Reprint from CP + T – Casting Plant and Technology, issue No. 1/87, pages 14–21

A new possibility for the economical conveyance of sand

Bernd Federhen, Siegen

Summary

A new type of slugs conveyor has enabled progress in the transport of quartz sand and similar products. The specific advantages include the size of the equipment, the cost for control and the energy requirement. The report includes details of the construction and functioning of the new plant as well as measurements of its performance in comparison with conventional conveyors and its practical use.

Large amounts of sand have to be transported in foundries. Pneumatic conveyance has become generally accepted for this purpose. The article presents a new type of equipment for the conveyance of quartz sand and similar materials that has noticeable advantages by comparison with equipments as previously used for this task.

Equipments currently employed

In order to cope with the heavy wear properties of quartz sand it is today practically only transported via pressure vessel conveyors whose sizes are matched to the conveying capacities. High conveying capacities require large vessels in order that the frequency of actuation of the different components in the system is not too high and they therefore have sufficient service life.

The sand moves through the conveying pipe in slugs. The slugs are formed in accordance with the frictional relationships between the sand and the wall of the conveying pipe and the porosity of the sand, without any mechanical assistance in the vessel itself.

The conveyors are costly to manufacture and incorporate relatively many components; the electrical control is also costly.

The mostly used level detecting devices which operate on a capacity basis can cause malfunctioning when there are fluctuations in the sand moisture and temperature.

Initial steps for development of a conveyor

The investigation of different sizes of conveyors showed that small units with a fast sequence of operation not only offer advantages with respect to costs and size but also with respect to the energy requirement. This was the reason for the development of a conveying device that was particularly suitable for the handling of quartz sand and that incorporated these advantages and also enabled a rapid cycle sequence **(Figure 1)**.

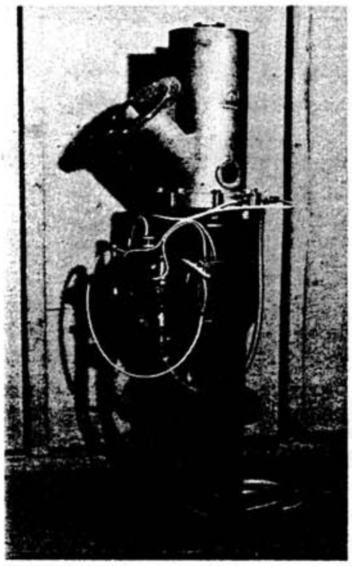

Figure 1. New type of conveying equipment *(Type SP 25)*

The cycle sequences on the new conveyor have been reduced to 14 s so that there is an almost continuous flow of material. The required individual functions are so amalgamated that only a few components are required and that the expenditure for the controls is also low.

Construction of the new conveyor

Figure 2 shows the construction of the new conveying vessel. The inlet housing has a lateral sand feed pipe and a vertical air exhaust connection and is mounted on top of the pressure vessel. A conical inlet valve with an integral exhaust valve is situated between the pressure vessel and inlet housing. The bottom of the pressure vessel is fitted with an automatically actuated discharge valve which incorporates an inductively operated minimum probe. The valve also has a flange for connection to the conveying

Ing. (grad.) Bernd Federhen is Manager for Development and Testing in the Pneumatic Conveyor and Foundry Equipment Division of Alb. Klein GmbH & Co. KG, Niederfischbach.

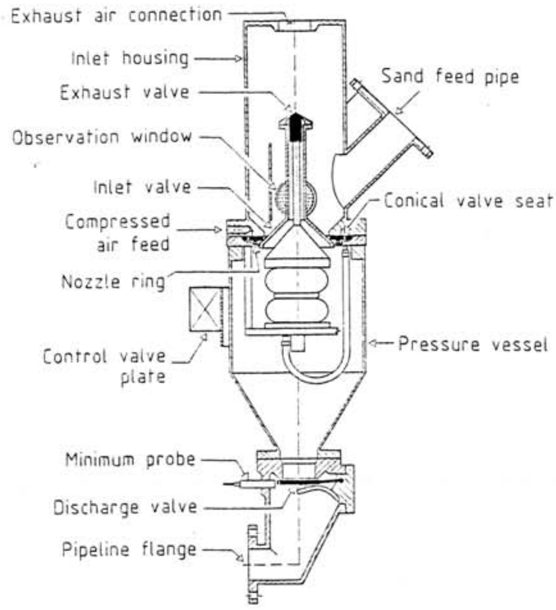

Figure 2. Construction of the new conveyor

pipe. Additional air is fed into the pipeline via an aerating flange. The magnetic valves are compactly mounted on a plate attached to the pressure vessel.

Most components consist of SG iron or aluminium castings. Hence, there is little in the way of mechanical machining.

The pressure vessel capacity is approximately 40 kg and the max. allowable conveying pressure 6 bar.

Functioning of the conveyor

The unit cyclically feeds the sand from the atmospheric pressure inlet vessel into the pressurized pipeline. As can be seen from **Figure 3**, each cycle consists of 5 stages.

Filling stage. The inlet valve is open. The discharge valve flap is closed by a leaf spring and the air pressure in the pipeline **(Figure 3a)**. The sand flows through the connecting sleeve and into the pressure vessel. An observation window in the inlet housing enables 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 region being simultaneously flushed with air from a ring of nozzles. This ensures airtight closing of the inlet with the minimum of wear **(Figure 3b)**. The discharge valve remains closed, with compressed air still flowing in the pipeline.

Conveying stage. After the inlet valve has closed, compressed air continues to flow through the nozzle ring and builds up pressure in the pressure vessel. When the pressure in the vessel exceeds that in the pipeline, the discharge valve then opens and sand flows from the vessel into the pipeline **(Figure 3c)**.

Switching stage. When the pressure vessel is empty a leaf spring closes the discharge valve flap onto its seat and, in doing so, actuates the inductively operating minimum probe. The air still flowing out of the pressure vessel cleans the sealing surface in the discharge valve. The compressed air feed into the pressure vessel is interrupted and the pressure in the inlet valve bellows cylinder is exhausted **(Figure 3d)**.

Exhaust stage. The pressure remaining in the pressure vessel at this point firstly collapses the bellows cylinder and, secondly, holds the inlet valve cone on its seat **(Figure 3e)**. This causes the exhaust valve to open and the pressure in the pressure vessel to fall until the inlet cone opens under its own weight and allows a clear passage for the refilling.

Switching on and off. The conveyor can be switched off in any position, with the control always reverting to the "filling" stage on re-starting.

Measurements on the new conveyor

Test plant

In parallel with the development work measurements were carried out in a test plant, using 41, 80 and 119 m lengths of 80 mm diameter pipe as well as 41 m lengths of 65 mm and 100 mm diameter pipe. The pipelines ended in a silo that was also the storage container for the conveying equipments. This then enabled the carrying out of long term circulation tests. The compressed air was supplied from a 6 bar (pressure burden) works main. The conveyed material was F 32 quartz sand.

The data concerning pressure, conveying air volume, slug velocity and length were electrically measured and synchronously registered by means of a multi-channel chart recorder. For comparison purposes, measurements were also made on a conventional equipment under the same conditions.

Figure 4 shows the arrangement of the equipments in the test plant. This shows the new conveyor, the conventional thrust transmitter, the pipeline and the receiving silo from which the conveying equipment is recharged.

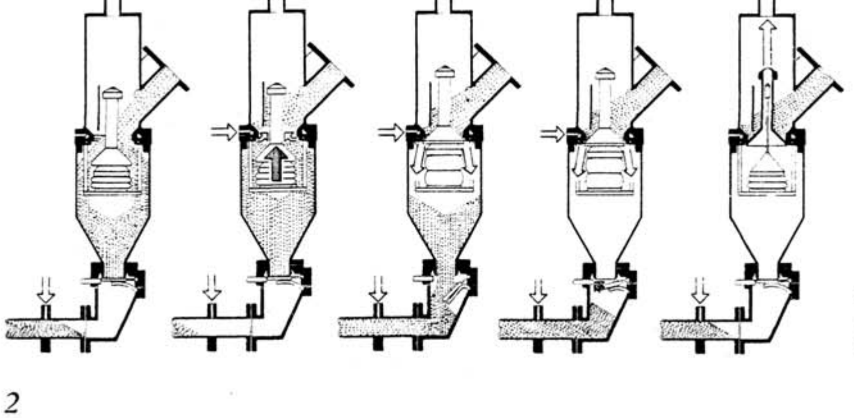

Figure 3. Individual stages of operation of the new conveyor: a) filling, b) closing, c) conveyance, d) switching, e) venting

Figure 4. Test plant with the new conveyor (right), the conventional thrust transmitter, conveying pipe and receiving silo

Results of measurements on new conveyor

Achievable conveying capacity, required conveying pressure. **Figure 5** shows the conveying capacity achievable over the different pipeline lengths and the required conveying pressure.

Up to a length of 40 m it is possible to achieve a capacity of 10 t/h and at 120 m this falls to 6 t/h. The pressure increases from 4 to 5 bar.

Compressed air consumption. **Figure 6a** shows the relationship of the air consumption to the conveying capacity (80 mm diameter pipe). The specific air consumption is shown in dm^3/min per 1 m length of pipeline.

By approximation from the measurements the following relationship was derived for the specific air consumption in the 80 mm diameter pipeline

$$\dot{V}_{f\,spec} = 3.0354 \cdot e^{0.3135 \cdot M_s}$$

where $\dot{V}_{f\,spec} = dm^3/(min \cdot m)$ and $M_s = t/h$

Energy requirement. The power consumption of the compressor to supply the plant can be calculated from the specific air consumption and the measured conveying pressures. This power consumption is shown in **Figure 6b as W/m** of conveyor length in relationship to the conveying capacity. The influence of the diameter of the pipeline on the energy requirement also results from this diagram.

With products like quartz sand the conveying speed has a large influence on the wear of the pipeline. Consequently, the pipe diameter cannot be selected on the basis of the energy requirement alone, allowance has also to be made for the conveying speeds required in accordance with the relevant pipeline diameters. This will be explained later.

Energy costs. Because the specific power consumption does not linearly increase with the conveying capacity, there is an optimal conveying capacity for a specific amount of sand which will result in minimum energy costs. **Figure 7** shows the relationship between the energy costs and conveying capacities for the transport of 1000 t of F 32 quartz sand through 75 m lengths of 65, 80 and 100 mm diameter pipes on the basis of a power cost of DM 0.21/(kW·h). Allowance must also be made here for the restrictions with respect to wear.

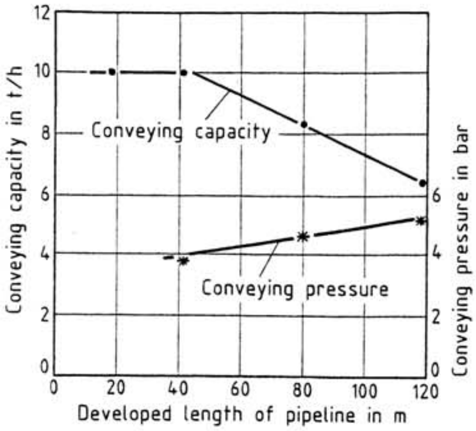

Figure 5. Conveying capacity and pressure in relationship to the pipeline length for the transport of F 32 sand with the new conveyor

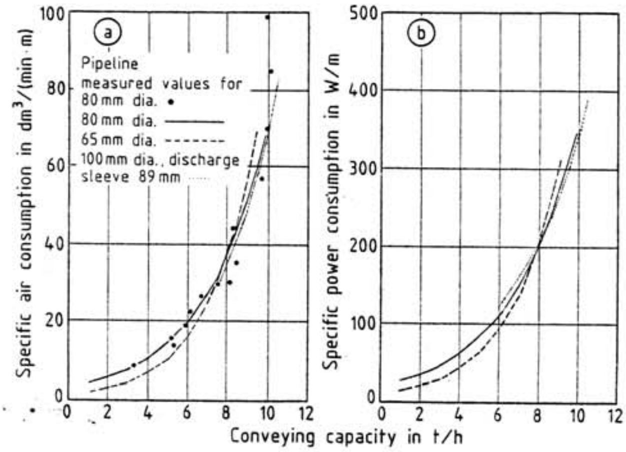

Figure 6. Specific air consumption (a) and specific compressor motor power (b) in relationship to the conveying capacity (approximation curves) for the transport of F 32 sand with the new conveyor

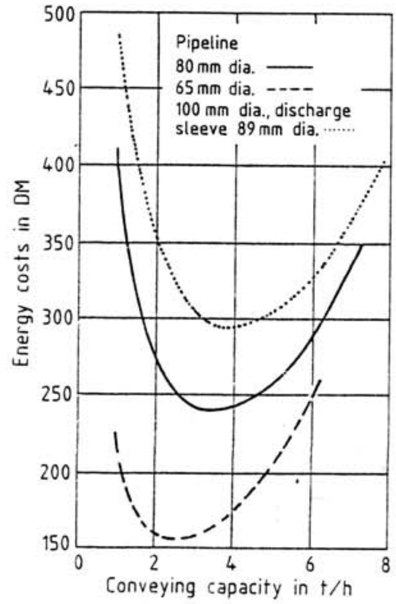

Figure 7. Relationship of energy costs and conveying capacity for the transport of 1000 t of F 32 sand over 75 m; assumed power cost of DM 0.21/(kW·h)

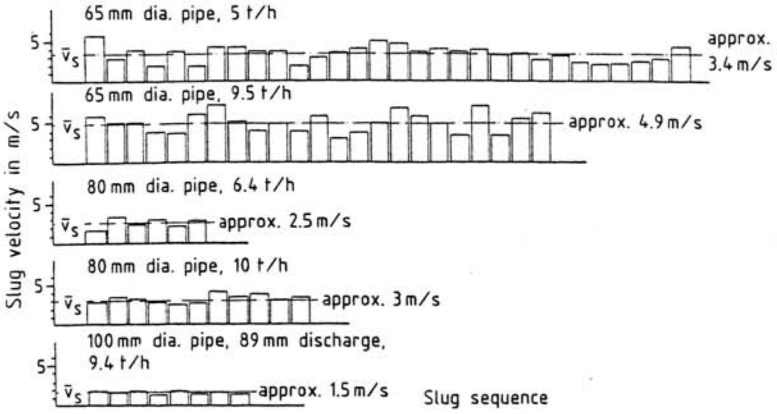

Figure 8. Relationships of the slug velocities in the pipe, the nominal diameters of conveying pipes and the conveying capacity for the transport of F 32 sand with the new conveyor

Table 1. Average slug velocity and length in the new conveyor in relationship to conveying capacity and pipeline cross-section

Pipeline nominal diameter in mm	Conveying capacity in t/h	Average slug velocity in m/s	Average slug length in m
DN 65	5,00	3,37	1,52
DN 65	9,45	4,91	1,53
DN 80	6,00	2,54	2,10
DN 80	10,00	3,00	2,15
DN 100	9,36	1,51	3,35

Procedures in the new conveyor pipeline. Two capacitively operating probes were installed in the top wall of the pipelines at a position near to the receiving silo. The distance between the probes was 2 m and as long as they were in contact with a slug they transmitted an electrical signal, both signals being synchronously registered on two channels of the multi-channel chart recorder.

A moving slug actuated the first probe and then subsequently the second probe. The velocity of the slug could then be calculated from the forward speed of the chart recorder, the recorded spacing between the signals and the fixed 2 m distance between the probes. **Figure 8** shows a bar diagram for the slug diameters, with the height of the bars corresponding with the velocity of a slug. The average value for each series of measurements is also incorporated in the diagram (consecutive sequence from left to right).

As long as a slug covers a probe this produces a signal on the chart recorder. The slug length can be determined from the forward speed of the chart recorder, the length of signal and the established slug velocity. **Table 1** shows the determined slug lengths and velocities.

Measurements with the conventional equipment

Measurements with the conventional conveying equipment were carried out on the same test plant **(Figure 4)**.

Air consumption. Figure 9 a shows the relationship between the specific air consumption and the conveying capacity for the 80 mm diameter pipeline.

Energy requirement. The power consumption of the required compressor was calculated from the specific air consumption and the conveying pressures. **Figure 9 b** shows this power consumption in W/m of conveyor length in relationship to the conveying capacity.

Energy costs, example. With the same data as that in the example for the new conveyor **Figure 10** shows the energy costs for sand transport through the 80 mm diameter pipe with the conventional conveyor.

Procedures in the conventional conveyor pipeline. The slug velocity and length during conveying with the conventional equipment was determined by the same method and equipment as used for the new conveyor. The measurements were taken at the end of the cycle, up to the time that the minimum probe ended the conveying cycle. **Figure 11** shows the results for the 41 m length of 80 mm diameter pipeline.

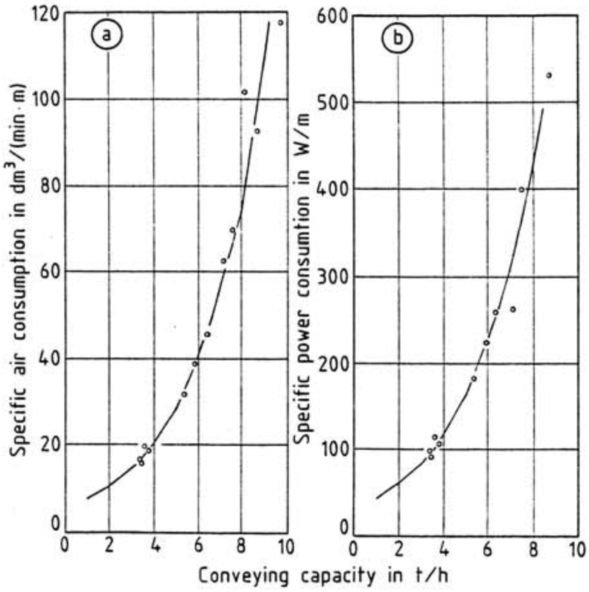

Figure 9. Specific air consumption (a) and specific compressor motor power (b) in relationship to the conveying capacity for the transport of F 32 sand through an 80 mm diameter pipe with the conventional conveyor

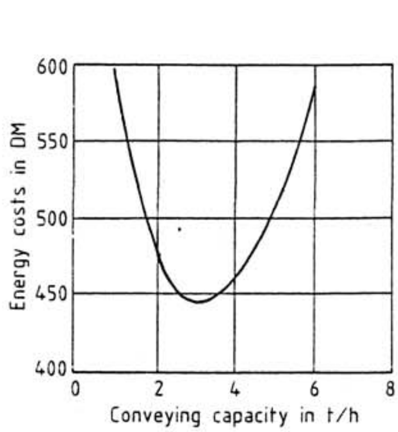

Figure 10. Relationship of energy costs and conveying capacity for the transport of 1000 t of F 32 sand over 75 m of 80 mm diameter pipe by means of the conventional conveyor; assumed power cost of DM 0.21/(kW·h)

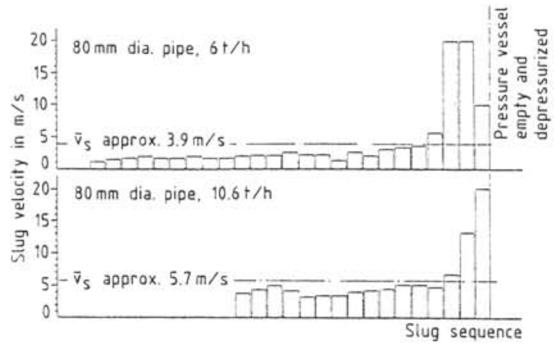

Figure 11. Slug velocities in the pipe in relationship to the conveying capacity with the conventional equipment (F 32 sand, 80 mm diameter pipe)

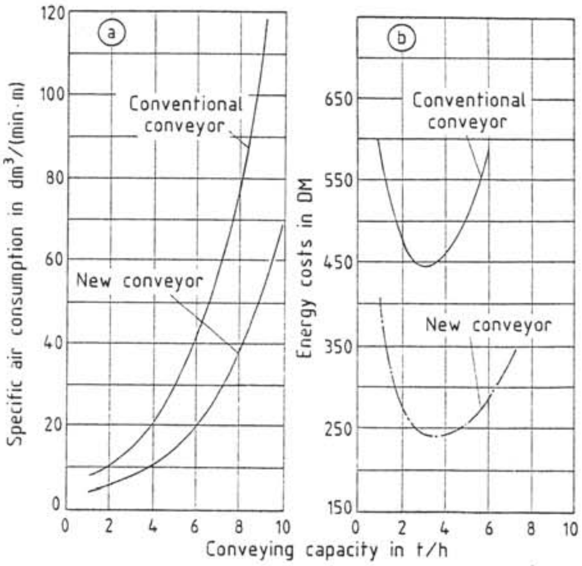

Figure 12. Comparison between the conventional and the new conveyor: specific air consumption (a) and energy costs for transporting 1000 t of sand over 75 mm (b) in relationship to the conveying capacity (F 32 sand, 80 mm diameter pipe)

Comparison between the conventional and the new conveyor

The specific compressed air consumption in relationship to the conveying capacity in an 80 mm diameter pipeline is shown in **Figure 12a** for both types of equipment. **Figure 12b** summarizes the energy costs for sand transport with both equipment for the amounts and lengths in the previous examples. It is to be noted that there is a conveying capacity that produces minimum energy consumption and that the optimal range with the new conveyor is substantially wider than that with the conventional conveyor, i.e. it is easier to set in practical operation.

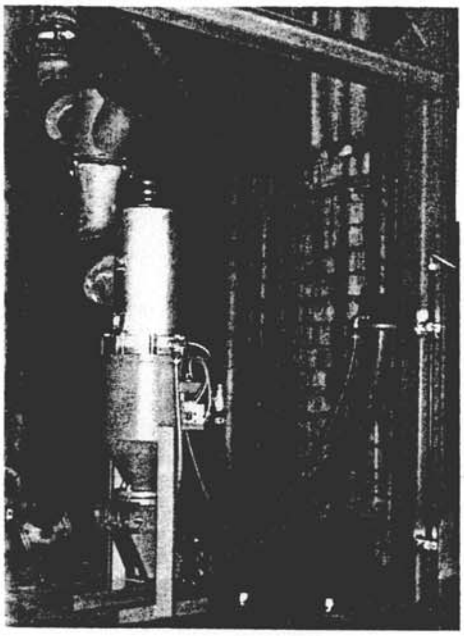

Figure 13. New conveyor for the transport of used sand with initial dosing of the sand feed; conveyor length approximately 60 m of 100 mm diameter pipe, conveying capacity approximately 9 t/h *(Photo, Schmolz + Bickenbach, Krefeld)*

Additionally, from the data selected from the examples, the energy costs for the new conveyor are only approximately 55% of those for the conventional equipment.

Practical use

A number of the new equipments have already been proved in practical use. The following shows some examples of the applications:

- Transport of used sand from a silo with initial dosing of the sand feed **(Figure 13)**.
- Removal of cooled used sand to a fluid bed cooler (conveyor length approximately 40 m of 80 mm diameter pipe, capacity approximately 6 t/h). In this case the almost continuous feed ensures a very constant bed level and therefore enables uniform dust extraction from the fluid bed.
- In the works of a German manufacturer of optical glass, wear in the old pneumatic conveyor caused iron contamination of the quartz sand and produced inadmissible colouring in the glass. The new conveyor removed this defect (conveyor length approximately 40 m of 80 mm diameter pipe, capacity approximately 7 t/h).

Translated from Giesserei 73, 1986, No. 24, p. 701-705.