A New Bulk Cement Storage and Transfer Complex

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Eine neue Silo- und Umschlagsanlage für Zement
Un nouveau complexe de stockage et de transfert de ciment en vrac
Un nuevo complejo para el almacenamiento y transbordo de cemento
粉体セメントの新型貯蔵・移動コンプレックス
一种新型的散装水泥储存和转运联合装置
مجمع جديد لتخزين ونقل الأسمنت السائب

1. Introduction

In business, just as much as in our own personal life, habits start as matters of expediency and continue long after their viability and practicability has been exhausted.

It is not always easy to change commercial habits, as other factors have to be taken into consideration and invariably the process in being cannot be interrupted let alone stopped, at the time major reorganisation plans demand.

This case study concerns an operation which had developed over a number of years and satisfied local requirements with reasonable speed and comparative low costs.

Cement manufactured was distributed both locally and to other depots some distance away. The depot under review was some hours train journey from the cement works.

At the depot, the cement arrived by the train load in pressure discharged railway wagons. Transfer of material was by the simple expedient of coupling rail wagon discharge to road container discharge by a flexible 4 in. diameter hose, known in the trade as *back loading*. The conveying air used was from a site compressor.

In some respects it was advantageous that the rail wagon had a 20t payload, as did the road vehicle, as a 200 yard journey was required to check weigh before going onto the highway and any excessive payload necessitated return to site, recoupling and discharge (judged by operator dexterity) to another container.

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Local area developments created demands for greater supplies of cement which consequently severely tested the system.

2. System Design Requirements

Kockums Industries Limited of Maidenhead, England, were called in to discuss a storage silo complex to facilitate and speed up the operation. At the same time other modifications were under consideration, such as new track laying, a system for monitoring and subsequently computerising wagon loadings and traffic programming, but such matters are outside the brief of this study.

A turnkey installation was required with emphasis placed on simplicity of operation both with the unloading and outloading of materials. It was decided that one elevated silo suitable for a cement capacity of 1.500t should be built and the work to be carried out in the minimum time, without interfering with current operations.

The silo had to be capable of accepting a train payload of 480t from either 24—20t payload single axle wagons or 12—40t payload bogie wagons, dispersed on two adjacent tracks. No further movement or shunting of wagons could be permitted until departure. The wagons, apart from size, would be of different configuration.

This problem was solved by having an offloading station of steel structures mounted between the two sets of tracks and extending either side of the silo centre line. Each side structure carrying two 5 in. (125 mm) diameter steel pipe runs, i.e. a total of four, terminating at one end into the upper part of the silo and at the other at six coupling terminals (12 in total).

At each terminal, each 5 in. diameter pipe terminates with a flexible hose and coupling to associate with those on the rail wagons and a 3 in. diameter pipe with flexible hose and connector conveys the compressed air for pressurising the rail wagon.

The connections to the wagons are made by the train side operator who also ensures that the appropriate local valves are correctly manipulated. The operator can make twelve individual material connections and twelve conveying air connections so that with the bogie wagons, no reconnections have to be made to discharge the complete train payload but with the single axle wagons, twelve reconnections must be made. However, as a total of four wagons — one per pipeline — can be discharged at any one time no discharging time is lost by recoupling.

The site being by the riverside, coupled with the heavy traffic expected, required special foundations including piling. In turn, this decided where the main caps should be positioned, the shape of the buildings, the position of the weighbridge pit, its size, depth, location of the various plinths and cable entries. Additionally new site roadways were required to provide a continuous traffic flow and not the least of the Authorities' problems was to agree to an entrance and exit which did not seriously effect the already congested area.

The weighbridge frame, loadcells and platform had to be the first installation and to safeguard the mechanism, chocks were strategically placed, gaps filled with temporary beading and protective covering over the platform to the greatest extent such working condition would allow.

The silo was designed for site welding and assembly from preformed sections and plates. Such a necessity did not ease site congestion but the transportation problems which would have resulted from other decisions, if indeed they would have been possible, left no choice (Fig. 1).

Fig. 1: View of the 1500t storage and transfer complex with the control room in the foreground

Erection started with works prepared stanchions being presented to the prepared foundations and some lateral bracings fitted into position. The cone having been fabricated at site in an inverted position and complete with supporting ring and first strake necessitated two mobile cranes, each of 100t capacity to turn it and place it onto the supporting structure 14m above ground level.

The cone, ring and first strake assembly measured 11.3 m dia x 11 m deep, weighed 32,000 kg.

Other barrel strakes complete with apex roof, weighing 24.500kg, were 11m dia and totalled 10m deep were partially welded together, hoisted into position and welded in situ to form the shell of the silo. Two mobile cranes of 100t and 60t capacity were used for this operation.

The erection was originally scheduled for spring and early summer (1978) but the problems which seem to beset everyone these days including strikes, delayed deliveries, apart from enforced stoppages occasioned by unforeseen natural conditions, reconsiderations and no accountable reasons whatsoever had their effect to provoke delays into one of the windiest and wettest winters for some time. In such condition the manoeuvring of the barrel sections was not easy and regrettably, enforced more delay.

Eventually everything was properly welded together and the mounting of ancillaries could then commence. Two filter units each 1.1 x 1.6 x 1.5 m weighing 400kg were mounted on the top of the silo (Fig. 1), an internal cable 18m long anchored to the base cone and roof of silo was complete. External walkway, ladders and safety rails fitted. Level probes, fluidising pads, vent air system and telescopic discharge chute were all mounted and the complete structure painted with three coats of Metalife paint.

A brick built two-floor building was designed to house the machinery and from the upper floor provide a panoramic view of all loading operations (Fig. 1). To ensure that building foundation did not interfere with silo foundations, resulted in a structure with a cantilevered upper floor. This formed a very spacious control room and most of the north wall of the control room was glazed with an insert glazed door to give access to the silo cone preset fluidising valves, chute mechanism and if necessary to the top of the road vehicles. Normal access is by external stairway.

The control room operator who has over-seeing and overriding control of all loading and off-loading operations, sits at a desk on which are mounted the weighbridge controls with digital display and print-out machine. Adjacent on his left-hand side, is the silo control panel with synoptic display illustrating all valve movement, loading chute movements, high, medium and low content level in the silo as well as a continuous level indicator marked in tons of content. All motions are on a cyclic sequence programme but by manipulation of a switch the operator can make individual motions at will. An audible alarm warns the operator not to accept further loads after the current operation, as the silo is nearing full to capacity.

2.1 Compressor House

Below the control room is the compressor house, which has a personnel door adjacent to the external stairway and a double access door in the opposite wall for machinery entry. Parts of the other two walls are fitted with louvred air ducts to provide adequate ventilation and also to ensure emanating machinery noises are at the lowest possible level.

Adjacent to the louvred ducts are mounted fan cooled water circulating air coolers to maintain an ambient temperature compatible with machinery requirements.

All incoming electrics, switch gear and main starters, controllers and ducted wiring are neatly and conveniently mounted on side walls to give maximum freedom of movement and easy access to machinery for inspection and maintenance purposes.

The power house also has installed: Four compressors each individually driven by a 100HP electric motor and separately controlled by a starter, to provide the conveying air for discharge of railwagons to silo. Such an arrangement permits one to four discharge lines to be in commission at any one time depending upon the demand of the prevailing circumstances.

One low-pressure compressor driven by a 30HP electric motor provides the fluidising air to silo cone air pad to give assisted gravity discharge from silo to road vehicle.

One high-pressure compressor with air receiver, which automatically functions to maintain an adequate reservoir of compressor air needed for control valves actuation and filter cleaning.

The installed rating for the complete plant is 335 kW and a 380 volt 3-phase 50Hz supply from a recently built substation.

2.2 The Weighbridge

The weighbridge with a capacity of 50t and an 18m platform was chosen to cater for a possible increase in road vehicle length and G.V.W., but has the advantage that road vehicle can enter from either end and be filled without further manoeuvring, split weighing or necessity to unhook the tractor.

The platform is balanced on four loadcells all mounted in a well with adequate draining facilities and manholes at both longitudinal ends for entry and inspection. Sheathed cables transmit imposed load from loadcells to comparator and display. Weighing is to fairly accurate limits and facilities are available to adjust these limits to suit the prevailing conditions.

The trades for which deliveries are made are such that the maximum payload cannot always be accepted and it is therefore necessary to have a recorded tare weight of the unit before being loaded. This is achieved by the vehicle being driven on to the bridge, the tare weight registered on the display is also stored in memory. The permissible G.V.W. of the vehicle (or any other gross weight decided upon) is selected and the difference dialled by thumbswitch and illustrated on the display. The pressing of appropriate buttons commences the vehicle filling operation which is automatically stopped on the required load being achieved. Inflight material is accounted for and the end result is a fairly accurate predetermined payload.

The vehicle loading operation's motions are actuated from the control panel but the efficiency of the operation is due to the fluidising and outloading system mounted on the base of the silo cone.

The silo fluidising pad is supplied with air provided exclusively for this purpose. Preset valves determine that dispensation of air is correctly apportioned to ensure fast even flow of material once the materials control valve has been actuated.

The telescopic loading chute with internal collapsible metal trunking and an external gaiter, both mounted to a metal spout designed to associate with the container filling cover, can be raised and lowered by press to run operation performed at the control desk, from which the functions are clearly visible. Overriding limit switch ensures that the requisite travel is according to the height of each individual vehicle.

The space between the materials trunking and gaiter acts as a venturi and is coupled to the filter system. This creates a slight negative pressure within the venturi so that all displaced air is expelled cleanly through the filter system and thereby gives a dust free filling operation.

Automatic cut off at the prescribed payload, and an inbuilt time delay before withdrawal of chute, ensures that all inflight material is discharged before completion of operation.

3. Operation

3.1 Start-Up

The instrument air compressor is started in the power house and runs automatically as the demand dictates through the day.

3.2 Train Off-Loading

The filter extraction fans are started; the conveying air compressors are individually started, one for each line to be employed; content search programme and instrument test surveillance checks are made. All these functions are performed by the operator at the control desk. As the train arrives on station the train side operator makes all 5 in. connections (if all are being used) between railway wagons and offloading station flexible hose and the air connections. He manipulates the appropriate valves on the wagons and switches appropriate diverter valves to OPEN position. This action also alerts the control room operators as lights appear on the synoptic display and all is ready for the offloading to start. The control room operator then actuates the remote controlled valves and discharge commences. The train side operator continuously checks the manometer on the wagons as a falling pressure indicates an almost empty container and zero pressure that the container is completely empty.

Scheduled input does not always associate with output requirements and for this reason an audible alarm is associated with the top level probe to give additional warning beyond the synoptic display, indicating that the silo is almost full and no more than the committed four wagons should be discharged. The audible alarm can be switched off and reset by the operator.

3.3 Vehicle Loading

The driver with filling hatch open, positions his vehicle on the weighbridge directly below the loading chute. All further outloading manipulations are under the control and are overseen by the control panel operator; in the following sequence:

From the digital display the desk operator can read the tare weight of the vehicle; this is also stored in the comparator's memory. The required payload is selected by thumb-wheel switch and displayed.

The loading chute is lowered to enter the vehicle's filling hatch. The comparator and material discharge valve are activated and the outloading operation starts and automatically ends on the selected payload being achieved. A multi-fold weighbridge ticket recording TARE, PAYLOAD, TIME, DATE, TICKET NO., CODE NO., is printed and presented. One copy is for the driver and others for suppliers' and customers' record purposes.

The loading chute is disconnected and raised. The vehicle's filling hatch is closed and the outloading operation is complete and vehicle ready to drive away. Immediately another empty vehicle can be positioned and a further outloading cycle commences, upon the insertion of a new weighbridge ticket. Accuracy is within very fine preset limits.

3.4 Through-put

Inloading from railway wagons is at a rate of 240 t/h. One complete 480 t payload train can be discharged in 2 hours.

Outloading to road vehicles — output is at the rate of at least 300 t per hour so a Kockums Interconsult STF1-27CS semitrailer unit having a payload of 21 t can be filled realistically including raising and lowering discharge chute, in about 4 minutes. A complete turn round of vehicle is about 5—7 minutes and one road vehicle can follow another in the time required for the operator to change weighbridge tickets.

Both the inloading and outloading operations can be performed simultaneously and the complete installation can be operated 24 hours a day if necessary, with a minimum of personnel.