Pneumatic Ship Unloading Plants for Poorly Flowing Bulk Materials

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Summary

The pneumatic discharge of free flowing materials has been realised for nearly a hundred years. The situation with respect to poorly flowing materials is rather more difficult; until recently, manual labour was used to loosen the product in the region of the suction nozzle. The author considers two loosening systems offered by Bühler-Miag to overcome this problem and gives examples of their use.

1. Introduction

During the second half of the last century the English engineer F.E. Duckham demonstrated the possibility of unloading grain from ships by means of suction, the principles were contained in several patent specifications. As Port Director of London he erected the very first pneumatic discharger "Mark Lane No. 1" in 1893. Five years later in 1898, Messrs. Luther of Braunschweig constructed the first grain discharging plant on the Continent. The pneumatic conveying system was known as "Flight Conveying" and was suitable for all pourable materials. Fig. 1 shows an older steam discharging plant in operation. The situation with regard to non-pourable, "difficult", materials is not as simple and extensive problems arise when trying to unload these from ships using pneumatic conveying systems. This article considers these problems and some means of overcoming them.

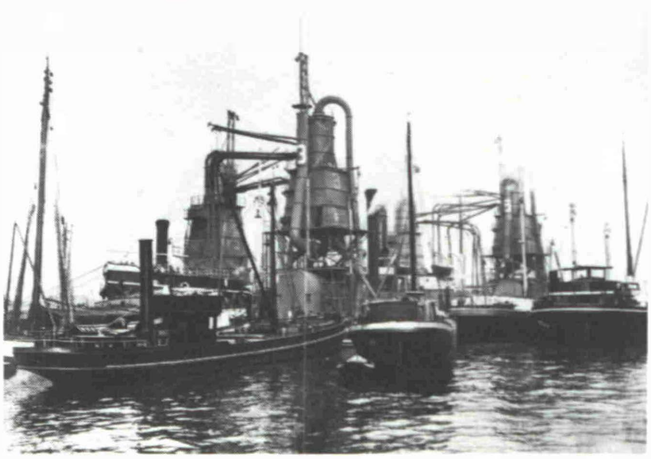

Fig. 1: Older steam discharging plant in operation

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Translation of paper delivered at the Conference of Conveying Technology TRANSMATIC 81, September 30—October 2, 1981, organised by the Department of Conveying Technology (Institut für Fördertechnik), University of Karlsruhe, Fed. Rep. of Germany.

2. Discharging of Difficult Materials

The products which can be termed difficult with regard to discharging, in both food and non-food sectors, have in recent years increased in importance. This can be shown by the statistical records of all ports. At the same time it has become necessary to develop more economical discharging systems in order to remain competitive. Part of this trend has been the ever increasing dimensions of the ships used for transport and consequently the unloading plants. Fig. 2 demonstrates this trend. In 1975 a new generation of ship unloading plant was introduced by BÜHLER-MIAG of Braunschweig.

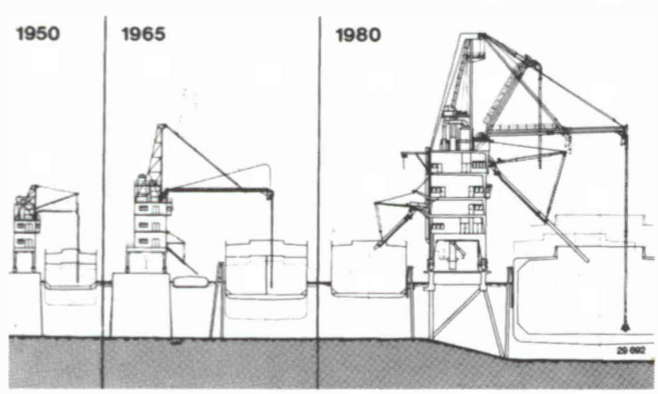

Fig. 2: Increase in dimensions of bulk solids unloading plant

The unloading of difficult materials was, up until this time, accomplished by manual labour loosening the product in the region of the suction nozzle, Fig. 3. Obviously with constantly rising labour costs and ever increasing dimensions this situation could not continue. The economical discharging of these materials depends essentially on the constant feeding of the suction nozzle and this requirement defined the development target.

Fig. 3: Previous procedure for difficult materials

3. Loosening Systems

The loosening system developed will be demonstrated by the practical example of a discharging plant for derivatives constructed in Denmark, Fig. 4. This rail-mounted plant is designed to unload 200 t/h of heavy grain under full load (maize, piled weight 0.75 t/m³). When unloading Tapioca powder, which is very poorly flowing, an hourly discharging capacity of 125 t/h under full load was achieved (without any allowance for idle time). The conventional manual loosening method (Fig. 3) would achieve a discharging rate of, at most, 40 t/h and would critically depend on the effectiveness of the trimming personnel in the ship.

The capacities quoted are peak values. The average capacities are always lower (a fact which is not always considered in practice). Apart from the technical equipment of the discharging plant and the working morale of the personnel, the type of ship and layout of the holds are of critical importance in the actual figures achieved.

The plant serving as our example operates with a low pressure of 4,500 mm WS produced by a rotary piston blower. The rotating loosening nozzle leads the poorly flowing material in loose condition to the suction nozzle where it is lifted by the conveying air-stream. After having passed through the vertical and horizontal telescopic conveying pipelines the material arrives at a combination separator which comprises recipient bottom and hopper top filter. Fig. 5 illustrates the first plant operating with this loosening system. Fig. 6 shows the latest design.

The derricking and slewing boom of the discharging plant is fixed in a universal joint and is supported by galvanized steel wire ropes from an upper rotary suspension point in the mast head. The vertical element of the boom is joined to the tele-

Fig. 4: Discharging plant for derivates in Denmark

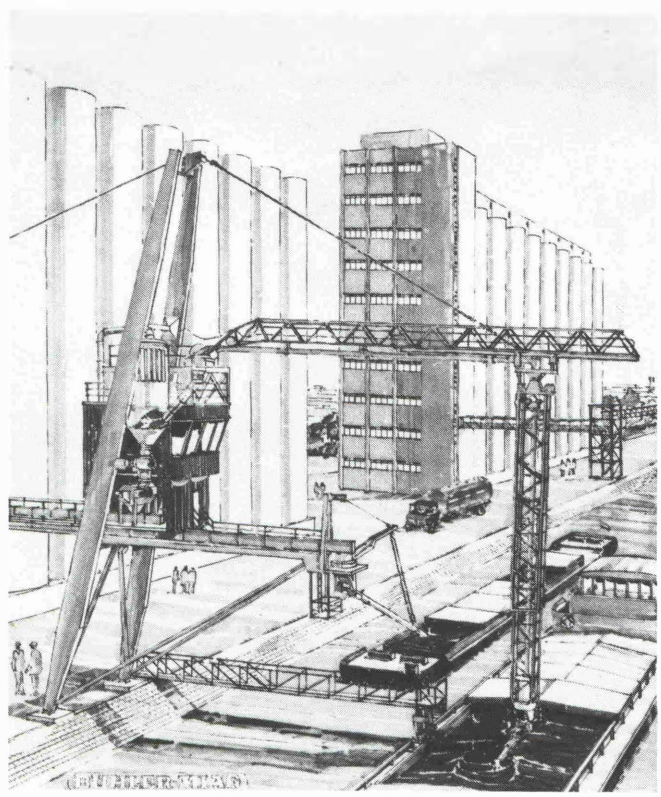

Fig. 5: Drawing of the first discharging plant with loosening system

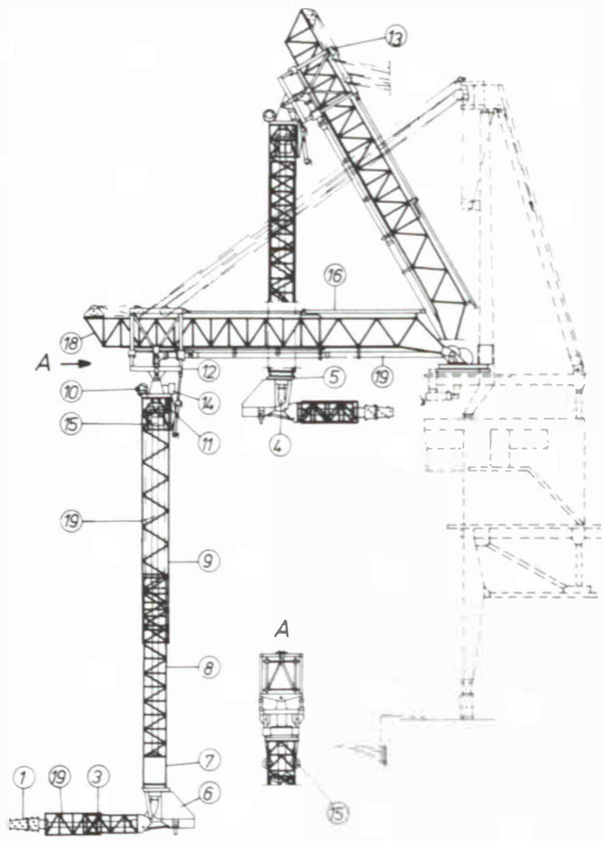

Fig. 6: Boom System (for inland and ocean-going vessels)

1 loosening nozzle
3 loosening bracket, telescopic
4 flexible tube
5 articulated body with ball bearing slewing rim
6 A-shaped arm, hydraulic
7 slip-ring
8 vertical part, telescopic
9 vertical part, fixed
10 rope winch
11 traction load cell
12 articulated ring
13 telescopic pipe carriage
14 operation and stop hydraulics
15 cable drum
16 driving cylinder
18 boom
19 conveying pipe

scopic pipe carriage by means of a two-axle articulated ring. The telescopic pipe carriage encloses the horizontal boom unlike the original prototype. The complete vertical element of the boom is moved by an hydraulic cylinder and in its resting position is securely fixed. The mobile part of the vertical boom element is suspended by ropes and is telescoped by a lifting winch. A load cell oversees rope underload and overload.

The real loosening of the material is performed at the mobile lower vertical part of the boom where the bracket of the loosening nozzle is attached and fixed in a universal ball joint. By this arrangement and by using a slip ring, an unlimited slewing of the loosening bracket as well as the rotation of the nozzle is obtained.

The hydraulically driven teeth, or flat iron pieces, are highly resistant to wear and are spirally arranged on the surface of the suction nozzle. They enter into the conveying material, break it and loosen it through lateral motion.

The design, dimensioning and the various speeds of the loosening suction nozzle, and, of course, the operator of the control panel, determine the conveying capacity for the various materials.

To allow loosening in between-decks, the supporting bracket of the loosening nozzle can be lifted up to 90° by hydraulic cylinders, as well as telescoped independently for about 2.5 m. The slewing motion is effected by the hydraulic system in the rear of the mobile vertical part of the boom.

In addition the complete vertical part of the boom can be adjusted about 5° in the horizontal plane towards the horizontal boom. In this way the working area inside the ship is enlarged. This motion is also performed hydraulically. The maximum conveying capacity is achieved when the loosening nozzle is in the vertical position, so that the loosening nozzle rotates fully in the conveying material and performs lateral motions by slewing the horizontal boom and moving the telescopic pipe carriage.

The suction level for the maximum conveying capacity is adjusted by the secondary air adjustment of the loosening nozzle. In the latest version this adjustment is automatically controlled by an hydraulic cylinder. The automatic control is of decisive importance since in the case of a change in position of the loosening bracket the secondary air is always adjustable and thus the most favourable suction pressure for the respective material is immediately available without interruption. This prevents, for example, that the air inlet device opens which can result from change in angular position of the loosening bracket increasing the suction. In all cases the operator can read the respective suction head directly from the switchboard.

The equipment for the hydraulically performed motions has been arranged in such a way that it is easily accessible and is, where possible, located directly by the hydraulic drive motor or the hydraulic cylinders.

All the operating motions of the complete boom system, as well as the drive for the discharger, are controlled from the control cabin or from a portable switchboard.

To avoid heavy and always break-threatened control cables, this control is effected by portable digital radio control.

As the illustrations demonstrate, the volume of the steel construction for plants equipped with the loosening system is considerably increased and can be estimated at approximately 25 % extra. The boom system weighs approximately three times the standard version. The additional steel construction includes, naturally, all parts from the tower construction to the travelling gear, which means that also the rail system and the quay foundation must be considered.

If compared to the standard plant an additional investment of approx. 20 %, can be considered as an approximate value resulting for a plant equipped with the loosening system. Nevertheless, this extra investment is recovered three times as quickly in respect of each transshipped ton of material due to the efficiency of the plant. This should also be considered as only an approximate value, calculation of efficiency has to take into account variable ship volumes and types as well as other cost factors which differ from port to port.

It should also be mentioned that even with the loosening system one cannot dispense with bulldozers or bobcats for the final stages of emptying the ship. The design on a ship unloading plant should therefore include provision for a lifting device, crane boom or auxiliary winch.

4. Loosening Nozzles

Before finishing, some comments will be given on the Bühler-Miag nozzle feeder, Fig. 7.

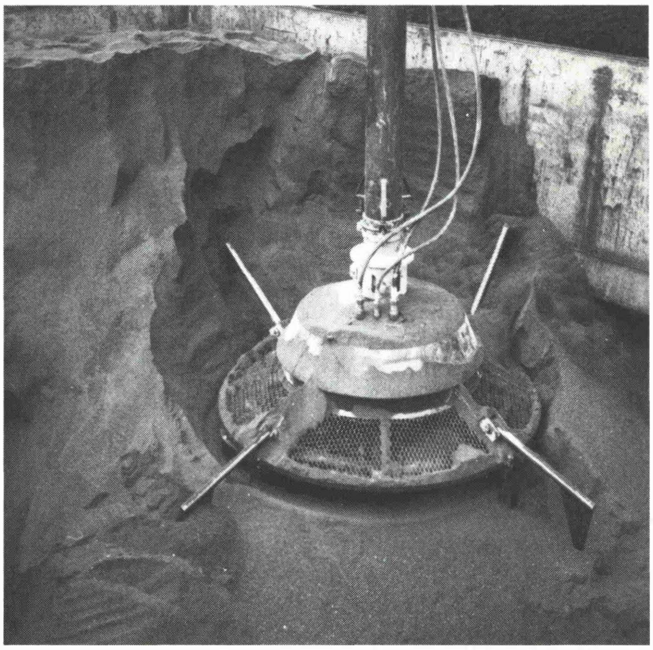

Fig. 7: Bühler-Miag nozzle feeder

This has been developed as additional equipment for plants with conventional ship unloading systems. If the statical calculation of the existing steel construction allows it, the nozzle feeder can be added to every existing plant without great effort. The nozzle feeder is particularly suited for plants which transship sluggish material only occasionally.

This appliance can be mounted immediately, using quick-fitting pipe unions, because it is fitted directly to the respective suction conveying pipe line. Due to the feeding capacity of such a nozzle feeder the discharging capacity of poorly flowing material can be increased to about a third of the nominal capacity for freely flowing materials.

Together with the telescopic vertical conveying pipeline the nozzle feeder is lowered onto the bulk material which cannot flow to the suction nozzle. Anti-torsion blades are located on the stationary upper part whose dead weight anchor them in the bulk material and absorb the feeder torque. The three spirals (Fig. 8) situated on the rotating lower part loosen up the bulk material and feed the suction nozzle located in the center. In this way the nozzle feeder operates in a vertical direction into the bulk material (Fig. 9). The necessary advance is performed by guiding the vertical telescopic pipeline.

The rotating lower part is hydraulically driven and owing to the features of this drive system the speed is continuously adjustable and efficiently protected against overload by possible foreign bodies in the material.

Due to its weight the complete hydraulic drive system is situated in the plant construction. To obtain sufficient freedom of motion inside the ship, the conveying pipeline should be telescopic in the horizontal as well as vertical positions.

If addition to an existing plant is considered it is absolutely necessary to check the steel construction in respect of the additional load. Designed with hydraulic system and low speed the nozzle feeder is non-polluting.

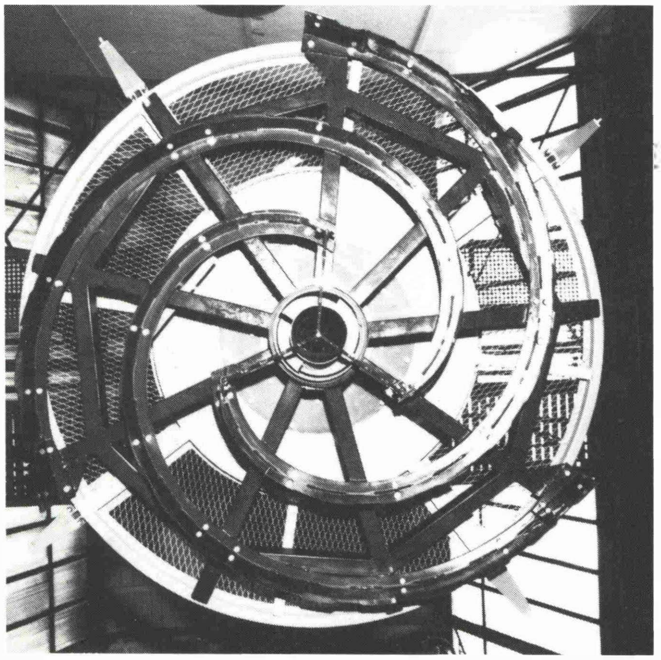

Fig. 8: Feeder spirals

Fig. 9: Nozzle feeder in bulk material

5. Future Development in Ship Unloading

Concerning non-pollution it should be finally mentioned that since the beginning of 1980 pollution controls have been greatly increased by the authorities, in particular for pneumatic ship unloading plants. There is not always conformity of ideas between the engineers and the authorities. The manufacturer faces great problems as there is no uniformity in the legal provisions. This situation causes the loss of free competition.

Considering the primary discussions of energy, recent development also tends greatly towards mechanical ship unloading plants. Mechanical ship unloaders, however, require special provision for the removal of the last parts of the cargo which are not accessible to the equipment, unlike pneumatic ship unloaders.