination Options

**TBA 3000/4000**
- >> Middle ring dosing system and dosing system into the mixer
- >> Multivariable dosing system and parallel drum

**BA 3000/4000/5000**
- >> Dosing system into the mixer and parallel drum
- (mixer directly underneath parallel drum optionally possible - RPP)
- >> Multivariable dosing system and parallel drum
- (mixer directly underneath parallel drum optionally possible - RPP)
- >> Dosing system into the mixer and parallel drum with hot gas generator
- >> Multivariable dosing system and parallel drum with hot gas generator

#### Plant Matrix

<table>
<thead>
<tr>
<th>Plant</th>
<th>Mixing capacity</th>
<th>Middle ring dosing system</th>
<th>Dosing system into the mixer</th>
<th>Multivariable dosing system</th>
<th>Parallel drum</th>
<th>RPP</th>
<th>Parallel drum in counterflow with hot gas generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBA 2000</td>
<td>160 t/h</td>
<td></td>
<td></td>
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<tr>
<td>MBA 3000</td>
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<tr>
<td>ECO 2000</td>
<td>160 t/h</td>
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<td>√</td>
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<tr>
<td>ECO 3000</td>
<td>240 t/h</td>
<td>√</td>
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</tr>
<tr>
<td>ECO 4000</td>
<td>320 t/h</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>TBA 2000</td>
<td>160 t/h</td>
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</tr>
<tr>
<td>TBA 3000</td>
<td>240 t/h</td>
<td>√</td>
<td></td>
<td>√</td>
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<td>TBA 4000</td>
<td>320 t/h</td>
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<tr>
<td>BA 3000</td>
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<td>BA 4000</td>
<td>320 t/h</td>
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<tr>
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<td>400 t/h</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RECIPE GENERATOR IN THE BLS 3000

DYNAMIC ADDITION OF RECYCLING.

Constant further developments at BENNINGHOVEN have lead to the development of a software for dynamic recipe adjustment during recycling feed. Dynamic RAP feed allows optimisation of RAP use and offers the following advantages.

> A basic recipe with variable recycling ratio replaces a whole range of recipes.
> Increased use of RAP material thanks to finer grading of the added quantity.
> Adjustment options for the product temperature through the RAP component.

### CONFIGURATION OF THE GENERATOR FUNCTION

The display of the limit values immediately indicates the cause for the limitation of the recycling component in each case. Limit value I is the limit value which results from the softening point. Limit value II results from the grading curve.

The lower of the two values yields the limit value for the maximum permitted RAP component. In addition, the limiting components of the grading curve are shown in each case. Other components of the basic recipe may be used for compensation of the different recycling components in order to increase limit zone II with regard to the grading curve.

The software was kept very user-friendly to ensure simple operation. This additional retrofit option was developed especially for the control of the BLS 3000.

### USE OF THE GENERATOR FUNCTION IN THE BLS 3000

After selecting a recipe with a recycling component, a slider is displayed. This can be used to adjust the recycling component. The target values for the selected recipe are calculated based on the corresponding analysis of the RAP material.

The target values calculated by the generator can be verified by pressing the "Test calculation" button. Clicking on the RAP component in the order calls up the extended configuration of the recipe generator.
CUSTOMER SUPPORT AT BENNINGHOVEN
RUNS LIKE CLOCKWORK.

// TECHNICAL SUPPORT
> Preventive inspection and system inspection
> Individual spare parts advice
> Consulting on innovative wear protection to extend the service life
> Heat and energy optimisation for the plant
> Perfectly prepared for the new season

// INFORMATION SYSTEMS
> Telephone support
> Error diagnosis through remote service
> Online support
> Software updates
> Replacement of old controls

// LOGISTICS
> Organisation and planning of transport, up to 100 lorries/project
> Support for approval processes
> Organisation of special transports
> Customs clearing

// TRAINING
> Safety instruction
> Plant induction
> Operation
> For service engineers
> For plant personnel

// SPARE PARTS
> 24/7 via special courier service
> Planning
> Logistics
> Creation of customer-specific spare parts packages

// PREVENTION
> Preventive inspection and system inspection
> Individual spare parts advice
> Consulting on innovative wear protection to extend the service life
> Heat and energy optimisation for the plant
> Perfectly prepared for the new season

// WINTER CHECK

When you consider that asphalt mixing plants have a service life or operating period of more than 40 years, during this period it is obvious that technology, requirements and standards will change and research findings will conquer the markets.

Accordingly, this creates the need for the asphalt mixing plants to remain in good condition, both internally and externally - by replacing components or general retrofitting of the plants. There are many reasons for this:

> Normal wear
> Upgrading to increase capacity
> Environmental awareness and tighter emission laws
> Reduction of the overall energy balance (e.g. use of heating media for drying, standby mode for units which are temporarily not being used)
> Control system retrofitting, from console control to PC
> Enabling RAP dosing
> Attaining the status quo for plants
> Improving efficiency

BENNINGHOVEN is able to retrofit components not just on its own plants but also on all third-party plants. As a technology leader, BENNINGHOVEN offers ideal solutions for optimising your mixing plants in many areas, e.g. burner technology, RAP systems or bitumen technology.

// RETROFITTING AT BENNINGHOVEN