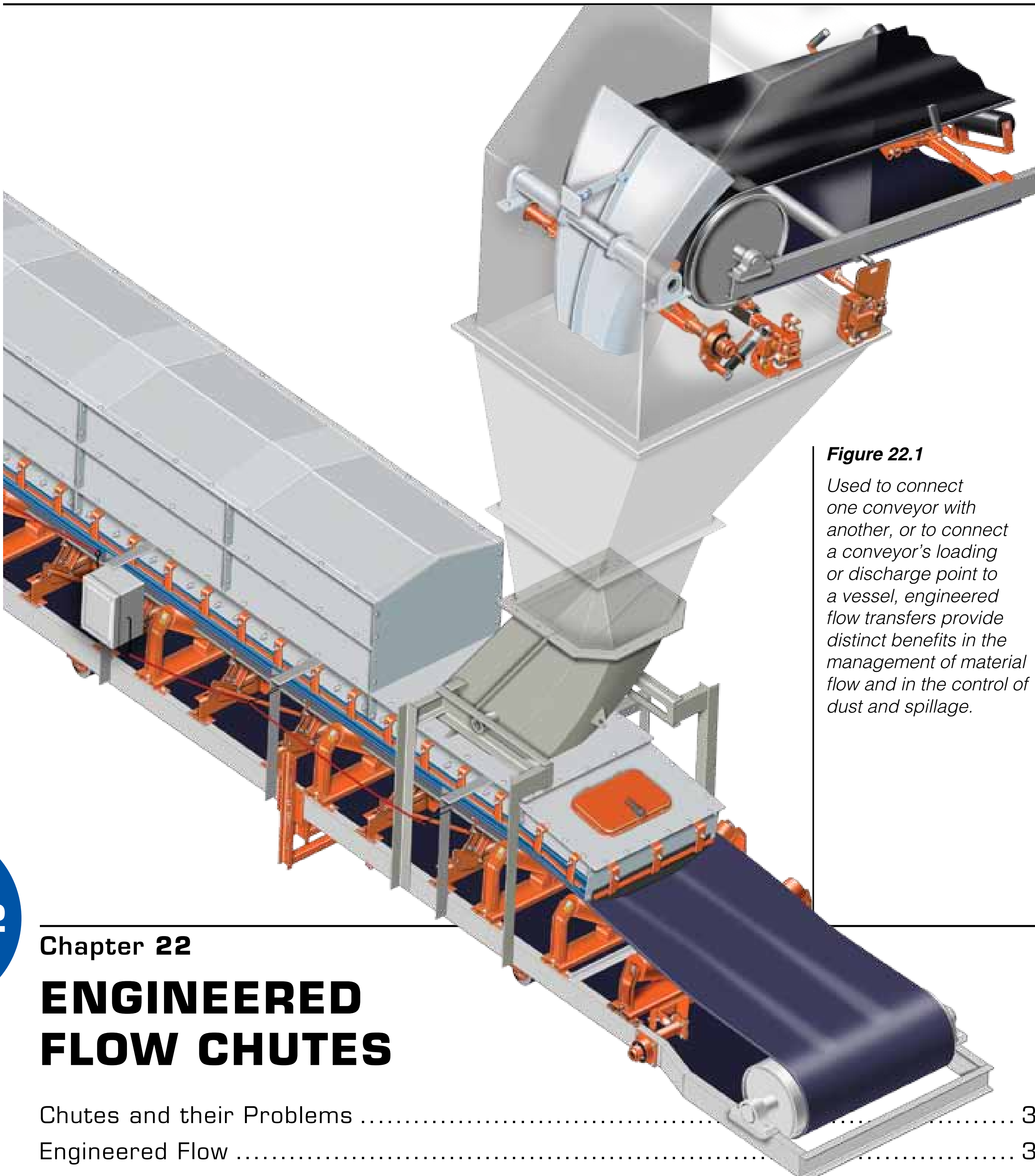

Figure 22.1

Used to connect one conveyor with another, or to connect a conveyor's loading or discharge point to a vessel, engineered flow transfers provide distinct benefits in the management of material flow and in the control of dust and spillage.

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Chapter **22**

ENGINEERED FLOW CHUTES

In this Chapter...

In this chapter, we discuss the benefits of engineered flow chutes and the ways they resolve problems common with transfer chutes. The components of engineered chutes—the hood, spoon, and settling zone—are defined. We also describe the process used to design them, along with information required by designers to do so.

One leading-edge development that improves the conveying of bulk materials is the advent of engineered flow chutes (**Figure 22.1**). Used to connect one conveyor with another, or to connect a conveyor's loading or discharge point to a storage vessel or other process step, engineered flow transfers provide distinct benefits in the management of material flow and in the control of dust and spillage.

Custom designed for each individual application, engineered flow chutes control the material stream from the discharge conveyor to the receiving conveyor. *(See Chapter 8: Conventional Transfer Chutes.)* A well-designed engineered flow chute maintains a consolidated material profile that minimizes dust generation and wear, by accomplishing all of the functions of a transfer chute:

A. Feeding the receiving conveyor in the direction of travel

B. Centering the material load

C. Minimizing impact on the receiving belt

D. Supplying the material at the speed of the receiving conveyor

E. Returning belt scrapings to the main material flow

F. Minimizing the generation and release of dust

Although the initial investment in an engineered flow chute may be greater than the cost of a traditional transfer chute, the return on investment to the plant will be prompt, through reduced operating and maintenance expenses. Problems such as belt damage, premature wear of belts and chutes, chute plugs, spillage, dust, spontaneous combustion, and material degradation are greatly reduced, if not eliminated, with the controlled material stream that travels through an engineered flow transfer chute.

CHUTES AND THEIR PROBLEMS

The engineering of bulk-materials handling systems has previously been largely based on experience, "rules of thumb," and educated guesses. But now sophisticated computers and software packages provide the design and modeling technologies that allow better understanding and management of material flow. These software and hardware systems allow the designer to work through a range of iterations that determine how a system will work with a specific material—in a range of conditions from best to worst case. A computer provides the kind of calculation power required for developing the models and generating the iterations—making small, step-by-step design adjustments that allow for the comparison of alternative solutions to improve bulk-materials handling.

Traditionally, there has been little thought given to the flow of materials through the chute beyond making sure the chute was big enough to accommodate the material stream and minimizing wear. It was a common practice for chutes to be generous in size to reduce plugging and control dust, but this actually represented a shortcoming in design methodology. Chutes were kept box like to avoid running up the expense for fabrication. Because these chute angles were designed based on the angles of repose, they were prone to buildups and blockages. With changes in flow direction from conveyor to conveyor and from the downward energy of the material movement, the chutes would suffer wear in their metal walls and on the surface of the receiving belt or vessel.

Traditionally-designed chutes generate dust by throwing a stream of uncontrolled material off the end of the conveyor and allowing it to spread. The movement of material displaces air as the body of material is diffused. The air passes through the material stream, thus dispersing and entraining the small particles of dust. The traditional chute essentially can create a "chimney effect" by adding the dust to the displaced and moving air.

In addition, the receiving areas were typically small and unsupported, and they released dust. When the stream of material "crash lands" on the receiving conveyor, the profile of the material is compressed, and the induced air is driven off. This air takes with it the smaller particles of material as airborne dust. A loosely-confined stream will carry larger amounts of induced air, so more dust is driven off. If the material has been allowed to move through the chute in a turbulent stream—with what might be called "billiard flow," where the lumps bounce off each other and the chutewalls—the material lumps will degrade, creating more dust that can be carried out of the enclosure.

ENGINEERED FLOW

What is Engineered Flow?

Chutes with "engineered flow" are based on the application of the principles of fluid mechanics and an understanding of particulate movement. Engineered material flow is based on controlling the material's movement as it exits a discharging conveyor or a silo, bin, or hopper. The direction and speed of flow can be steered through subtle changes by guiding it down surfaces with known friction values. The gradual course modifications will minimize dust generation and center load the belt. This allows the energy lost through friction to be calculable and accountable.

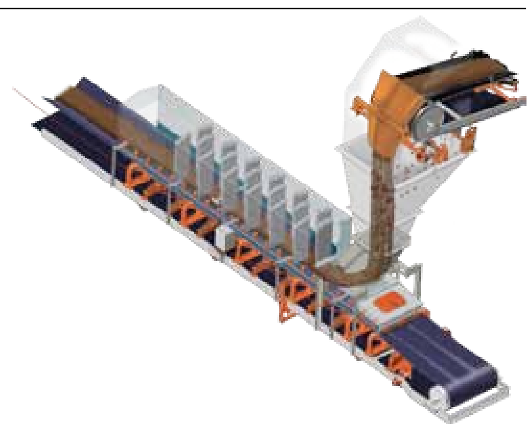

Figure 22.2

In an engineered flow transfer, the material is kept as a tight, coherent stream, minimizing the amount of induced air. Therefore, there is less air released and less airborne dust created.

What is an Engineered Flow Chute?

Developed from sophisticated material tests and computer flow simulations, engineered flow chutes are designed to satisfy a plant's operating requirements, so the material stays in continuous motion though the transfer chute, with the material moving as a tight, coherent stream.

This will minimize the amount of induced air carried along with the stream of material. As a result, there is less air released and less airborne dust created (**Figure 22.2**). In addition, the stream is directed or channeled, so the material is placed gently onto the receiving belt, minimizing impact and belt abrasion.

The material moves smoothly—like water through a faucet. The material slides in unison in a "fluid-like flow," rather than allowing the lumps to bounce off each other in the traditional "billiard-flow" fashion.

Benefits of Engineered Flow

There are a number of benefits to accrue from the installation of an engineered flow chute in a facility. These include:

A. Passive dust control

   They reduce dust escape while minimizing, or eliminating, the need for active collection methods.

B. Increased material flow rate

   They eliminate chutes as a production bottleneck.

C. Reduced material buildups and blockages

   They reduce or prevent chute plugging.

D. Reduced loading impact

   They extend belt-life by reducing damage and abrasion.

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E. Reduced degradation of material

They minimize creation of dust.

F. Controlled load placement

They prevent mistracking, spillage, and belt-edge damage.

It should be noted, however, that engineered flow chutes are designed to accommodate a narrow range of parameters. Changes in the performance of these chutes (and in the wear life of the linings inside them) will occur when conditions vary, including:

A. Inconsistent flow rates

Variations of more than 20 percent from the stated flow, other than at start up and shut down

B. Inconsistent material characteristics

Variations of more than 20 percent in any attribute from the material samples tested prior to system design

C. Inconsistent environmental conditions

Variations that create alterations in the material, such as precipitation that changes the moisture content by more than 10 percent from the stated characteristics

Components of Engineered Flow Transfers

An engineered flow chute incorporates geometry that captures and concentrates the material stream as it travels through the chute, which has the dual benefit of minimizing aeration and preventing accumulation of materials inside the chute. Preventing accumulation of materials within a chute is particularly important when dealing with combustible materials, such as coal.

Engineered chutes typically employ a design called "hood and spoon" transfer. This design is composed of a "hood" discharge chute, at the top of the system, and a "spoon" receiving chute, which places the material onto the belt being loaded. The hood and spoon are typically installed as a pair, although a particular material-handling situation might require only one or the other. These components are custom-designed using the characteristics of the conveyed material and of the materials used for chute construction. The goal of hood and spoon is to confine the moving material stream, reducing the entrainment of air and minimizing the impact forces, while placing the material in the proper direction on the receiving belt with minimal impact—or "splash"—to reduce spillage, abrasion, dust, and damage. This controlled loading also prevents side loading of material, which causes belt mistracking.

In addition, many engineered flow chutes incorporate an additional area for dust confinement—called a settling zone or stilling zone. Here the air current above the material stream is slowed so that the residual dust can settle back onto the conveyor.

Hood

Installed at the discharge, a hood captures and confines the moving material stream at a low impact angle (**Figure 22.3**). This minimizes impact force, build-up, and wear. The hood redirects the material stream vertically, so it flows smoothly toward the conveyor system below (**Figure 22.4**). Once flow is vertical, then the direction of the material stream is gently modified to align the flow with the receiving conveyor.

Spoon

A spoon is installed at the bottom of the transfer chute, where it receives the mate-

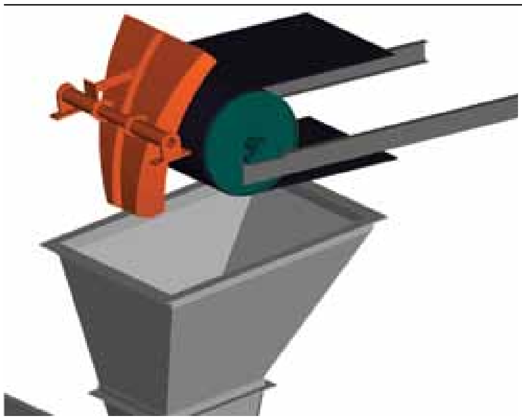

Figure 22.3

Installed at the discharge, a hood captures and confines the moving material stream at a low impact angle.

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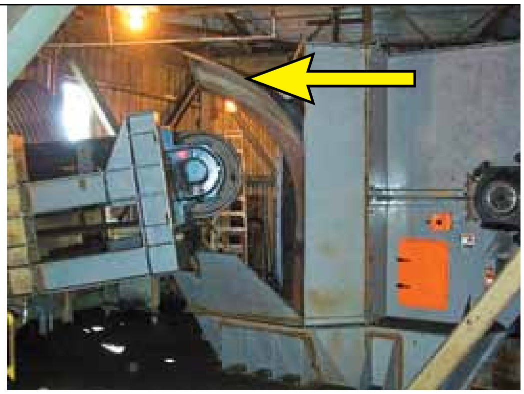

Figure 22.4

A hood is installed to redirect the material stream vertically, so it flows smoothly toward the conveyor system below.

Figure 22.5

A spoon is installed at the bottom of the transfer chute, where it receives the material stream and places it on the receiving belt.

Figure 22.6

By directing the concentrated stream of material onto the center of the receiving belt with the proper speed and angle, the spoon reduces impact on the belt, belt abrasion, dust creation, off-center loading, wear on wear liners, and other problems.

Figure 22.7

The settling zone, typically installed after the spoon on the receiving conveyor, corresponds to the conventional skirted and covered portion of the receiving conveyor.

rial stream and places it on the receiving belt (**Figure 22.5**). The spoon is designed to gently load the material onto the receiving conveyor, so the cargo is moving in the same direction as, and near the velocity of, the belt. By directing the concentrated stream of material onto the center of the receiving belt with the proper speed and angle, the spoon reduces impact on the belt, belt abrasion, dust creation, off-center loading, wear on wear liners, and other problems (**Figure 22.6**).

Another benefit of loading via an engineered spoon is that the belt may require less belt support in the load zone. Loading the material onto the belt at a similar speed and in the same direction as the belt is traveling provides less impact onto the belt and, consequently, less need for impact cradles and belt-support cradles.

In some complex chutes or transfers with large drop distances, more than one "hood and spoon" pair might be used to control flow.

Settling Zone

The settling zone, typically installed after the spoon on the receiving conveyor, corresponds to the conventional skirted and covered portion of the receiving conveyor (**Figure 22.7**). This area is carefully engineered to provide for optimum settling of dust-laden air and settlement of any airborne dust, by holding the air long enough to slow its velocity. The settling zone typically uses a higher, covered skirtboard to allow any airborne dust to settle out of the air, returning most of the dust to the main material bed without being released to the outside (**Figure 22.8**). The air currents are slowed by the larger area of the settling zone and the use of dust curtains within the area.

Some system designers omit a settling zone from their designs, using only conventional covered skirtboard designs. However, it is almost impossible to design a chute that will handle every possible material condition. Therefore, it is safer to include the settling zone to accommodate unforeseen circumstances or to handle future changes in material characteristics.

DESIGNING FOR ENGINEERED FLOW

Even if two conveyors run at the same speed, gravity can cause the velocity of the material to increase during a transfer from one conveyor to the other if the flow is left unrestrained. Both the hood and the spoon must be designed to intercept the material trajectory at a low angle of incidence. This uses the natural forces of the material movement to steer the flow into the spoon for proper placement on the receiving belt with reduced impact and wear. Because the hood and spoon are designed with both the material specifications and the flow requirements as criteria, the chute can operate at the required flow with reduced risk of plugs or chute blockages that will choke operations.

To achieve the proper design of hood, spoon, and settling area, engineered flow chutes are created using three-dimensional (3D) computer-based modeling to define the geometry of the chute (**Figure 22.9**). The angle and force of impact should be minimized to maintain as much momentum as possible. Ideally, the impact angle should be no more than 15 to 20 degrees. This design must be based on rigorous processes and procedures to provide a precise, accurate, and complete design. Dimensional data can be determined from a site survey or—particularly for new facilities—from a review of the site plans and conveyor specifications.

It is essential for the designer of an engineered flow chute to have detailed information about the material that will be flowing through the chute and the parameters of the conveyor system itself. This information includes:

A. Feed system

  a. Type of feed system (e.g., crusher, vibratory feeder, stockpile, reclaim)
  b. Number of feed systems
  c. Angle of incline or decline (**Figure 22.10**)
  d. Belt speed
  e. Belt thickness
  f. Belt width
  g. Trough angle
  h. Transfer capacity
  i. Type of conveyor structure (channel, truss, cable)
  j. Method by which material is delivered to plant (e.g., barge, railcar, truck)

B. Transfer

  a. Interface angle (**Figure 22.11**)
  b. Horizontal distance to loading point (**Figure 22.10**)
  c. Drop height (**Figure 22.10**)
  d. Transfer capacity
  e. Number of transfers

Figure 22.8

The settling zone is carefully engineered to provide for optimum stilling of dust-laden air and settlement of any airborne dust, by holding the air long enough to slow its velocity.

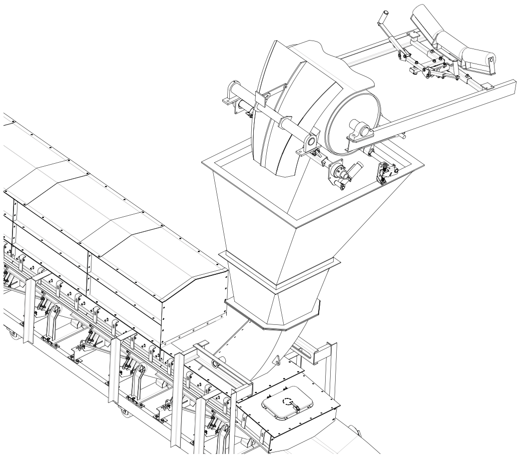

Figure 22.9

To achieve the proper design of hood, spoon, and settling area, engineered flow chutes are created using 3D computer-based modeling to define the geometry of the chute.

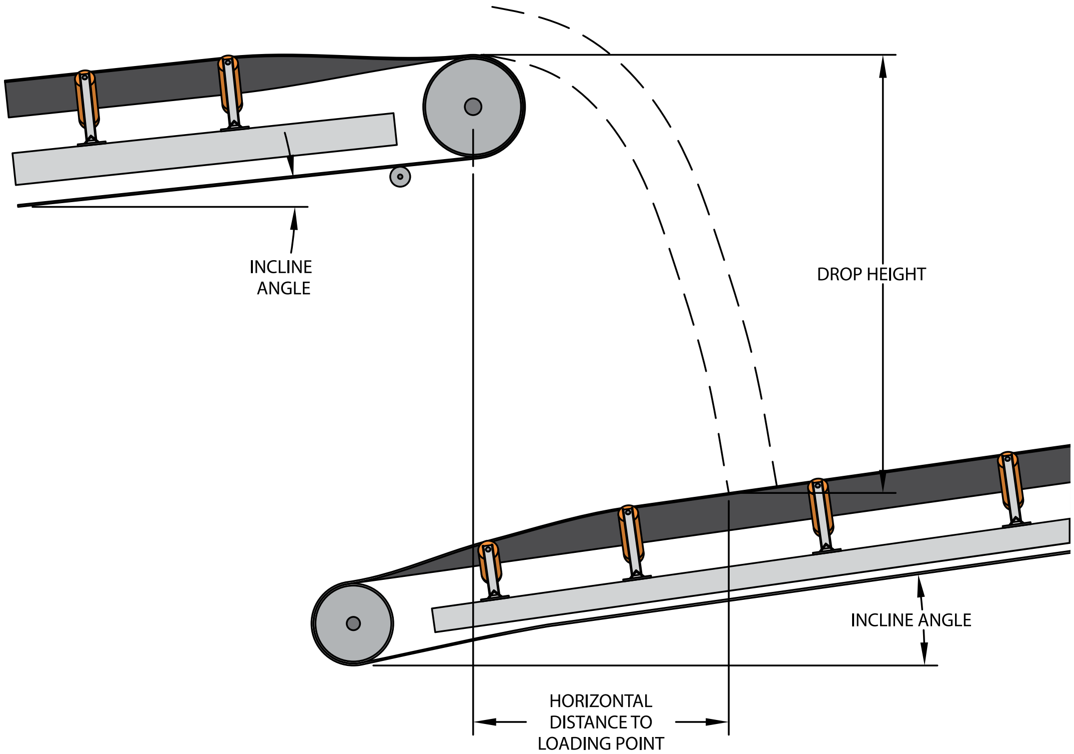

Figure 22.10

The designer of engineered flow chutes needs detailed information about the conveyor system and the material it carries.

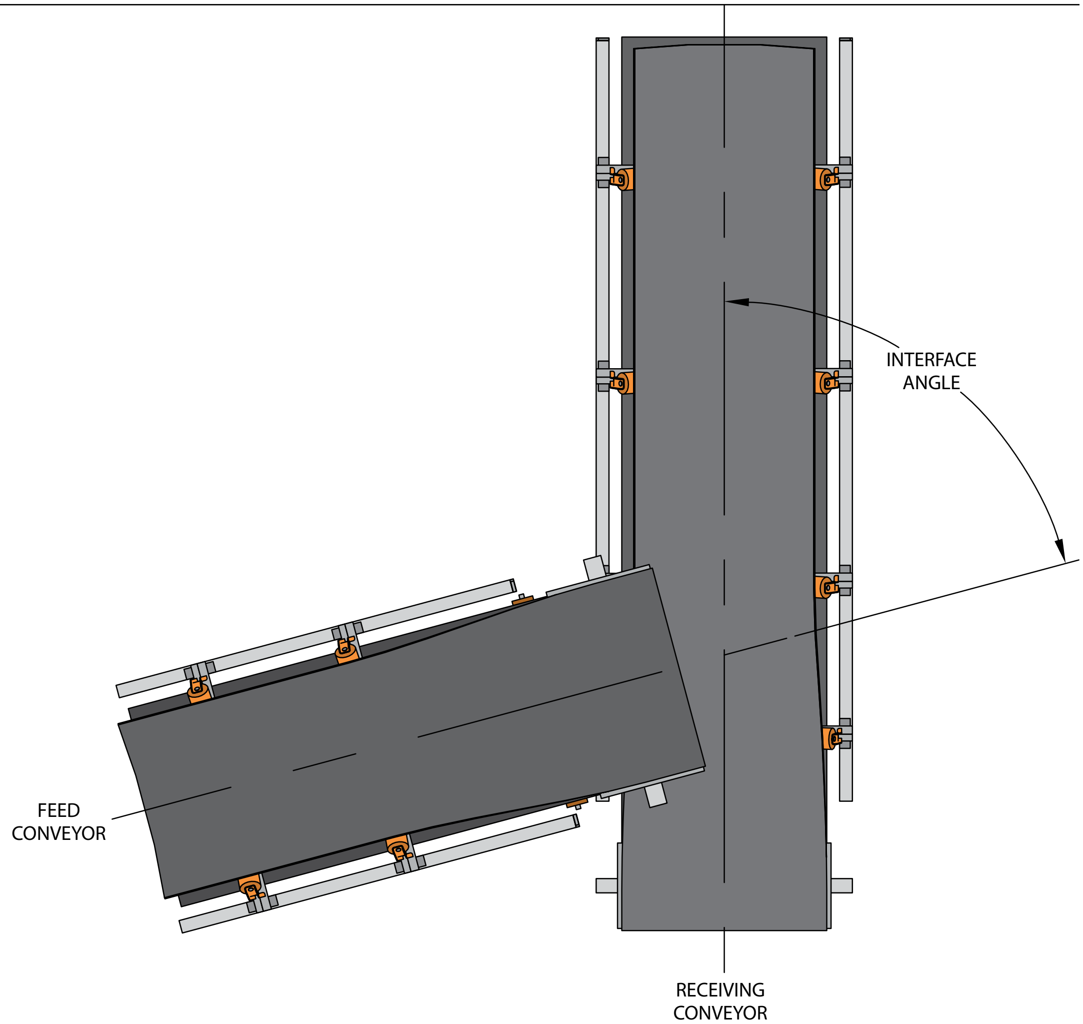

Figure 22.11

The interface angle of a transfer point is a key element in the design of engineered chutes.

f. Number of gates and purpose (e.g., splitting the flow or changing direction of the flow)
g. Interference due to surrounding structure

C. Receiving system
a. Type of receiving system
b. Number of receiving systems
c. Belt speed
d. Belt thickness
e. Incline/decline angle of conveyor (**Figure 22.10**)
f. Belt width
g. Type of conveyor structure (channel, truss, cable)
h. Trough angle
i. Transfer capacity
j. Belt/load support system
k. Distance of conveyor to curve or interference for settling zone

D. Material conveyed
a. Material type
b. Temperature ranges (high and low)
c. Moisture content
d. Environmental conditions that affect material condition (including distance from source/supplier and location where sample was collected)
e. Material size
f. Bulk density
g. Interface friction
h. Cohesion/adhesion properties
i. Particle size and percentage distribution
j. Average lump size and maximum lump size
k. Surcharge angle
l. Angle of repose

E. Construction materials
a. Chute construction materials
b. Chute liner materials
c. Tolerances for fabrication and installation
d. Interface friction values for construction materials in contact with the bulk material

Design of Engineered Flow Transfers

Engineered flow transfer chutes are developed in a three-step engineering process. Phase one is testing of the conveyed material properties and the interface friction values in relation to the belt and construction materials, to establish the material characteristics and its performance in materials-handling systems. After the various conveyor and material parameters are defined, the material discharge trajectory can be determined using conventional methods such as the Conveyor Equipment Manufacturers Association (CEMA) method.

The second phase of the process includes verification of current field dimensions and development of preliminary engineering. A set of two-dimension conceptual drawings and a three-dimension pictorial representation of the chutework using 3D software are created, and the flow characteristics are verified using Discrete Element Modeling (DEM) method.

The third and final phase is the creation of the final design, followed by the detailed engineering and then, in turn, by the fabrication and installation of the system.

Phase 1: Material Analysis

The first step in the design of an engineered chute is testing of the actual conveyed material that will be passing through it. Information obtained includes material composition and physical properties, moisture content, lump size range, and fines size. Testing usually includes analysis of the bulk-material strength at several moisture contents—from "as-received" to "saturation" level—to allow for changing material conditions. There are typically at least three different types of tests, including direct shear, interface friction, and bulk density, at each of these moisture content levels. Direct linear or rotational shear testers are often used to measure the material flow and interface properties. The fine components of the material are usually used in testing, because the fines define the worst-case flow properties.

Testing samples of the actual material to be conveyed in relation to the actual belting and construction materials to be used must be performed to provide this important data. *(See Chapter 25: Material Science for additional information on material testing and analysis.)*

Material testing concludes with a recommendation for the chute angles, based on boundary friction required to find a balance between reliable flow through a transfer chute and acceptable levels of chute and belt wear. Recommendations for the material(s) to be used as liners inside the chute may also be included.

The various conveyor and material parameters and the material discharge trajectory are used to develop the transfer chute design.

Phase 2: Discrete Element Modeling (DEM) Method

The parameters developed in Phase 1 are used in developing a computer-generated 3D discrete element model of the chute system (**Figure 22.12**).

DEM is a design verification tool. The basic operating equation is Newton's Second Law: Force = mass times acceleration (F = ma), solved for every interaction between particle and particle, and particle and chutewall, as modified with the properties of the particles and of the interacting elements. The forces, which act on each particle, are computed from the initial data and the relevant physical laws. Some of the forces that affect the particle motion include:

A. Friction

When two particles touch each other or move against the wall

B. Impact

When two particles collide

C. Frictional, or viscous, damping

When energy is lost during the compression and recoil of particles in a collision

D. Cohesion and/or adhesion

When two particles collide and stick to each other

E. Gravity

Solutions based on a DEM approach are more insightful than those based on basic design equations and "rules of thumb," because they enable the designer to more accurately evaluate important issues such as center loading of a receiving conveyor. The chute designer is also able to predict areas in the chute that may be prone to low material velocity—therefore plugging—and take corrective action to prevent them. When coupled with basic equations, DEM enables a designer to quickly determine the optimum chute design through a series of iterations. A minor downside of DEM is that only relatively few particles, compared to the total number of particles in the material stream, can be simulated in a reasonable length of time with computers that are commonly available, although advancements in computer technology may rapidly eliminate this problem.

An additional advantage of this computer-based system is that changes can be quickly developed to compensate for changes in the system characteristics.

Of course, the "garbage in, garbage out" principle still applies. If the data going into the software is not accurate, the

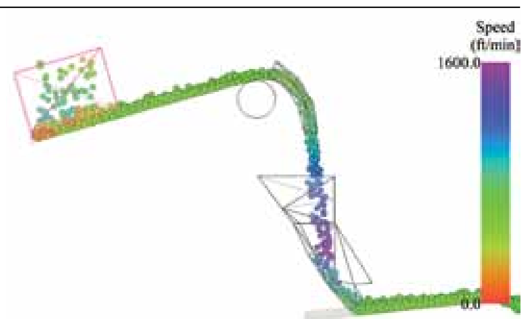

Figure 22.12

The parameters developed in Phase 1 are used in developing a computer-generated 3D discrete element model (DEM) of the chute system.

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design coming out will not be accurate. That is why testing of the actual material to be conveyed, in the various conditions in which it will be handled—including “worst-case”—is critical.

Phase 3: Final Design

The use of computer-based modeling techniques allows the quick and efficient turnaround of a chute design to meet the requirements of a specific belt-to-belt transfer. The 3D model is used to produce the fabrication and installation drawings.

The completed engineered chute project includes hood(s), drop chute, spoon(s), wear liner, belt-support cradles, belt-tracking system, belt-cleaning systems, dribble chute, access doors, skirtboard seal, tailgate sealing box, and settling zone.

Other Items

Other items to be considered during chute design are the requirements for heaters, insulation, access to the interior of the chute, lighting, access platforms, plugged-chute switches, appropriate guards, and adequate space for replacement of belt cleaners, flow aids, or other components.

Other Design Considerations

In its simplest sense, a transfer chute should have internal surfaces that are sufficiently steep and smooth, with rounded corners, to prevent flow problems—such as material buildups and choking—even when transporting material with worst-case flow properties. Ideally, this geometry would be governed by the effects of gravity only. The reality is that there are a number of other considerations that should be included and calculated when planning for the installation of engineered flow transfers. These factors include:

A. Material trajectory

Calculation of the trajectory of the material stream as it leaves the discharge conveyor involves consideration of the center of mass of the material, velocities, the point on the discharge pulley where the trajectory begins, and the shape of the load. (A detailed discussion of discharge trajectory can be found in Chapter 12 of CEMA’s *BELT CONVEYORS for BULK MATERIALS, Sixth Edition*.)

B. Wear

Impact, corrosion, and abrasion are primary contributors to chute wear, which takes place where the material stream hits the chute surface. Sliding abrasion is the passing of the material stream along the surface of the chutewall. The amount of abrasion that takes place is dependent on the difference in hardness between the material stream and the wear liner and on the amount, velocity, and force of the load on the wear liner surface. Because the design of engineered flow chutes links the material behavior with the interface at the chutewalls, analysis of impact and sliding abrasion is important in controlling the shape and speed of the material stream.

C. Tolerances

Even small differences in the installation of the components can affect the smooth flow of material and air through the transfer point. Manufacturers’ recommendations for installation of components and materials must be strictly followed.

D. Two-phase flow analysis

Two-phase flow analysis takes into consideration the movement of both the material stream through a transfer chute and the induced air that travels with it into the settling zone of the receiving conveyor. If the material stream remains in contact with the chute surface—rather than bouncing off from it—there is less aeration and reduced impact force in the loading zone. During the chute’s design phase, the analysis of the movement of both material particles and air through the transfer chute enables the chute designer to minimize induced air, which, in turn, reduces dust generation.

A variety of computer-based techniques, including DEM, Computational Fluid Dynamics (CFD), and Finite Element Analysis (FEA) are used to model two-phase flow. This analysis should include the displaced air, induced air, and generated air. *(See Chapter 7: Air Control.)*

Depending on the calculated airflow and the properties of the material, including particle size distribution and cohesion level, various systems—from rubber curtains to dust suppression and filter bags—can be utilized to minimize the effects of air currents in the transfer chute.

E. Structural concerns

Design of the support structure for a transfer chute generally requires analysis of four factors:

a. Dead load

Weight of chute (and structure) itself

b. Live loads

Wind, snow, and ice accumulations and fugitive material accumulating on flat surfaces

c. Dynamic load

The forces resulting from the movement and impact of material in the chute and other process equipment

d. Loaded capacity

Weight of the material in the chute—calculated using the highest value of material bulk density in the worst-case scenario of chute plugging

Figure 22.13

To ensure accurate designs as well as to ensure that the engineered system will fit properly into place without requiring field adjustments, a site survey using laser measurement technique is recommended.

The objective of this analysis is to efficiently and effectively support the transfer chute without spending excessive amounts on the support structure. Developing a support structure that complies with local building codes is another important consideration.

INSTALLATION OF ENGINEERED FLOW SYSTEMS

Project Installation

Engineered chutes can easily be designed into new conveyor systems. They can be pre-assembled and aligned into manageable assemblies that can easily be rigged, hoisted, and bolted-in-place to reduce construction cost.

Engineered flow chutes can also be retrofit into an existing operation as a way of controlling dust to improve operations and achieve regulatory limits on dust, usually without installation of expensive "baghouse" systems. Regardless of whether it is a new or retrofit installation, the design and installation of engineered chutes should be left to companies experienced with the technology.

Chutes for Retrofit Applications

One of the earliest applications of engineered flow chutes was in the improvement of the transfer points in existing conveyor systems. The incorporation of these engineered systems into existing plants can pose some problems with fitting within existing structures.

To ensure accurate designs as well as to ensure that the engineered system will fit properly into place without requiring field adjustments, a site survey using laser measurement techniques is recommended (**Figure 22.13**). This precise survey uses a pulsed-laser technology to scan target areas and return a 3D "point cloud," which looks like a detailed rendering of a scene (**Figure 22.14**). Because this point cloud is three-dimensional, it can be viewed from any perspective, and every point has accurate x-, y-, and z-axis coordinates. The geometry of the points can then be exported to 3D modeling software packages as a starting point for the development of chute geometry. This will ensure the engineering of systems that will fit within the existing clearances.

In a retrofit application, before and after release of fugitive materials testing and analysis can also be performed, allowing the opportunity for performance to be compared and for improvements to confirm the justification for the project.

Flow Aids and Engineered Chutes

Even a well-engineered chute should make provision for the future installation of flow-aid devices by incorporating mounting brackets in the original design. Changes in material flow properties, or less-than-optimum design constraints, may lead a designer to require flow-promotion devices, such as vibration or air cannons, in a given design. It is difficult, especially in retrofit applications, to have the luxury of an optimum design. Compromises are often inevitable, because the locations of the feed and receiving conveyors are set, and moving them would be economically unfeasible. Potential flow problems, caused by variations in material characteristics in the future, can then be accommodated with the installation of vibrators or air cannons. Including the brackets during the initial installation of the chute will save money and time over retrofitting a bracket (**Figure 22.15**).

Flow aids enhance material flow in those situations where compromises are made to what would have been an optimum design. *(See Chapter 9: Flow Aids.)*

SYSTEM MAINTENANCE

An operation should keep accurate records of chute and liner design and positioning to simplify the fabrication and installation of replacement liners as they become needed.

In order to simplify the replacement of liners, the chute should be designed with an easy-opening flange system that allows one wall—in most cases, the back wall and liner-bearing wall—of the chute to slide away from its position (**Figure 22.16**). This will allow more efficient access for inspection and replacement of liners inside the chute structures (**Figure 22.17**).

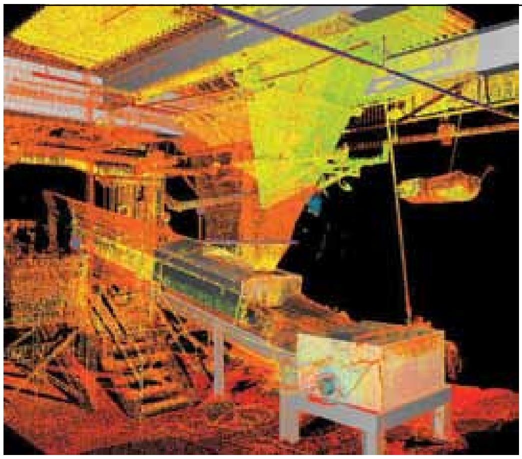

Figure 22.14

Pulsed-laser technology is used to scan target areas and return a 3D "point cloud," which looks like a detailed rendering of a scene.

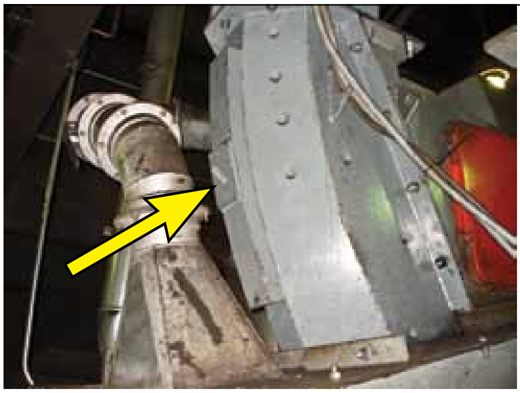

Figure 22.15

Including brackets for the installation of flow aids during the initial construction of the chute will save money and time over retrofitting a bracket.

Figure 22.16

To simplify the replacement of liners, the chute should be designed with an easy-opening flange system that allows one wall—in most cases, the back wall and liner-bearing wall—of the chute to slide away from its position.

Figure 22.17

The flanged back of the chute will allow more efficient access for inspection and replacement of liners inside the chute structures.

TYPICAL SPECIFICATIONS

A. Material specifications

The material-transfer system will incorporate belt-to-belt transfer chutes custom engineered to match material specifications and flow requirements. Through testing of material properties, the chute system will be designed to provide the required flow rate without plugging and to eliminate the creation of additional dust from the degradation of material and the entrainment of air.

B. "Hood" and "spoon"

Included in the chute system will be a "hood" discharge chute and a "spoon" receiving chute. The "hood" will take the flow of material from the discharging belt, confining it to limit air entrainment and creating a consistent inertial flow through its trajectory onto the receiving "spoon." The "spoon" receiving chute will receive the material stream and place the material on the receiving belt with the proper direction and speed to minimize material turbulence, impact, belt abrasion, and belt mistracking.

C. Volume

The volumetric design of the head chute and skirted area will be calculated to reduce air speed and turbulence. Fugitive and respirable dust levels will be greatly reduced through the settling features of the design.

D. Access

The chute will be fitted with an easy-opening flange closure system to enable simplified inspection and replacement of liners inside the chute structures.

E. Settling zone

The exit of the receiving conveyor will be fitted with an extended covered skirtboard system to form a settling zone. The settling zone will incorporate multiple dust curtains to form a serpentine plenum that reduces the air velocity and provides time for airborne particles to return to the main material cargo by gravity.

SAFETY CONCERNS

Engineered chutes should be designed with an access opening on the non-flowing side of the enclosure. These doors should be fitted with restricted-access screens to reduce the hazard from materials flying out of an opening, and warning labels should be applied.

Personnel entry to any chute should be governed by confined-space entry regulations.

ADVANCED TOPICS

Engineering Calculation: Continuity

The continuity calculation determines the cross section of the material stream within a transfer chute and is important in determining the ideal chute size (**Equation 22.1**). This helps to keep the cost of chute fabrication under control. The industry and CEMA's standard indicates the chute should be at least four times the material cross-sectional area at any position.

More important than the calculation of the area is the acknowledgment of the relationship between velocity and cross-sectional area. A designer must keep this continuity relationship in mind when the velocity of the material needs to match the speed and direction of the receiving belt (**Equation 22.1**). Material velocity is influenced by many things, such as fall height, change in direction of flow, surface friction, internal friction, and instantaneous density to name a few. These factors will alter the stream velocity in a predictable way, but it is important to note that this change in velocity will influence the cross-sectional area of the stream. Conversely, the area can be altered to influence the velocity. The cross-sectional area of the stream is vitally important when designing to prevent problems with chute blockage.

THE PAYBACK OF ENGINEERED CHUTES

In Closing...

An engineered transfer chute can be applied in virtually any transfer chute application, so facility management often will use a cost justification procedure to evaluate its payback for the operation. Applications in which there is a significant drop height from the discharge conveyor to the receiving conveyor will usually warrant the investment. Facilities that are attempting to meet regulatory requirements or satisfy environmental and safety concerns may find the investment in an engineered flow chute has a short-term payback. The additional investment required for an engineered flow chute over the cost of a traditional transfer chute is promptly repaid through increase in productivity, accident reduction, and meeting environmental regulations rather than cleaning up fugitive materials, coping with plugged chutes, or tracking an improperly loaded belt.

Looking Ahead...

This chapter, Engineered Flow Chutes, the second chapter in the section Leading-Edge Concepts, provided information about another method of reducing fugitive materials. The next chapters continue this section, focusing on Air-Supported Conveyors and Belt-Washing Systems.

$$A = \frac{Q \cdot k}{\gamma \cdot v}$$

Given: *A coal stream carrying 1800 tons per hour (2000 st/h) with a density of 800 kilograms per cubic meter (50 lb_m/ft^3) is traveling at 4,0 meters per second (800 ft/min).* ***Find:*** *The cross-sectional area of the coal stream.*

Variables		Metric Units	Imperial Units
A	Cross-Sectional Area	square meters	square feet
Q	Flow Rate	1800 t/h	2000 st/h
γ	Material Bulk Density	800 kg/m³	50 lb_m/ft^3
v	Average Materials Velocity at Cross Section in Question	4,0 m/s	800 ft/min
k	Conversion Factor	0,278	33.3

Metric: $A = \frac{1800 \cdot 0,278}{800 \cdot 4,0} = 0,16$

Imperial: $A = \frac{2000 \cdot 33.3}{50 \cdot 800} = 1.67$

A	Cross-Sectional Area	0,16 m²	1.67 ft²

Note: The stream cross-sectional area will be different from the cross-sectional area when the material is on the belt due to the differences between conveyed density and loose bulk density. (See Chapter 25: Material Science for additional information.)

Equation 22.1

Continuity Calculation for Cross-Sectional Area of Material Stream

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22.3 Roberts, A.W. (August 1999). "Design guide for chutes in bulk solids handling operations," *Centre for Bulk Solids & Particulate Technologies*, Version 1, 2nd Draft.

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