The Angle-Pivot™ Tooling System For Powder Finishing Conveyors

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Introduction

Overhead monorail conveyors carrying parts through paint or porcelain spray finishing systems almost always require altitude changes from floor level when traveling between the various processing steps. Since the cleaning and painting operations require the racks to be disposed in the plane of symmetry of the conveyor, they must be spaced apart sufficiently that the horizontal foreshortening on inclines and declines does not cause adjacent racks to contact each other. Minimum pitch between racks on a system with 45° incline/decline angles, for example, is 1.5 times the rack width. By the use of an articulated linkage in the rack-to-conveyor attachment point, the racks may be automatically rotated up to 70° about a vertical axis during the transition from level travel into an incline or a decline. This necessitates only that the thickness dimension of the rack be accommodated in the foreshortened horizontal distance, and permits an essentially *Solid Wall* of parts to pass through the level racking, cleaning, painting, baking, and packing operations. By merely changing the tooling, the throughput capacity of an existing system can be increased 20–50%, maintaining the existing processing cycle times and changing only the feed rates of paint and pretreatment chemicals.

Figure 1

Description

The active element of the articulation linkage is a horizontal bar suspended by loosely mounted hooks from two adjacent conveyor chain links (***Figure 1***). Similar elements are used to provide load spreading between links or trolleys, to increase the capacity of a conveyor for single-point loads. The distinguishing feature of the Angle-Pivot linkage is the angulation from horizontal of the central pivot axis. By tilting the pivot axis by the appropriate amount, single-hung individual racks may be made to assume any angle up to 70° from the plane of the conveyor on inclines and declines.

There is a unique relationship between incline/decline angle, yaw angle, and the angle down from horizontal (called the *pivot angle* – see ***Figure 2***) of the central pivot axis, so that the appropriate yaw angle can be designed into each individual rack. The rack will actually *tell* the horizontal bar how far out of the plane of symmetry of the conveyor, to turn it. In this way, single-hung long parts may be turned out of the plane of the conveyor only slightly, while shorter and thicker parts may be yawed as much as necessary. With long parts which also have some thickness, a compound linkage tool can be used to yaw the parts quickly during the first fraction of the transition, then maintain that yaw angle to remain within the width envelope. ***Figures 3 and 4*** show this relationship in graphic form, for two popular incline and decline angles.

The spacing of trolleys or conveyor chain links along a line almost always results in wasted envelope space when processing wider parts, because parts that are too close must be bumped out another 6", 8", 12", 16", 18", or 24" to catch the next hang point. Horizontal load bars containing multiple holes on two or three inch centers

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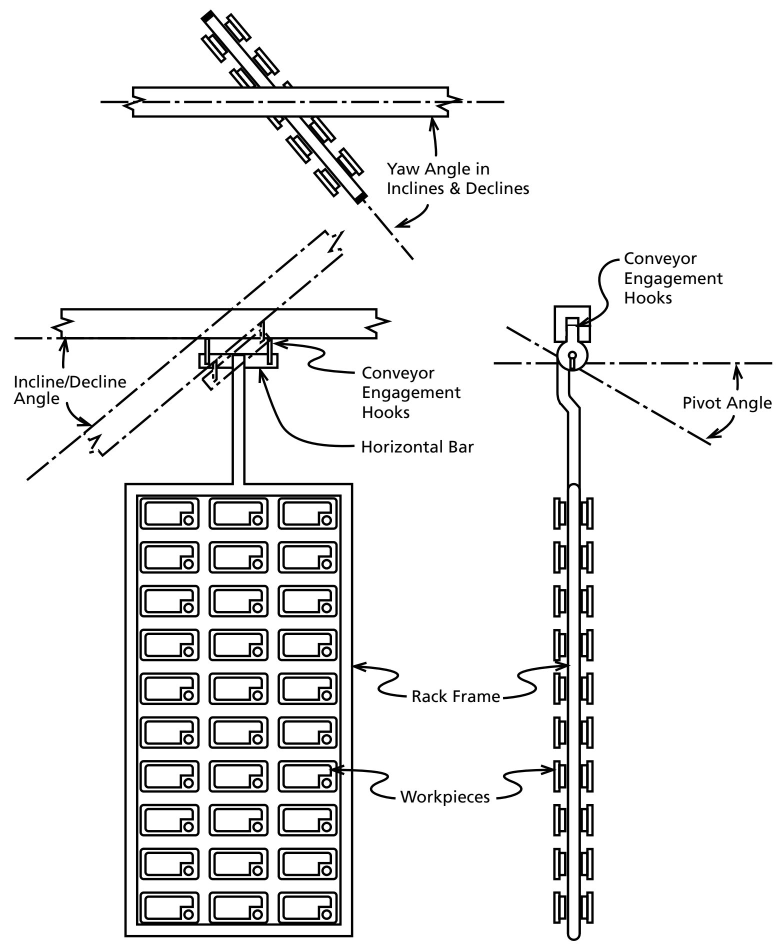
may be used to span between the links or trolleys and form a continuous row of holes around the entire system ***(Figure 5)***. By means of this, empty line space due to trolley/link spacing restrictions and the necessity to maintain clearance in inclines and declines, can be virtually eliminated. Remaining minimum spacing restrictions are established by coverage requirements on vertical part edges, corner-to-corner clearance on the horizontal turns, or an edge touch in *pushover* transitions from level to decline, and incline to level. An electronically controlled, programmable LED bar spacer sign is used to assist tool change operators in maintaining proper tool positioning on the load bar row.

Figure 2

Angle-Pivot™ Paint Rack – General Arrangement and Terminology



Advantages

Recalling *Engleberger's Law* on robotics, an increase in productivity is always good because one can decide how to take advantage of it. Here are the advantages of the Angle Pivot™ system, along with a short explanation of each:

1. **Maximum Production Rates from the Line** – Can beat H-attachment mounted tooling by 20–50%. This provides necessary capacity increases in existing systems, and will permit new systems to be built smaller and cheaper.
2. **Better First Pass Transfer Efficiency.** Having a solid wall of parts in front of the guns at all times gets a maximum percentage of sprayed powder onto the parts and a minimum onto the booth walls, floor, and overspray collection system. This minimizes the *milling* of the powder particle sizes from the optimum 20-50 micron size at which they are packaged, down to 5–10 microns and below. These *fines*, if created by many successive passes through the spraying collection systems, will reduce the ability of the sprayed powder to accept a charge from the ionized air surrounding the spray gun charging electrodes. They also have a much-increased surface area to volume ratio, rendering them more susceptible to aerodynamic drag and inhibiting the ability of the powder to deposit a usable film thickness in recessed areas of the workpiece primary surfaces.

   Other advantages of better FPTE are reduced powder residence time in the booth, which reduces exposure to foreign material contamination, and reduced squeegeeing of the booth walls and floors to get the oversprayed powder back into the collection system.
3. **More Accurate Gun-to-Part Spacing.** Tracking or yaw stability of the individual workholder tools is established across the entire *wheelbase* of the load bar, rather than the 3/8 to 1/2" width of engagement surface between the hook and the clevis pin through the trolley H-attachment fittings. With well maintained workholder tools, tracking accuracy of ± 1/4" at the edges of the rack can be consistently achieved. This removes another variable which can otherwise cause uneven coverage from leading to trailing edges of the workpiece envelope.

4. **Mutual Robbing Between Vertical Edges.** As vertical edges of the work envelope of the racks are brought within 2"– 4" of each other, the high current density surrounding the edges is brought much closer to the average value at the center of the envelope. This reduces the *haloing* or *picture framing* tendency which would otherwise cause heavier film deposition on these edges. With solid colors this causes some waste of powder. In systems spraying metallic or tinted clear, a color shift at these heavier edges will also occur. Control on three of the four edges can be obtained if a grounded *robber* or *cheater* bar is mounted from the booth floor up to a similar distance below the bottom of the envelope. Leveling of millage of powder frit between edges and center of porcelain enameled appliance panels will reduce the edge chipping tendency, in both assembly and in field installation of the complete washer or range units.
5. **Sixty–Degree Incline and Decline Capability at No Loss in Capacity.** This is advantageous if equipment modifications impose routing constraints on the inclines and declines of an existing system, or if heat-seal washers and ovens with bottom entry are used in the design of a new system.
6. **Availability of Rotators and/or C-Hooks.** Two or four position detended rotators, with manual, star wheel, or torpedo actuation, can be used with the continuous load bar Angle Pivot™ system at any time, to facilitate coverage or to ease the loading and unloading of the tools. C-Hooks with sanitary pans below the load bar row may also be employed for an additional increment of cleanliness in the washer-though-oven portion of the system.

Pivot vs. Yaw Angles for 30° and 45° Incline/Decline

Figure 3

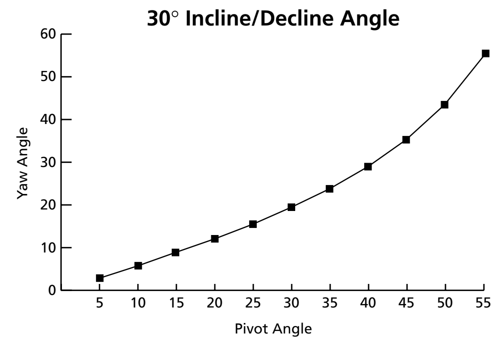
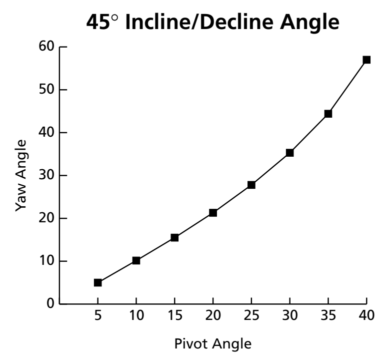


Figure 4



7. **Fast Installation.** With proper advance preparations, conversion of a line to the Angle Pivot™ system can be accomplished over a long weekend or a vacation shutdown. Comparable capacity increases from any other source will require major equipment surgery to extend washers, ovens, and cooling lanes, resulting in protracted down time at the minimum and possibly also the acquisition of additional environmental permits.
8. **Increased Equipment Maintenance Time.** Taking a three-shift painting operation to two shifts will enable necessary routine maintenance and cleaning to be performed on the third shift. This will increase yield percentages of good parts on the two production shifts, and will probably help solve the supervision problem that all third shift production operations seem to share.

Figure 5

Suggested Cost Savings Calculation

Since the adoption of Angle Pivot™ tooling on an existing line will nearly always result in a significant capacity increase, it is conservative to use this by itself in initial payback calculations. This way the other less-quantifiable advantages will count as *fringe benefits*. Present per-part labor and material usages will not be significantly reduced, except indirectly through reduced production of rejects.

Three parameters must be determined to perform the calculations:

- Running Hours per Day
- Percentage Production Increase from Conversion
- Zero-Production Cost of running the line. This is the cost to run all blowers, fans, pumps, burners, air conditioners, air compressors, etc., and to have fixed-cost supervision, material handling and quality control personnel in place, but with no hanging and packing crew present and no powder coming from the spray guns.

Calculations are as follows:

Assume:

- 16 hours per day present running time
- 30% increase from the conversion
- $150 per hour zero production cost

If improvement is taken as increased production:

1.3 x 16 hrs./day = 20.8 hours of production per day will come from 16 running hours

This is a gain of **20.8 – 16 = 4.8 hrs./day**

(4.8 hrs./day) ($150/hr.) (250 production days/yr.) = $180,000/yr. savings

If improvement is taken as early shutdown:

16/1.3 = 12.31 hrs. run to produce 16 hrs. worth of parts

This is a gain of **16 – 12.31 = 3.69 hrs./day**

(3.69 hrs./day) ($150/hr.) (250 days/yr.) = $138,461/yr. savings

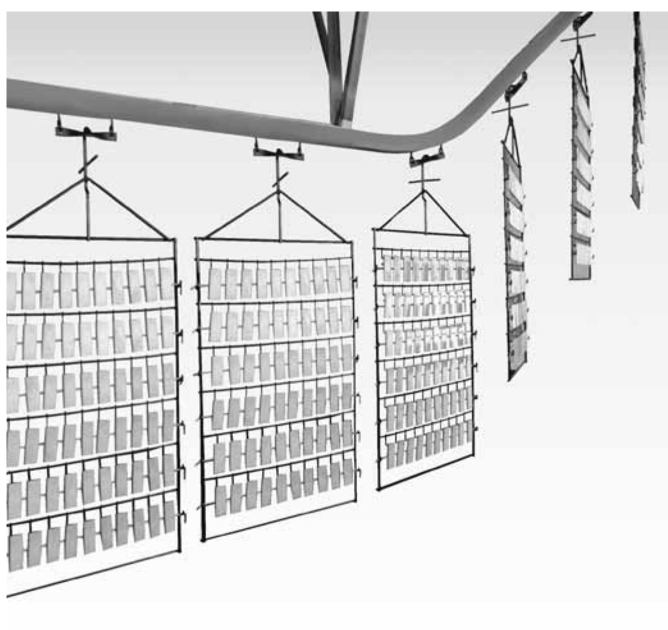
Actual situation will be somewhere between these two extremes.

Conclusions

There is an old adage in the painting business that if you can't walk through the parts on your line, you're making money with it ***(Figure 6)***. Angle Pivot™ tooling offers an effective way to do this, but it is important to note at the outset what can and cannot be expected. Per-part usages of labor and paint may not be significantly reduced (except indirectly through reduced production of rejects). Logistics at the hanging and packing areas may require attention because crew sizes will increase with production rates, and increased marshalling area for pallets and boxes, may be required. Off-line racking of small parts, and transferring the loaded tools onto and off of the line, many become more attractive.

The single disadvantage of Angle Pivot™ tooling is that, on the continuous load bar system for an external chain conveyor, the ability to break the chain and collapse or *Stack* it in the loading area and dryoff oven during pickling of the washer, is lost. If this is intended, a switch or strong-back at one end of the machine will permit removing the chain into tubs or onto the plant floor.

Figure 6



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.