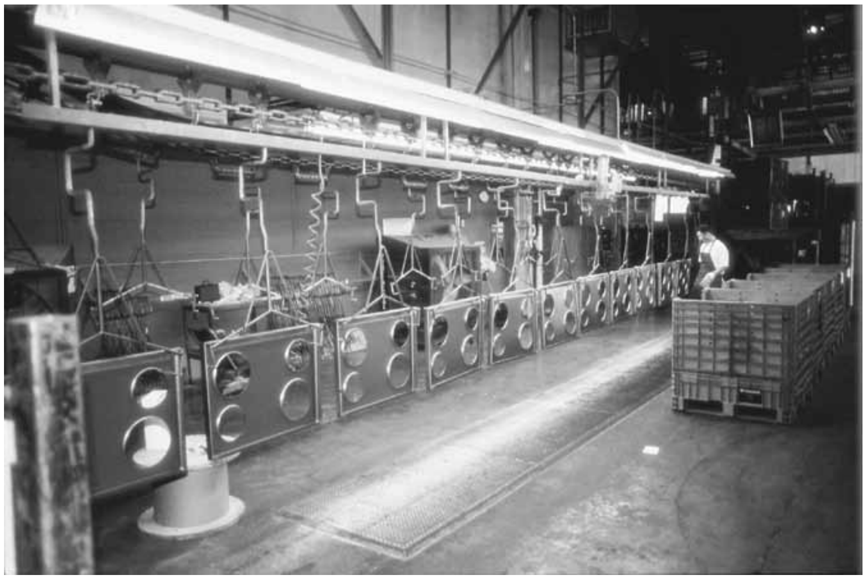

Optimizing Conveyor Loading Space

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A system that reduces conveyor loading space is described. The use of a special Angle Pivoting hanger system is explained. Resulting improvements in capacity, processing and quality are identified. Overall benefits and limitations are listed.

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Case History

In 1993 the Frigidaire Range Plant added new pretreatment equipment to upgrade maintop production. Because of limited floor space, it was decided to install a two-story washer system. This, however, would require a conveyor system with incline and decline sections to transport parts up to the washer/dryer/cooling tunnel and back down to floor level for powder application, unloading onto the furnace chain, and returning to the part load area. Because the parts were 30" range maintops, the part-to-part hanging pattern would have to be at least 40" to prevent parts from touching each other on the 30° maximum incline and decline sections. However, again because of the very limited floor space, a 30° or less incline section would not allow sufficient space for loading maintops onto the conveyor hanger.

The solution to this problem was to install a special Angle Pivoting hanging system. ***Figure 1*** shows our present maintop loading area. You can see that we now have 14 hangers available for loading, because we were able to install a 45° conveyor incline section leaving the load area. If we had used a conventional conveyor system with 40" part spacing and a 30° incline, the load area would have had only 4 hangers available for loading.

Figure 2 shows this 45° incline section. Notice how the parts rotate out of plane, which prevents them from touching each other because they actually are overlapping as they go up the incline section.

Figure 3 is a close up view of the Angle Pivoting system. A load bar hangs below every other set of trolleys on 16" centers. Each load bar has 8 holes located 2" apart, therefore the first holes on each of the load bars are located 32 inches apart. Also note the C-shaped hook on the top on each part hanger. By positioning this C-hook in different load bar holes, the load spacing between parts can be changed in 2" increments. A spacing of 34" was found to be ideal for 30" maintops. This unique C-hook design not only allows for variable load spacing but also is the Angle Pivoting device that causes the parts to rotate.

Several major benefits were obtained by installing this system. The reduction in part spacing from 40" to 34" increased powder porcelain output rate by 17.5%. Likewise, the more densely loaded parts improved the transfer efficiency of powder to part. Finally, with a maximum 4" gap between parts, we obtained a reduction in excessive powder coating buildup along part edges.

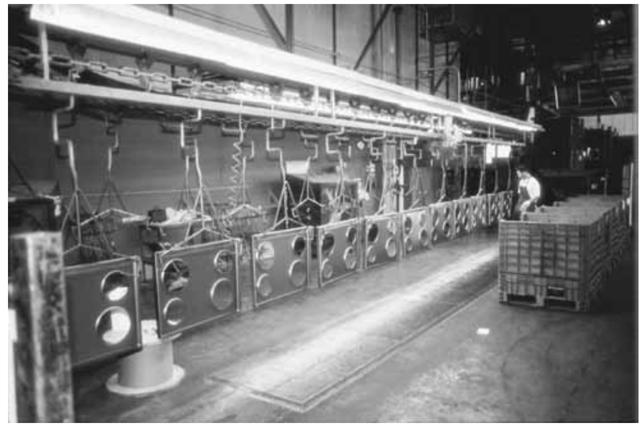

Figure 1 *– Present main top loading area after installation of Angle Pivoting hanging system.*

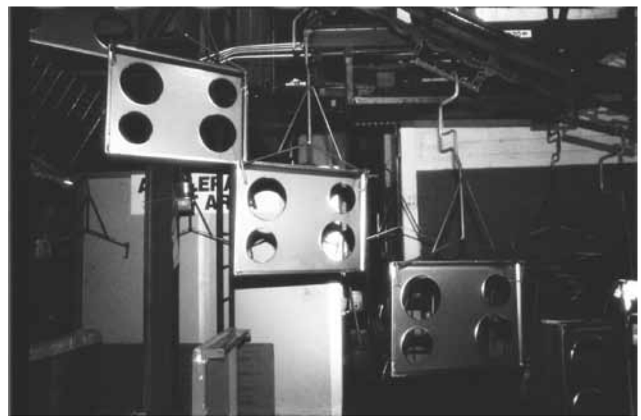

Figure 2 *– 457 incline section of the Angle Pivoting system.*

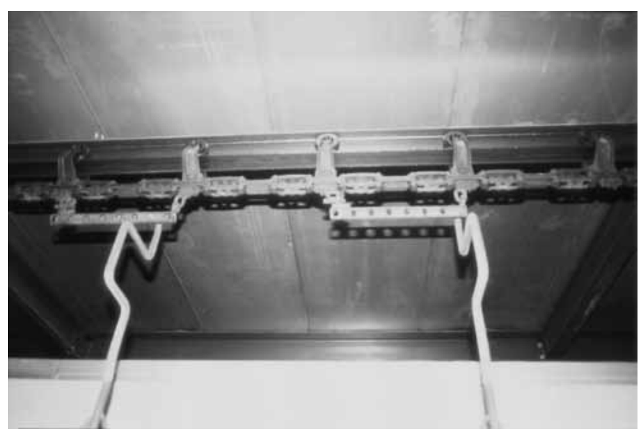

Figure 3 *– A close up view of the Angle Pivoting system.*

Background

This is one specific example of the usefulness of a technique developed in one finishing shop that is now taking root in many others. In the past, a similar effect was obtained with conventional four-position detented rotators, but rough operation and positioning uncertainty have limited their usefulness. Use of the rack-to-conveyor mounting point as an active element in the system can eliminate these disadvantages in certain cases. If the ware package length-to-thickness ratio is 2.5:1 or greater, it can permit the use of up to 60° inclines and declines in conveyor routing at no loss in processing capacity, compared to a single-level system.

Principles of Operation

The normal and familiar method of mounting racks to an overhead monorail conveyor is with H-attachments or C-hooks bolted into the trolleys or chain links. Weight carrying capacity beyond single-trolley ratings can be gained by bridging across two trolley sets with a beam, called a load bar, and mounting the payload at a single point halfway between them. By modifying this load bar so the center mounting bearing between the payload and the bar has a non-horizontal axis, the payload can be made to rotate out of the plane of the conveyor around a vertical axis when the load bar is not horizontal, that is, on the inclines and declines of the conveyor routing. This out-of-plane rotation is the basic principle underlying Angle Pivot™ tooling.

Variations

Many variations are possible to cater to workpiece size and configuration, conveyor design, circumstances of routing proximity to immovable building or equipment structure, and type of finishing process(es) employed. In all cased, the objective is to get a solid wall of parts going through all level portions of the system. This will maximize production rates, raise transfer efficiency, and allow better film uniformity across and between parts because of more accurate tracking and the minimization of haloing or picture framing. Versions to date have included the following:

- **Basic:** A load bar between two hang points on the conveyor chain, with a single payload mount bearing in the center ***(Figure 4)***.
- **Compound:** A load bar between two hang points, with a single payload mount bearing on or off the centerline, yaw stops on this bearing, and a second horizontal axis bearing below this to permit relative

Figure 4 *– Basic: A load bar between two hang points on the conveyor chain, with a single payload mount bearing in the center.*

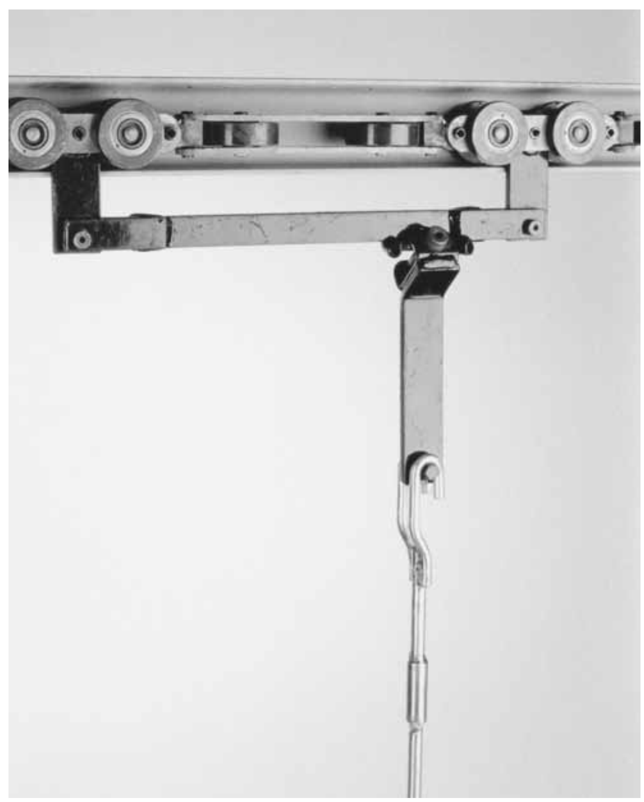

Figure 5 *– Compound: A load bar between two hang points, with a single payload mount bearing on or off the centerline.*

rotation between payload and device up or down to the incline or decline angle of the conveyor track ***(Figure 5)***. This lower bearing may also serve as the attachment point between the Angle Pivot device and workholder tools.

- Discrete devices most often use variations of the familiar Cardan U-joint, mounted from a single trolley or chain link, but have also used other mechanisms under special circumstances ***(Figure 6)***.
- Continuous load bars are a more general-purpose adaptation of the first two and provide the advantage of a continuous row of hang points at 2" or 3" intervals around the entire system. This permits hanging parts of varying width irrespective of trolley centers. Load bars for the different conveyor designs and sizes all have a common bar section and hole configuration, so tooling used with different systems in a plant can be made interchangeable ***(Figure 7)***.
- C-hooks are custom designed for each system, and can be used to accommodate sanitary pans without modification on existing systems ***(Figure 8)***.
- Positive lock rotators are double–detent devices that may be manually or automatically turned to facilitate loading and unloading the racks. This makes walking between racks to do this unnecessary ***(Figure 9)***.
- Rotation-stop equipped load bars for use with non-counterweighted C-hooks save weight on the conveyor and reduce unnecessary heat loss from ovens and washer ***(Figure 10)***.
- Ground braid-equipped load bars and integral bearing C-hooks for nonyawing service in E-coat systems permit spacing work irrespective of trolley centers, and on almost-maxed systems can provide a useful additional increment in capacity ***(Figure 11)***.
- Eye bar tools for flat parts of varying widths on continuous load bar systems. Compared with T-bars, these never create a situation where spacing is dictated by T-bar length rather than part width up and down the line ***(Figure 12)***.
- Paired J-hooks with the pivot angle built into the top and mounted in the same hole on continuous load bar systems are another way of accommodating flat parts of varying widths, without the length of a T-bar as the limiting spacing requirement and with the advantage of Angle Pivot mounting on inclines and declines ***(Figure 13)***.

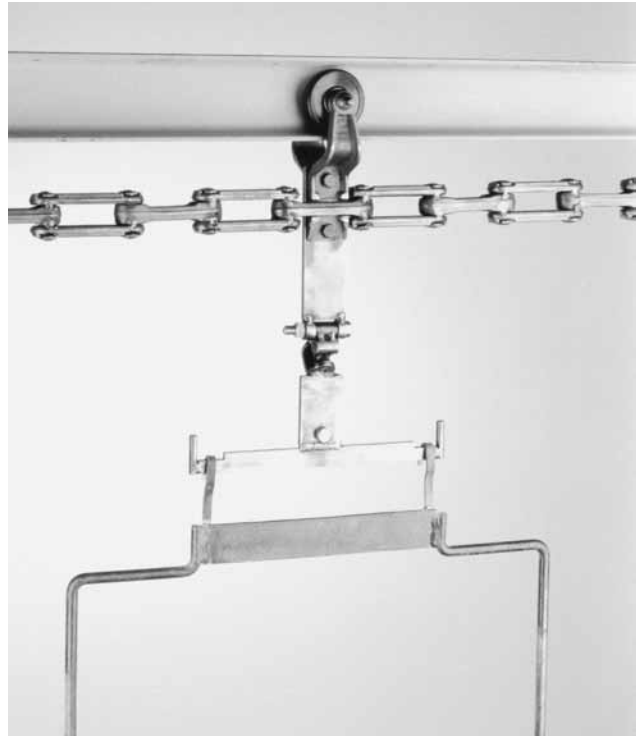

Figure 6 *– Discrete device: Most often use variations of the familiar Cardan U-joint, mounted from a single trolley or chain link.*

Figure 7 *– Continuous load bar: A more general purpose adaptation of the versions shown in Figures 4 and 5.*

- Discrete devices built integral with the rack top, for use with carriers on power and free systems ***(Figure 14)***. On retrofit installations, these are made to also fit the rack storage carts and the pyrolytic stripping oven fixtures without any modifications to them required.
- Powered rotators for small round parts, built into the proper planform configuration for Angle Pivot use, can double line density for parts like shower curtain rod tubes ***(Figure 15)***.

Ware Package Planform Limitations

Because the Angle Pivot™ system avails itself of the space flanking the processing envelope to accommodate foreshortening on inclines and declines, a relatively flat ware package is required for its proper use. For the simple linkage that will work in the majority of situations, a 4:1 length-to-thickness ratio is the practical minimum. This means, for example, that a 20" wide (up and down line) ware package must be less than 5" thick; a 30" package, 7.5"; a 40" package, 10" With the compound linkage, which pops the parts out of the conveyor plane more quickly, a 2.5:1 length-to-thickness ratio is minimum. Length-to-thickness ratios of less than this cannot be swung out of plane fast enough for the diagonal dimensions to miss each other – the package gets longer in the plane of the conveyor until the diagonal crosses it. And as the ware package approaches square, a touch of the vertical edges in the horizontal turns becomes the ultimate limitation.

Several arrangement schemes for the individual racks can be employed to reach these minimum length-to-thickness ratio values. One-to-one relatively small ware packages or small round ware packages can frequently be combined on single racks two or three pieces wide to make up the 2.5:1 planform shape. And racks less than 2.5:1 can be built double width to take them to 4:1 or greater, for example.

Immovable structural elements of the processing equipment (openings in the floors of heat seal ovens is an example), drop screens, or parts of the building itself can limit the lane width and hence the maximum rack width in the yawed position. This can sometimes complicate an otherwise flawless application. Before building a system to incorporate them or considering retrofit of an existing system, a thorough takeoff must be done before the Angle Pivot devices are decided upon and designed. Even systems that use standard components will also usually require custom features to supplement them.

***Figure 8** – C-hooks are custom designed for each system.*

***Figure 9** – Positive lock rotators are double-detent devices that may be turned (manually or automatically) to facilitate loading and unloading.*

***Figure 10** – Rotation-stop equipped load bars for use with non-counterweighted C-hooks.*

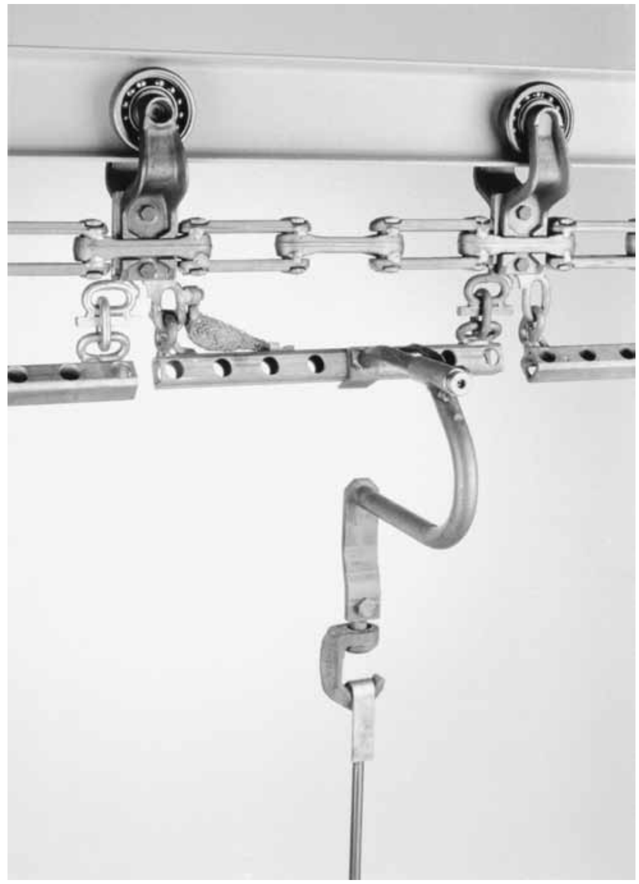

***Figure 11** – Ground-braid-equipped load bars and integral bearing C-hooks for nonyawing service in E-coat systems.*

Characteristics of Angle Pivot™ System Candidate Lines

The Angle Pivot™ tooling system is applicable to overhead monorail finishing systems, both continuous and power and free systems. It will work on all types of conveyors. System prerequisites are:

- Inclines and declines in the routing: 30° is minimum, 45° is excellent, 60° is possible. Improvements in production rates of 20-50% are possible.
- A ware package that is significantly thinner in the third dimension, with the third dimension disposed perpendicular to the plane of the conveyor. Minimum length-to-thickness ratio is 2.5:1; less than this will touch on horizontal corners at minimum spacing.
- Steady conveyor drives, so parts don't get into a "chiming" condition.
- Need for a production increase. Quality enhancement and paint savings from better FPTE are nice sweeteners but will usually not sell by themselves.
- A mechanized method of paint application must be used for the majority of the finish material. This avoids the hand spray painter problem.

Conclusions

In any plant where production finishing is performed, the finishing lines, taken as functional unit, are by far the largest and most expensive machines in the plant. Usually they are designed to accommodate the then-current production plus a 30-100% increase, so capacity is not a restriction to plant output over the intended life span. Some additional incremental increases in capacity are obtainable by boosting line speed (at a sacrifice in quality) or by adding piecemeal to washers, booths, and ovens. Angle Pivot™ tooling can provide another way to obtain this incremental increase without the quality, downtime, space, or environmental permit limitations inherent in other methods.

***Figure 12** – Eye bar tools for flat parts of varying widths on continuous load bar systems.*

***Figure 13** – Paired J-hooks with pivot angle built into top, mounted in the same hole on continuous load bar systems.*

***Figure 14** – Discrete devices built integral with the rack top for use on power and free systems.*

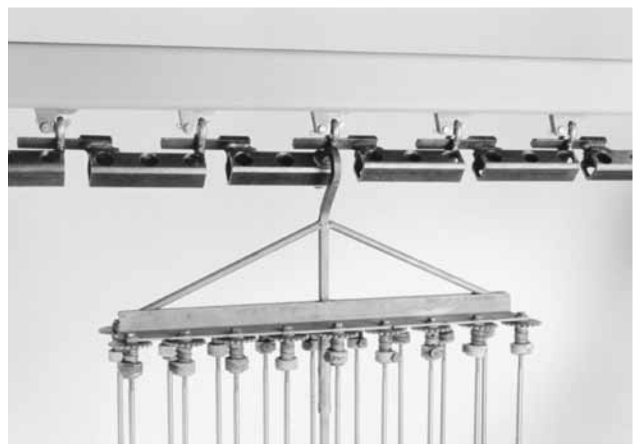

***Figure 15** – Power rotators for small round parts, built into the proper configuration for angle pivot use.*

On new lines, more plant floor space is made available by the ability to roof or overhead mount more easily most of the equipment plus all of the connecting conveyors.

In both cases the fringe benefits of increased transfer efficiency, better tracking, reduction in haloing, and 2" spacing intervals around the entire system are nice enhancements.

These tools are covered by U.S. Patent Numbers 5,000,309; 5,226,525; 5,253,742; 5,303,815; and 5,566,815, plus others pending.

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