Material flow in foundries

Dipl.-Ing Bernd Federhen, manager at the Development/Testing Department, at KLEIN Anlagenbau GmbH, Niederfleischbach, Germany discusses the economical aspects of the handling of sands and dusts.

In foundries large amounts of various sands and dusts have to be transported over considerable distances. Transport facilities are available which, when chosen according to the properties of the materials, facilitate trouble-free, economical transport. When looking at the flow of the various materials through a foundry one can clearly recognise streams of material which are brought together, partly mixed, separated, treated, stored and discharged.

Figure 1 shows this in a simplified manner. Sand in various states is an important part of material handling in foundries. The sand flow forms a cycle where partial flows are added to and taken from.

The typical flow is from storage silos for new sand/used sand to mixers where the sand is mixed with liquid or solid binders and possibly additives and from where it is then transported to the moulding core shop. In the casting process, the sand meets the metal flow. From the knock out station the sand flows back to the preparation or reclamation systems, dust and waste sands being discharged and stored until they are disposed of. In used sand reclamation systems additional internal sand cycles are necessary.

The space available for the necessary transport systems in foundries is very limited. It is therefore desirable to have transport systems with very small dimensions which can be easily integrated in the allowable space. Energy consumption and maintenance input should be minimal.

Table 1 shows possible transport methods for the various materials.

The tendency of the core sands to build up and their poor flow properties require a corresponding design and material choice of the transport buckets. Rails and transport cars are a relatively rigid system which has a strong influence on the erection of the facilities in core shops and requires considerable space.

Figure 1 shows that sand or dust handling occurs at many places in foundries. The distances and the handling capacities are sometimes considerable, and the space available for material transport is usually limited. This requires a very adaptable conveying system – the pneumatic conveying system.

The conveying principle itself is based on the fact that the material is transferred into a conveying pipe, accelerated by the conveying air due to its flow resistance and transported through the conveying pipe. The greatest advantages of pneumatic conveying lie in the simplicity of the principle itself. There is hardly a simpler conveying means than a pipe through which the material is moved. It is cheap, very adaptable, space saving, dust tight, weather independent and only requires little maintenance.

In foundries, pneumatically conveyed materials have widely varying conveying properties. These can be accommodated when the suitable conveying process is chosen according to the properties of the materials and when the system is equipped with rugged components.

Depending on the distance, materials of group A (Table 2) are transported with the dense phase or lean phase process. The air velocity is higher than 10m/s, the air flow turbulent. The product particles move through the conveying pipe at a relatively great distance to each other. The air pressure decreases almost linearly over the conveying distance. Since the product particles only have a very small mass (dust grains), the wear on the pipes is low even with these conveying velocities despite higher ranges. The static pressure of the flowing conveying air on the dust particles acts as motive force of the product particles. If larger material accumulations form at one point in the pipe, the energy flow is interrupted at that point and the pipe will clog.

Conveying vessels are suitable feeding locks, the filling process being monitored by a level probe. The conveying process is completed when the vessel and the pipe have been emptied to an extent where only the flow resistance of the empty pipe acts on the pressure switch, i.e., the conveying pipe empties after each conveying process. The product is discharged from the vessel into the pipe by means of a fluidisation bottom. To minimise the air consumption, these conveyors can be equipped with a loading control unit.

Product and conveying air are separated at the receiving hopper by means of a separator and a filter.

When transported at high velocities, as necessary for group A materials, group B materials cause considerable wear due to their hardness, grain shape and the relatively large grain mass. Wear occurs at bends, pipes and the sand grains themselves and causes interruptions in operation and high replacement parts costs. Wear of the sand grains increases the percentage of fines in the sand, thus extending its surface, and consequently increases the binder consumption with all its known negative influences. For that reason, everything possible must be done to carefully transport moulding and core sands.

A slug type conveying process facilitates trouble free transport of these materials when their properties are taken into account.

The dustfree grain composition results in great porosity of these sands, through which the conveying air flows, even if slugs form in the conveying pipe and move through it relatively slowly. The air flows from one air cushion through the slug into the air cushion downstream and loosens the slug to where it can easily shift in the conveying pipe. The air flowing in the spaces between the sand grains produces a static pressure on them, which is sufficient for the transport.

**Table 1: Possible transport methods for the various materials**

<table>
<thead>
<tr>
<th>Material</th>
<th>Transport method (example)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sands, moist</td>
<td>Mechanical transport</td>
</tr>
<tr>
<td>Dust</td>
<td>Pneumatic conveying, big bag</td>
</tr>
<tr>
<td>Sands, dry</td>
<td>Pneumatic conveying, bucket, curing pan</td>
</tr>
<tr>
<td>Metal, solid</td>
<td>Ladle, runner</td>
</tr>
<tr>
<td>Metal, liquid</td>
<td>Pipeline with pump</td>
</tr>
<tr>
<td>Liquids</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Essential material flows in foundries

Figure 2: Dependency of the conveying capacity on the air velocity at the end of the conveying pipe (Conveyor type T, Sand F, 32. Pneumatic pipe DN 80, Conveying distance 40 m)

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The velocity of the sand slugs is below 5 m/s, characteristic conveying pressures being between 5 and 6 bar. Coarser sands, eg sand H32, result in a more uniform, smoother conveying process than fine-grain sands, e.g. F35. Up to a PLI number of approx 300, new sands can be transported very uniformly and carefully by means of the usual slug type conveyance. The PLI number is a value resulting from experience and can be easily calculated from a sieve analysis.

Sands with splinterly grain shape and those with a rougher surface, eg sand on which bentonite particles were calcined in a thermal reclamation system, are more difficult to convey than spherical new sand. This results in a higher specific air requirement and lower conveying capacities.

Pneumatic conveying systems for sand are generally supplied with 6 bar overpressure from the company's compressed air system. The most economical operation is achieved when the air pressure is utilised and the air volume is kept minimal. Thus, the energy of the compressed air is used and the conveying velocity remains small.

In order to reach the required conveying capacity over a given distance with a minimum of wear, it is therefore important to determine the optimum combination of conveying pipe cross section and air velocity.

Figure 2 shows measured values for the dependency of the conveying capacity on the air velocity at the end of the conveying pipe. The air velocity results from the measured air quantity, the measuring time and the cross section of the pipe. The sand slugs reach approximately half of the air velocity. The smoothing of the drawn regression curve shows that the air requirement and thus the energy consumption increase in proportionally with increasing air velocity. Since the wear also increases proportionally with increasing air velocity [4, 5], it is clearly better to use larger pipe cross sections for higher conveying capacities than to work with higher velocities. This must also be taken into consideration when existing conveying systems are extended.

If the conveying air velocity is increased to more than approx 8 m/s at the end of the pipe, the sand slugs in the pipe produce hammering in the pipe; a part of the energy contained in the conveying air is thus converted and causes wear instead of transport.

Conventional pneumatic sand conveyors operate discontinuously according to the principle shown in Figure 3. In this state the sand runs from the primary vessel (number 1 in the diagram) through the inlet closure (number 3 in the diagram) into the conveying vessel (number 2 in the diagram) through such inlet probe (number 6 in the diagram) responds. The inlet closes, and air is fed into the vessel through the connection (number 4 in the diagram). The conveying pipe (number 8 in the diagram) still contains slugs from the previous cycle. The air flows through the sand in the vessel into the conveying pipe, through the sand slugs up to the receiving hopper (number 10 in the diagram). The sand slug which is closest to the receiving hopper is fluidised by the conveying air and transported to the receiving hopper. When it has fallen from the conveying pipe into the receiving hopper, the air pressure which has built up in the vessel is higher than necessary for moving the remaining sand slugs in the pipe. Therefore, all sand slugs are then moved towards the receiving hopper, and the air flowing through the vessel to the conveying pipe carries sand from the vessel into the pipe where a new slug forms. This process is repeated until the low level probe (number 7 in the diagram) is reached, the conveying air supply is interrupted and the vent valve (number 5 in the diagram) for reduction of the pressure is opened. The conveying vessel can then be refilled. During the filling time there is no movement in the conveying pipe.

Before the conveying movement restarts, the air must penetrate all the sand remaining in the pipe from the previous cycle. This requires time. With regard to wear, it would be impractical to blow the conveying pipe empty after each cycle in order to shorten the next starting process.

Thus, with discontinuous pneumatic sand conveyors only a part of the cycle time is available as actual conveying time. The complete conveying capacity must occur in that time i.e. higher velocities and correspondingly higher energy conversion and wear occur. Continuously operating pneumatic sand conveyors do not have these disadvantages.

With the continuous pneumatic conveyor a well designed hopper transport unit for the transport of sand is available. Compared with conventional units, it offers striking advantages: continuous transport process, considerably lower conveying air consumption, lower transport velocity, less wear, lower space requirement, lower burden on filter, very good accessibility of the components and suitable as measuring unit for sand consumption.

The pneumatic conveyor takes the sand from the screw batch-wise and conveys it to the receiving hopper continuously. Each cycle consists of five stages. These are shown in Figure 4.

Filling stage: The inlet valve is open. The discharge valve flap is closed by a leaf spring and the air pressure in the conveying pipe (Figure 4a). The sand flows through the conveying sleeves and into the pressure vessel. A slight glass in the inlet housing facilitates the determination of the required filling time, which can then be set accordingly.

Closing stage: A bellows cylinder forces the inlet cone up to its seating, the valve area being simultaneously flushed with air from a ring of nozzles. This ensures airtight closing of the inlet valve with a minimum of wear (Figure 4b). The discharge valve remains closed, with compressed air still flowing in the conveying pipe.

Conveying stage: After the inlet valve has closed, compressed air continues to flow through the nozzle ring and builds up

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**Table 2: Classification of the pneumatically conveyable materials in foundries according to their conveying properties**

<table>
<thead>
<tr>
<th>Material group</th>
<th>Materials</th>
<th>Grain size</th>
<th>Possible conveying processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - dusts</td>
<td>Bentonite Coat dust Cement Iron oxide and similar filter dusts</td>
<td>0.1 mm dustlike definable constant bulk low porosity wide grain spectrum</td>
<td>Lean phase to dense phase conveyance (conveyor type S)</td>
</tr>
<tr>
<td>B - sands</td>
<td>New sand Chemically bonded prepared used sand and the like Crowning sand</td>
<td>0.063 to 0.7 mm granular, dustfree definable constant bulk is porous narrow grain spectrum</td>
<td>Slug-type conveyance T (conveyor type and SIF 25)</td>
</tr>
<tr>
<td>C - other</td>
<td>Waste sand Used bentonite-bonded sand (dry) Blasting sand and the like</td>
<td>Distilike to granular variable bulk very low porosity wide grain spectrum</td>
<td>Slug-type conveyance (PLI)</td>
</tr>
</tbody>
</table>

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**Diagram 3:** Pneumatic slug-type conveyance of sand according to the conventional slug-type conveying process (conveyor type T)

**Diagram 4:** Function of the conveyor with continuous slug-type conveyance: a) Filling stage; b) Closing stage; c) Conveying stage; d) Transfer stage; e) Exhaust stage
sand preparation

![Graphs showing specific air consumption and air velocity at the end of the conveying pipe.](image)

The continuous conveying process results in significant possibilities to save conveying air. Figure 5 shows the comparison with a conventional conveyor. It states the air consumption in relation to the conveying capacity. The considerably lower air consumption of the new conveyor is quite apparent.

Practical experience and laboratory examinations show the overproportional influence of the particle velocity on wear [4, 5]. Therefore, the transport velocity of the sand in the conveying pipe is very important for the trouble-free operation of pneumatic sand conveying systems. With the quasi-continuous conveyor a required capacity can be reached at clearly lower air velocities (Figure 6).

Increasing demands on capacities necessitated an extension of the capacity range of this pneumatic conveyor. By combining two single conveyors to form a tandem system, the possible transport capacity could be increased considerably. During the filling time of one conveyor the other one transports material. The conveying process is absolutely continuous and very gentle.

The two conveyors discharge into a common intermediate housing to which a conveying pipe up to a size of DN 125 is connected. The conveyor requires much less space than conventional conveyors. Therefore, well accessible plants can be built even with restricted space.

**References**

2. Company brochure Albo KLEIN: Pressure vessel conveyor type S.
6. Company brochure Albo KLEIN: Pressure vessel conveyor type T.

**Reader Reply No.25**

**Improved laboratory sand rammer**

Ridsdale & Co Ltd, manufacturer and supplier of foundry sand testing and control equipment, has introduced a new design laboratory sand rammer.

The new sand rammer from Ridsdale & Co Ltd, the Type 'N' sand rammer, is more user friendly to the operator, is better designed to withstand the rigours of the modern foundry and is easier to maintain than the conventional sand rammer.

The Type 'N' sand rammer is constructed using high strength cast iron, and special attention has been given to the areas where wear might take place. Thus, the shaft is made using high molybdenum precision ground steel bar, which has high oxidation resistance and reduces wear to the rammer.

It has a thicker rammer head to transpose the ramming energy over the diameter of the sand specimen, and a second steel cam has been incorporated, which raises the main shaft and rammer head and locks them in an elevated position to enable the specimen tube and the pedestal cup containing the sand sample to be located correctly.

Both lifting cams are fitted with sealed bearings and should the cams ever wear over the years, they can be readily replaced. Results compared using the conventional sand rammer and the Type 'N' has shown a more uniform distribution of the sand compaction across the diameter of a sand specimen when using the thicker type rammer head.

As with the conventional model, the new sand rammer is available in imperial and metric versions and is used to prepare specimens for many standard tests including:

* Green and dry permeability
* Compression strength
* Shear strength
* Splitting strength
* Transverse core strength
* Tensile core strength

It is also used for compactability tests and determining the flowability of foundry materials.

The Type 'N' sand rammer thus represents an improvement in performance and working life compared with earlier models and is available immediately from Ridsdale & Co Ltd.

**Reader Reply No.26**

*The new sand rammer – the Type 'N'*