

Pellet line layout and design: A systems approach

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In new plant construction there may be little concern or focus on developing a detailed layout for the pellet line because space in the new structure seems unlimited. In renovations, the pellet mill is often selected on the basis of meeting increasing production demand—with “equipment layout” reduced to shoehorning the new unit into wherever it will fit in the existing plant.

A new or upgraded pelleting system is more than the pellet mill. It needs to be a well-balanced, fully-integrated pelleted feed manufacturing system, incorporating the upstream and downstream component equipment, and encompassing all of the storage, processing and transfer equipment from the feed cleaner to the finished product bins.

Whether a pellet line is to be configured for a new facility, integrated into an existing plant or when an existing pellet mill is being replaced with a larger unit, thorough analysis and detailed planning—undertaken before purchasing the pellet mill—can save money up front on the equipment and structures; reduce labor and operating costs; eliminate potential bottlenecks; and make future upgrades and expansions easier and more cost-effective.

Optimum sizing of pelleting system equipment

Generally, most managers and operators know what size pellet mill they need based on the number of tonnes of product to be manufactured during a fixed number of hours. Optimum sizing of equipment requires further analysis, determining how a variety of factors, specific and unique to each individual

plant, will impact the rated efficiency of the equipment and the overall throughput of the facility. As part of the optimization analysis, the initial calculations for equipment sizing are based on meeting the target production requirements during a single shift. This approach ensures that the system is in balance and can easily accommodate additional hours (up to three full shifts) without bottlenecks or the unplanned replacement of undersized equipment.

An efficiency analysis for a pelleting system will include the type and characteristics of the feed; how easily the formula is pelleted; desired level of pellet durability; number of formulas; tonnage per run; and the actual number of tonnes delivered to the finished feed bins versus the number of tonnes through the pellet mill. The analysis must also account for where and how liquids are added; whether product is screened; how fines are generated; the volume of fines; and how fines will be recycled or disposed of.

In addition, consideration must be given to the number of die changes and time required for die changeovers; the time needed to clear the system and reset routing for the next formula; the impact on efficiency of the size and number of pellet mill surge bins; and the level of plant automation. All of these factors affect equipment efficiency and, subsequently, the optimum size of the equipment.

For example, compare the efficiency of two 40 tonne-per-hour (TPH) pellet mills—one installed in a single-species plant and one in a multi-species feed mill. The single-species plant runs six broiler feed formulas with an average production run of

200 tonnes; there are two surge bins over the pellet mill and minimal die changes. The multi-species plant manufactures an array of products, including textured horse and swine feed for commercial and retail customers. There are 90 formulas and the longest run is 10 tonnes. The plant has two surge bins over the pellet mill, multiple die changes per day and stringent flushing requirements between production runs. The calculated efficiency of the 40 TPH pellet mill is about 85-95% in the single-species plant, while the efficiency for the multi-species facility could be as low as 35% and may never be more than 70%. This illustrates how just a few factors can substantially reduce the rated capacity of the equipment.

Why perform an optimization analysis? The optimization calculations result in an analysis that more accurately depicts the actual plant operations and allows the designer to more closely define the required processing rate for the equipment. In many situations, an optimization analysis indicates that a smaller capacity unit will perform satisfactorily. And selecting smaller, optimally-sized equipment saves money on major process equipment, the corresponding up and downstream equipment and the structure.

Optimization analysis also ensures that equipment isn't undersized for a particular application and that production capacity can be met within the targeted hours of operation—avoiding overtime and additional shifts. Determining the optimum size for system equipment also includes evaluating how the system will grow with the business. In some situations it may be prudent, and more cost-effective, to specify a larger piece of equipment than needed at start-up if the initial cost is less than the cost of upgrading at a later date.

Layout of pelleting equipment

In the equipment layout stage, the primary focus is on the configuration of the core pelleting equipment and any specialty processes directly related to pelleting, followed by the layout of the upstream and downstream equipment that service the pelleting system.

After establishing the optimum size of the equipment, the designer can commence the layout process. Unless there is an unusually long delivery lead time, it should not be necessary to select a specific pellet mill until the design is complete. The designer should use a general dimensional footprint in the preliminary design that will accommodate any manufacturer's comparably-sized machine (including belt-driven units), enabling management to solicit competitive bids for the equipment.

Steel vs. concrete—does it matter?

In new construction, the choice of steel versus concrete for the mill tower structure does not impact the layout of equipment, but in an existing facility the type of structure can make a lot of difference. It may be easier to retrofit additional equipment or larger equipment into a steel mill structure. In general, the interior of this type of tower is more open because it utilizes discrete columns versus load-bearing interior walls. A steel frame metal-clad tower offers flexibility and several options for expansion. Siding can be removed and wall sections can be extended to create needed clearance for higher-capacity equipment, bigger motors and drives or new conveying systems.

In major plant expansions, a new parallel tower can be framed and portions of the siding of the existing tower removed to create larger open areas that eliminate walls between the old and new towers. When modifying a steel structure to accommodate the equipment layout, or for any other reason, it is essential to maintain the integrity of the major columns. Beams and the lateral bracing should be designed to resist wind and seismic loads. Random cutting, removal or alteration of any structural components, without consulting a structural engineer, should be avoided.

One of the major unsung benefits of an existing concrete structure is its inherent structural integrity. Utilizing the excess structural capacity of the slipformed tower may allow the full or partial support of new surge bins, prefabricated structures, process and transfer equipment and service platforms. This approach eliminates or minimizes the cost and space requirements for structural steel-

support framing for the new equipment and structures.

A concrete structure does not offer the same flexibility as a steel structure, and removing reinforced concrete is difficult and costly. Annex towers cannot be constructed as close to existing towers because of the amount of space needed around the new tower to accommodate the slipforming process. In general, it is not structurally efficient or cost-effective to remove large sections of slipformed wall to create open areas between the two structures.

Location of pellet mill: New facilities

In new facilities, the location of the pellet mill is a major factor in the overall design of the structure and equipment layout. There are three basic layouts and elevations for locating the pellet mill, but owner preference and site conditions dictate the final configuration.

The first layout option is the mill tower with full basement/pellet mill at grade or warehouse floor level. This layout is common in older plants and is based on placing the pellet mill, control room, micro-ingredient system and hand-add station at grade. Less manpower is required because the major work areas are clustered together on one level and more tasks can be handled by fewer people. Forklifts can drive up to the micro system to deliver ingredients, and can also drive up to the pellet mill for die changes or maintenance. When the pellet mill is placed at grade, the cooler and crumbler are placed in the basement. The cooler cyclones and fan may also be located in the basement. Placing these units in the basement minimizes the length of the dirty-side ductwork and better insulates the cyclones with respect to temperature changes. While the cost for concrete and steel for a deep basement may be about the same as the foundation for an at-grade mill tower, more excavation is needed for the deep basement, which increases the cost. Deep basement structures lack flexibility for expansion. There may be little or no space in the basement to add larger equipment or a second line, and no easy, direct access to the basement. In older plants, there may be no available space to expand the structure or

to accommodate the excavation.

The second layout option is the mill tower foundation at grade and the pellet mill at 6-9 meters above grade. When site restrictions, such as a high water table or owner preference, dictate building the mill tower foundation at grade, the pellet mill will be located about 6-9 meters above grade. Generally, the control room, micro system, hand-add station and the working micro-storage area will also be located on this level to enhance operational efficiency. Since this level is not accessible by forklift, it is necessary to add a freight elevator for transferring bags and totes of micro-ingredients, equipment parts and maintenance gear to the work floor. This configuration allows the designer to create an efficient equipment layout, with minimum ductwork, and easy access to the pellet mill and pellet leg for operation and maintenance. The at-grade structure is more flexible and it is easier and less expensive to expand since it requires no excavation. Separating the control room and work floor from the receiving and load-out areas, which requires several flights of stairs, may be considered a drawback. The freight elevator also adds capital cost and additional costs in yearly maintenance.

The third new layout option is to have the mill tower with partial basement and pellet mill at 3-4.5 meters above warehouse level. This hybrid, split-level approach ties the mill tower and warehouse area together with a mezzanine and a shallow basement. The basement, where the cooler and crumbler are located, can be open on two sides. This layout looks like a recessed, but open, work area in the warehouse floor. The depth of the recessed work area is between 2-3.7 meters and the depth is dependent on the topography and the desired warehouse dock height. The pellet mill is located on a mezzanine that is open to the warehouse. The control room and microsystem are also located on this level. Micro-ingredients are stored in the warehouse and these ingredients, as well as the dies, rolls and parts, are placed on the mezzanine by forklift. This layout increases the plant efficiency by opening up the areas housing the pellet mill, cooler and ingredient storage for easy access and monitoring.

Renovations: Addition of new pellet lines and equipment upgrades

Over the years, some plants have been designed to accommodate the future addition of one or more pellet lines. From a structural standpoint, the installation has been simplified; however, it is still essential to validate the sizing of the upstream and downstream equipment established in the original plan since plants are sold, the types and volumes of feed may be different and the hours of operation and management philosophy may have changed.

There are plants where the original pellet line is removed or where the second or third line is never installed. Although it is prudent to plan for expansion, it is also important to evaluate the cost of this under-utilized space. While flexibility is highly desirable, and every effort should be made in the design phase to create a plant that can be expanded, consideration should also be given to alternate approaches for adding a pellet line if and when it is needed.

As noted earlier, there is often little available space within an existing plant in which to place new equipment. When capacity is an issue and a smaller pellet line can be replaced with higher-capacity equipment—for example upgrading to 40 from 20 tonnes per hour—the conditioner, feeder and pellet mill can, in many cases, be retrofitted in place of the old equipment.

The challenge in many pellet system renovations is to provide optimal surge capacity for the upgraded equipment, and in some cases older plants do not have pellet mill surge bins. In either case, the existing mill tower usually isn't configured structurally to add or upgrade the surge bins. In these situations, the first option is to look at the ingredient storage bins to determine whether one or two bins can be utilized for surge capacity. Subsequent options include hanging one or more bins on the side of the existing structure; erecting new bins outside the main tower and conveying the feed back into the pellet mill; or adapting an existing load-out bin (or adding a bin to the load-out group) and transferring the feed back to the pellet mill.

Space for upgrading or adding new pelleting equipment can also be created by relocating other processes. For example the grinding, steaming and flaking equipment may be relocated to other areas of the plant or housed in new, lower-cost structures located close to the grain storage area.

When the new equipment is too large to reinstall in place of the existing system, every option should be explored for locating the equipment within the confines or footprint of the existing plant structures. This approach can be cost-effective since it takes advantage of the foundations, as well as the sheltering capabilities and excess structural capacity of the existing buildings.

Warehouses adjoining the mill tower offer several options in an expansion scenario. Space taken from the warehouse area to accommodate plant expansion is generally easier and less expensive to replace by expanding the warehouse (and often raising the warehouse roof) than by adding onto the plant or constructing a free-standing tower. Mezzanines can be erected within the warehouse to accommodate a new or additional pellet mill line. This approach takes advantage of both the existing warehouse foundation and the supporting capacity of the mill tower structure. In some situations, it is feasible to raze several roof sections on the warehouse and found a new processing tower to house the equipment stack for all of the pelleting equipment. The warehouse may also be a feasible area for locating or relocating coolers, dryers and micro-ingredient systems—provided that the warehouse can be expanded to accommodate any lost storage space.

Designing a new pellet line to be housed in a new structure and tied back into the existing plant is more expensive than an equipment retrofit or an expansion performed within the confines of the old facility; however, in many cases, it may be the only option. A self-contained pelleting tower offers more layout flexibility, but it also incurs major costs for a new foundation and tower structure, as well as added costs for such items as electrical, piping and process control. A remote pelleting system located outside the main tower may require additional

manpower to monitor the operation or investment in a pellet mill controller. In any of these applications, it is essential to keep the cooler immediately in line with the pellet mill and minimize product degradation by eliminating any unnecessary handling or transfer of hot pellets.

Structural considerations

The pellet mill is a heavy, dynamic piece of process equipment. While it is possible to mount a pellet mill on a steel frame with a steel deck, the optimum design will place the pellet mill on a concrete floor slab at least 15 centimeters thick. When a steel frame is used, it should be designed with a concrete floor slab. In either situation, the concrete—in addition to a vibration dampening pad supplied by the equipment manufacturer—will absorb and dampen vibrations from the pellet mill. This approach keeps potentially harmful vibrations from being transferred to the structure and improves working conditions by reducing noise in the plant and vibrations in the work floor.

Equipment access and ergonomic issues

Good layout design focuses on making the equipment accessible for ease of operation, observation, cleaning and maintenance. Equipment doors should open to the appropriate side and have adequate space to swing out of the way. The area around the pellet mill also needs to be generous enough to store multiple dies and accommodate die-changing equipment. Work areas and service platforms should be sized to accommodate one to two workers and their tools, and should provide enough space in which to accomplish the tasks. Cleaning, maintenance and observation of the process equipment are performed more easily, and therefore more frequently, when the platforms are accessible by stairs or standard service ladders and when hoists and service beams are incorporated into the layout.

Preconditioning and conditioning equipment layout

There is a variety of mash conditioning and preconditioning devices that may be installed singly

or in combination ahead of the pelleting system. These units include ripening kettles, compactors, expanders, single- and twin-shaft conditioning cylinders and multiple conditioning cylinders—as well as insulated or jacketed conditioning cylinders. While the footprint of these devices is usually not larger than the pellet mill, their height makes a significant impact on the design of the structure and the layout of equipment.

Compactors, expanders and other equipment that function by placing mash feed under extremely high pressures are ruggedly built and quite heavy. Ripening kettles and cylinder conditions are lighter, but hold a larger volume of feed. In addition to the weight of the equipment, it is also important to consider the weight of the feed in the unit. Structural design of the supports for this type of equipment should be based on a plugged condition. Many existing structures do not have enough height between floors to incorporate a conditioning device above the pellet mill. While it is more economical to build, maintain and operate the integrated system if the various components are stacked vertically and are closely coupled, it is still feasible to design a functional horizontal layout. For example, a compactor or other conditioning device could be located adjacent, and as close as possible, to the pellet mill. Mash feed would be routed from the surge bin to the conditioning unit via a feeder screw, and conditioned mash feed could be transferred to the pellet mill feeder from the conditioner outlet via a screw conveyor. The horizontal approach also enables the use of multiple in-line conditioning techniques, and may be more flexible for the future addition or reconfiguration of equipment as processing theories and technologies are advanced.

Incorporating vertically-stacked conditioning equipment over a pellet mill in a new structure adds to the capital cost of the project. This is considering the labor, construction materials and the additional cost to increase contingent items—like the height of the elevator legs and manlift, wiring, piping and ducting. Except for steam or water (and molasses in certain types of dairy and horse pellets) liquids are generally not introduced into the conditioning chamber. And adding fat at the

conditioner, even in small amounts, can affect pellet durability. Currently, fat and enzymes are the most common post-pelleting liquid additions; molasses addition is normally part of a separate texturing process.

Gravimetric and volumetric blending systems are the primary method used for downstream application of liquid fat and liquid enzymes. Enzymes are added at much lower inclusion rates than fat and need to be added as accurately as possible. In most situations, enzymes are sprayed into the blending system immediately ahead of the liquid fat. These systems should be located after the last elevation of the pelleted feed, and as close as possible to the inlet of the finished feed storage bins to minimize the build-up of fat in the process and transfer equipment. While the height and length of the equipment are important in the development of the layout, there is some flexibility in locating a blender and the dimensions are not as critical as finding the right type of equipment.

In most climates, the fat application system should not be located prior to any elevation because of the potential for fat to migrate through the plant. Even at moderate levels of fat addition, fat applied before the bucket elevator will build-up in the cups, casing and belting, creating a regular housekeeping problem and increasing the potential for contamination and biosecurity issues. Similarly, migration issues occur with fat-at-the-die application systems, and even at levels of 4%, fat build-up becomes a problem in the pellet cooler and the pellet cooler air system.

Pellet cooling and crumbling

Vertical coolers are generally not used in new construction and renovation. Years ago, horizontal coolers were placed in deep basements and additional sections were added to increase capacity until the unit was literally up against the wall. The layout problem posed by the length of the horizontal cooler was often solved by relocating the horizontal unit to the warehouse.

Counterflow coolers became popular because of lower cost; the ability to retrofit them into spaces

where a horizontal cooler would not fit; and ease of maintenance. In new construction there are few layout issues. In renovations, the counterflow cooler is fairly flexible, although it is often necessary to place the unit in basements or other areas with limited access. One of the benefits of this type of cooler is that it is easy to disassemble and reassemble when needed for difficult installations.

Incorporating a crumbler into a new or existing system generally does not pose much of a problem in layout. Ideally, the crumbler should be closely coupled to the cooler outlet. However, in a retrofit, the unit could be placed almost anywhere without affecting the process flow or product quality.

Upstream and downstream equipment

An upgrade in pelleting capacity can affect the functioning of both the upstream and downstream equipment. Upstream equipment must be capable of processing and delivering ingredients to the pelleting system and the downstream equipment needs to be sized to process, distribute and transfer pelleted feed. Although the focus of this chapter is on equipment layout relative to the pellet mill, it is important to note that a change of any magnitude to one of the processing systems should trigger a validation review of the overall plant equipment capacities from receiving and ingredient storage through finished feed storage and load-out.

All transfer equipment should be checked for capacity. Existing equipment may need to be altered or adjusted, fitted with new motors and/or drives or replaced. The type of conveyances, gates and distribution devices should be evaluated with respect to capacity, product handling characteristics and contamination issues and then adjusted, upgraded or replaced to create a balanced transfer system commensurate with the new products and production rates.

A rotary screener (or similar device) sized to the capacity of the mixing system should be located before the pellet mill surge bins to remove whole kernels of corn, or bolts or other items that could affect pellet quality or damage the die. Many pellet

mills come with a magnet positioned between the final feeder and the pellet mill conditioner. This provides good protection, but only as long as the magnet is cleaned on a regular basis. To be certain that there is adequate protection, a magnet should also be located immediately before or after the last elevation to the pellet mill surge bin. This placement is often dependent on owner/manager preference. As additional insurance, there should be no bypass around either the magnet or the feed cleaner. If the feed cleaner malfunctions, standard operating procedure should require that the process be stopped and repairs made to the cleaner. No feed should be allowed to go to the pellet mill surge bin without passing through the magnet and feed cleaner.

Good equipment layout makes an effort to minimize the amount of dirty-side duct between the cooler outlet and cyclone inlet to minimize any build-up in the ducting. While ducting requires a substantial amount of space in both new construction and renovation, physical restrictions can be overcome by adapting the aerodynamics of an air ducting system with options like rectangular ducts with interior vanes and increasing horsepower to compensate for loss in static pressure.

While it's good to have the boiler close to the tower and the pellet mill, it is not always practical for a variety of reasons—even in new construction. The boiler location is not a major layout issue, and any additional cost for longer runs of steam piping and insulation are not enough to dictate the location. What is important in the design is sizing the boiler, steam line and accessories to ensure that water is removed from the steam line prior to injecting it into conditioner, and that saturated, low-pressure steam is readily available at the conditioner to provide the most efficient transfer of heat from the steam to the mash feed.

In general, the electrical, piping and process control installation are flexible and have little effect on equipment layout. In some older plants, and in Canada, the use of cable trays instead of conduit can conflict with equipment placement, making it important for the electrical engineer, the installer and the plant designer to work closely on the layout.

The analysis and layout of pelleting systems, whether in new or existing facilities, focus as much on controlling cost and maximizing the capital investment in structures and equipment as they do on finding the appropriate space for installing the equipment. Taking the time to do the math, layout the process and balance the upstream and downstream components can save money up-front on the equipment and structures, reduce labor and operating costs, eliminate potential bottlenecks and make future upgrades and expansions easier and more cost-effective.

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