TECHNICAL PAPER

F.C.C. Additives Injection Systems

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SUMMARY

The injection of F.C.C. additives to regenerators in the petrochemical industry requires special considerations. The paper describes these considerations and the methods by which they can be addressed.

F.C.C. Additives Injection Systems

Abstract

In the competitive refining environment, many companies require that F.C.C. additives are accurately and economically delivered to the F.C.C. regenerator. Since regenerators operate at elevated pressures, the delivery must be made by a pneumatic conveying system. This paper will describe the dense-phase method of injection and its advantages. There are several variants of the system, and each type will be discussed.

1. Introduction

Fluid Catalytic cracker (F.C.C.) additives are injected into the F.C.C. regenerator mainly for sulfur control during the cat-cracking process. In the competitive refining industry, the accurate delivery of additives without material degradation is becoming increasingly important. Almost all regenerators operate at elevated pressures, and with OSHA and EPA regulations requiring dust free operations, the only effective method of delivery is that of pneumatic conveying system. Moreover, since material degradation must be minimized, the form of conveying must be dense phase.

This paper will summarize the user's requirements and which pneumatic conveying regime is most suitable to address these requirements. There are several variants of the basic injection system, and these will also be discussed.

2. Customer Requirements

Each user will have different requirements. There will be variations in batch size and frequency of injection, conveying distance, regenerator operating pressure, and also material reception and handling requirements. The pneumatic injection system must be capable of addressing all of these requirements while at the same time being user-friendly, durable and reliable. F.C.C. additives are usually very similar in most applications; however, the system designer must be aware of all of the additive's material characteristics and how this could affect the system design.

The process and system requirements can be summarized as follows.

2.1 Batch Size, Frequency and Accuracy

Each user will have different batch requirements. The overall size of the batch may vary between 10 and 120 lbs, and the batch weight will need to be as accurate as possible. In order to ensure this, the batch will be weighed using a load cell system attached to the pneumatic transporter.

Depending on the actual batch size, accuracy will be within plus or minus 0.5 to 1.0%. The frequency of batch delivery will also be variable according to the needs of the process. Not only will each process requirement be different, but the user will want to maintain a great deal of flexibility over the batch size and frequency to aid in optimization of their process. Therefore, the batch size and injection frequency must be made easily adjustable.

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2.2 Injection Distance

One of the great advantages of a pneumatic conveying system is the flexibility over the conveying distance and routing. Every application will be different, depending upon the specific plant layout, location of the additive storage point, regenerator arrangement, etc. The conveying distance can be as short as 30 ft., and as long as 200 ft. It is possible, in fact, to be able to convey as far as 500 ft. without problem. However, it is always advisable to obtain the shortest, most direct pipe route with as few bends as possible. This will reduce air consumption, and hence optimize the energy usage as well as minimize the degeneration of the additive.

2.3 Regenerator Pressure

The operating pressure of every generator will be different, depending upon the process. The operating pressure may vary between 10 and 40 psig. It is important that the designer accurately determines the maximum operating pressure as well as the normal operating pressure.

The conveying gas consumption is directly affected by the operating pressure, and if this is estimated using the normal operating pressure, there could be flow problems in the conveying line when an upset condition occurs and maximum pressure is experienced.

2.4 Operating Conditions

As with all modern, efficient operations, the refining industry will usually demand:

2.4.1 Dust-free Operation of any System

Since the additives injection system will be operating at relatively high pressures, a good reliable transport filling valve must be used. The discharge valve must also be reliable and have dust-free operation.

2.4.2 User-friendly Operation

The system must be easy to operate, and as much as the operation as possible should be automatic in nature. A man-machine interface which allows the operator to quickly and easily adjust the batch size and frequency of batch injection should be provided.

2.4.3 Reliable Operation/Low Maintenance

Maintenance costs should be reduced to the minimum level possible. A simple design requiring few spare parts is desirable, plus the frequency of part replacement should be as infrequent as possible.

2.4.4 Hazardous Area Operation

Many additive systems are located in classified areas. Therefore, depending upon the plant's local regulations, some degree of explosion-proofing may be required for the controls and the weigh system.

3. Material Characteristics

As with all pneumatic conveying system design, consideration of the characteristics of the material to be handled must be made. F.C.C. additives can vary in nature, depending upon the particular manufacturer of the product.

However, the following specification is fairly typical of F.C.C. additives.

- *Bulk Density*: 52 lbs/ft^3 (≈ 800 kg/m^3). This is the aerated bulk density which is always used when designing pneumatic conveying systems.
- *Particle Size*: 75 microns
- *Particle Shape*: Spherical
- *Moisture Content*: Zero by weight (surface moisture only)
- *Temperature*: Ambient
- *Condition*: The particle distribution and particle shape indicate this material to be a good candidate for dense-phase conveying.

To obtain specific conveying data, i.e., gas consumption, conveying rates, levels of degradation, etc., a test program is always advisable if the designer does not possess this information.

4. Pneumatic Conveying Regimes

The pneumatic conveying system designer can choose from several different "regimes" or flow patterns in order to meet the requirements of the system.

There are many regimes; some are considered stable, others are unstable. Obviously from practical considerations, we are only interested in stable flow patterns. JODLOWSKI [1] identified four stable flow patterns. These are described in Fig. 1 and as follows.

4.1 Dilute Phase

Material is fully suspended in the gas stream, and a homogeneous gas/material mixture is observed. Velocities are typically very high, line loadings are low, and low pressure/high volume gas supplies are used.

4.2 Continuous Dense Phase

The material is conveyed in a continuous, unbroken, moving bed. Velocities are lower than for dilute phase, and line loadings higher. Medium pressure/volume gas supplies are typically used.

4.3 Discontinuous Dense Phase

The material is conveyed as a plug or series of plugs in a discontinuous fashion. Velocities are lower than continuous dense phase, and line loadings can also be higher. High pressure/low volume gas supplies are used. . .

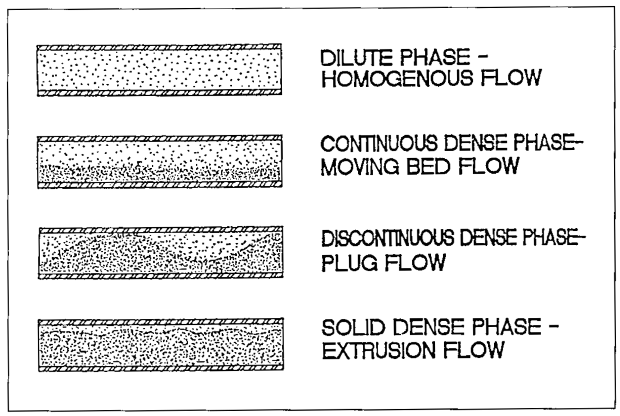
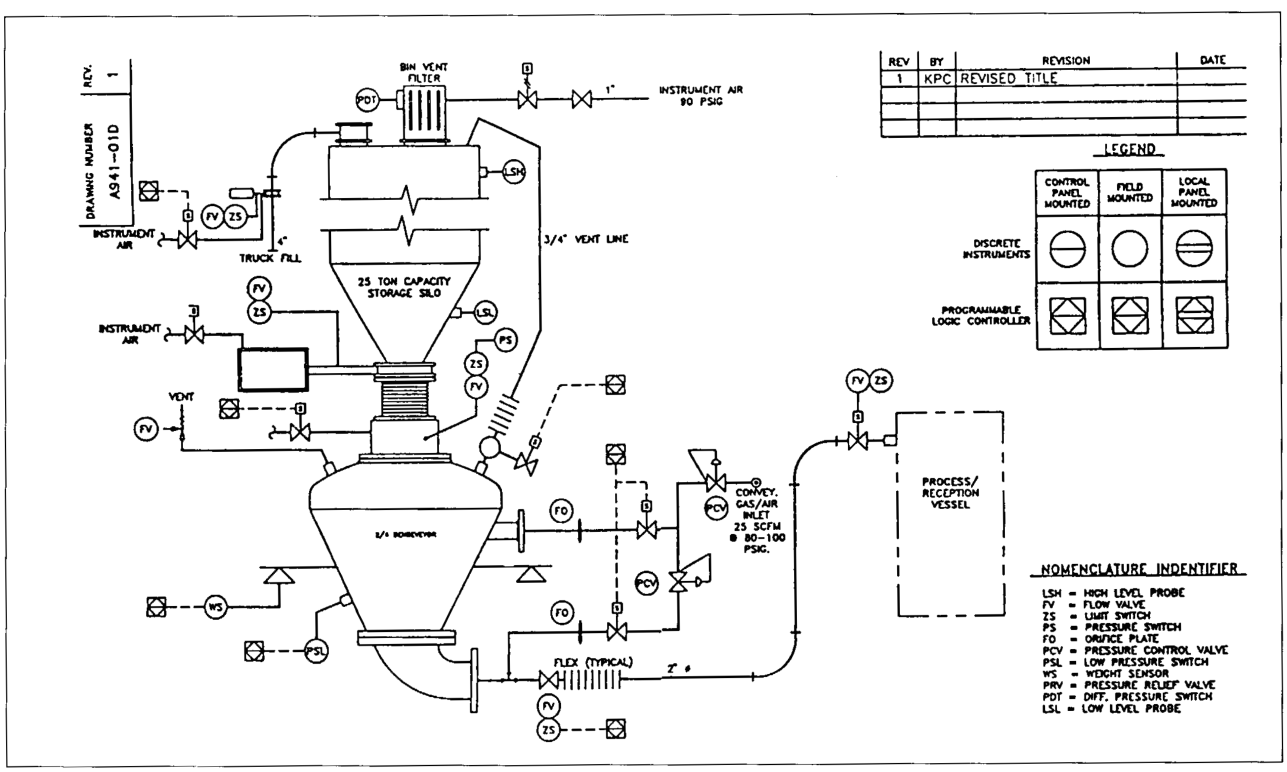


Fig. 1: Jodlowski's stable flow classification

Fig. 2: Plant layout



4.4 Solid Dense Phase

The material completely fills the pipeline, and material is conveyed in an extrusion form of flow. Velocities are very low; however, this regime is only suitable for certain types of materials.

5. System Design

5.1 Layout

Based upon the customer's design objectives, examination of the materials's characteristics, and testing using representative samples and production-sized equipment, it was concluded that a discontinuous dense-phase regime would be the most suitable method of conveying. The regime would produce low velocities to protect the integrity of the particles; however, the velocity would be high enough to ensure that all of the batch is conveyed to the regenerator after weighing has been completed.

A Denseveyor dense-phase transporter was selected to provide the means of weighing, pressurizing and conveying the additives. The system is depicted in Fig. 2 (prev. page). In this case, the Denseveyor is being supplied by a 25-ton storage silo which is itself filled from pneumatic tanker trucks via a 4" truck fill line. Conveying air is vented via a reverse jet filter unit, and overfilling is prevented by a high level sensor.

The Denseveyor is located directly below the silo and is mounted on load cells. The weight signals are fed into a scale instrument which, in conjunction with the Denseveyor PLC, controls the entire system. A batching valve and flexible connection are provided on the inlet of the Denseveyor filling valve, and a discharge valve and flexible connection is provided on the outlet of the Denseveyor.

A shut-off valve is (usually) provided by the customer at the regenerator to isolate the system from the pressurized regenerator when the system is filling or is at rest.

5.2 Typical Operation

The plant operator can, via the control panel, select the size of the batch required and set the time interval between batches. This facility provides complete flexibility of injection to the regenerator. Once these settings have been made, the system operates automatically until stopped or a new set of settings are made.

The inlet valve into the Denseveyor (called a Dome Valve) has a pneumatic seal (see. Fig. 3). This provides for a long wear life with very little maintenance.

Initially the Dome Valve opens, followed by the batch valve. Material gravity flows into the vessel. During this time both the discharge valve and the regenerator isolation valve are closed. Displaced air from the vessel is exhausted via a vent valve and vent line to the top of the silo. When the material weight has reached 90% of the set batch weight, the batch valve will close to a dribble feed position. When the set point is reached, the batch valve will fully close; and shortly after, the Dome Valve will close and pressure seal. The vent valve will also close at this time.

The vessel discharge valve opens, and the gas supply to the vessel also opens allowing the vessel and pipeline to pressurize. When the pressure in the line equals the pressure in the regenerator the regenerator shut-off valve opens, and the material begins to move through the pipeline. The pressure continues to rise, and all of the batch is conveyed into the regenerator.

When the material exits the pipeline into the regenerator, the pressure falls, and this is monitored by a pressure switch. The system gas supply valve is maintained open for a few seconds to ensure all of the batch has been conveyed. The gas valve closes, the vent valve opens, and any residual pressure in the system and pipeline is exhausted via the vent line. The vessel discharge valve now closes, and the system is ready for the next batch.

5.3 Alternative Arrangements

For applications where smaller batches and the overall quantity of additives is smaller, two alternate arrangements can be used. Since lower quantities of additives are required, a storage silo may not be required. The additives can be received either in tote bins or paper sacks.

For tote bins a smaller feed bin to the Denseveyor is used, and a vacuum loading system is provided (Fig. 4). A lance connected by flexible hose is inserted into the tote bin. The additives are transferred by vacuum into the feed bin. The vacuum

Fig. 3: Bulkhead *Dome Valve*

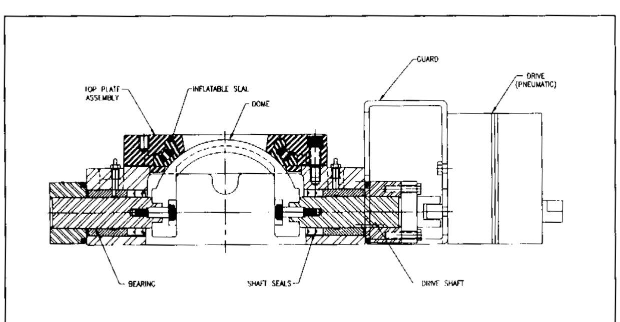
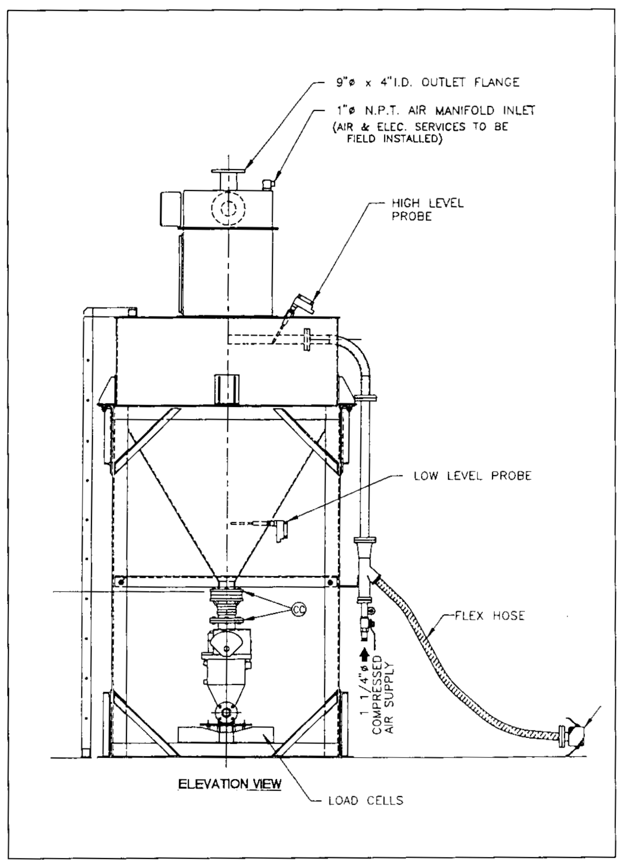


Fig. 4: Installation for F.C.C. supply via tote bins, utilizing a vacuum system to fill the surge hopper



can be produced either by a vacuum blower; or, if a compressed air supply is available, an eductor can be used to produce the vacuum.

Paper sacks can be emptied through a bag dump into a small surge bin above the Denseveyor (Fig. 5). The bag dump is equipped with a fan-assisted filter. This produces a negative pressure in the bag dump which helps to reduce any dusting which may occur during the bag emptying operation.

6. Conclusions

It is possible to provide a system which can pneumatically inject F.C.C. additives into the F.C.C. regenerator with low degradation to the additives during conveying.

Batches of additives can be injected at accuracies of 0.5 to 1.0%. The batch size can be variable, and the frequency of batch adjustable.

Local plant conditions, such as conveying distance, regenerator pressure, area classification, etc., can easily be accommodated.

Various additive receipt and storage arrangements can be provided.

References

[1] JODLOWSKI: Considerations on Two-Phase Gas/Solids Flow at Low Velocity; Proc. Pneumatech Conf., Canterbury, U.K., (1984).

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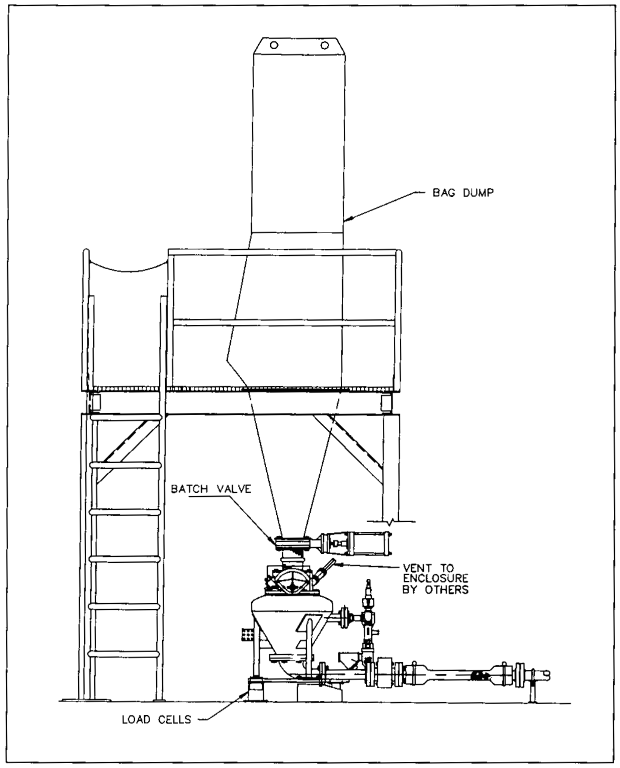

Fig. 5: F.C.C.-supply through paper sacks