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COATINGS

FLAT-LINE POWDER COATING APPLICATIONS

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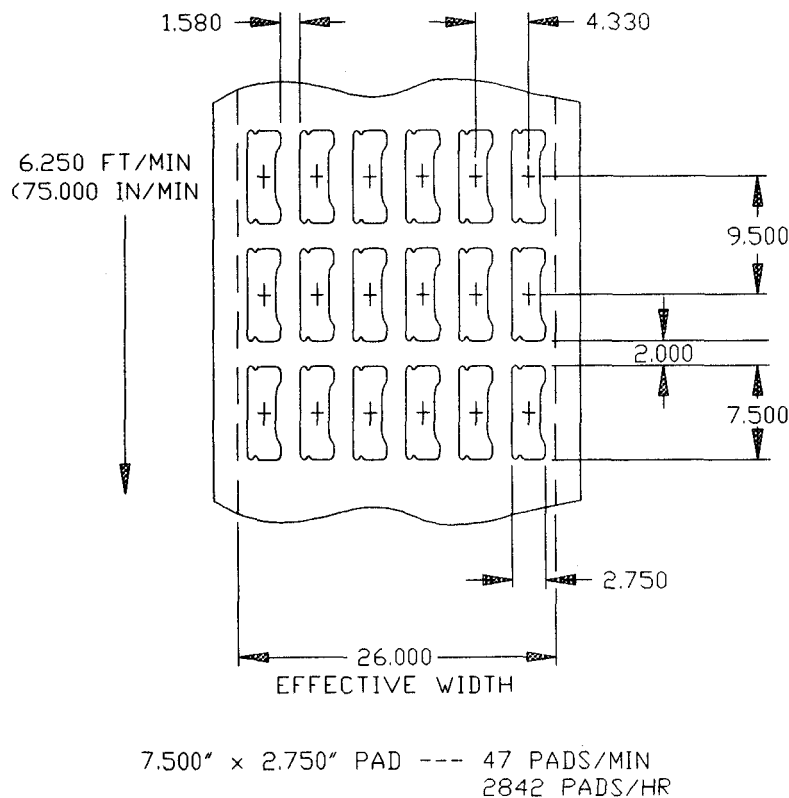
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ABSTRACT

Most everyone involved with an industrial finishing application or working in an industrial finishing environment is familiar with the powder coating process to some degree. But what exactly is flat-line powder coating? It is essentially the powder coating of two-dimensional and three-dimensional parts conveyed on a flat belt conveyor or suspended through the booth and conveyed horizontally. Typically, three dimensional parts powder coated “in the flat” are parts that were previously hung vertically. In addition to three dimensional parts, flat-line powder coating may in many cases be the only viable method for applying powder to a two-dimensional substrate.

Three -Dimensional Parts

Brake pads, automobile wheel weights, air conditioner condenser coils, steel I-beams for flat-bed trailer frames, and door skins are all examples of three-dimensional parts that are currently being powder coated horizontally, or in the flat. In each case, prior to making the transition to flat-line powder coating, these parts were coated vertically. The previous vertical coating process could have been a liquid dip-coat, liquid spray, and yes, even a powder spray application. You may ask then, why would someone with a current coating process for three dimensional parts, or even a new coating process for three dimensional parts consider purchasing or converting to a flat-line powder coating system? Flat-line powder coating offers several advantages that cannot be attained with the conventional process of coating vertically hung, three dimensional parts. Ease of material handling, greater line density, and part masking are only some of the advantages that will be covered in detail.



(fig. 1)

Material Handling & Line Density

From a material handling as well as equipment configuration standpoint, a powder coating flat-line system requires less material handling and the overall system is more compact. No parts hangers are required to hang the parts vertically. Therefore, the problems associated with hangers such as repairing or replacing damaged hangers, as well as cleaning coated hangers do not exist. Also, from load station to unload station the entire system is completely automatic. For example, a typical flat-line system for coating brake pads would begin with the loading of brake pads into feed chutes. The "load station" typically consists of anywhere from six to eight load chutes. This allows for a predetermined spacing between rows of parts. The parts are dispensed automatically onto a flat "feed" or "ramp-up" conveyor prior to the powder spray booth. In addition to a uniform spacing between rows of parts, automatic feed allows for a uniform spacing between trailing and leading edges of parts. All of this allows for minimum spacing between parts, or "maximum line density" (see fig.1).

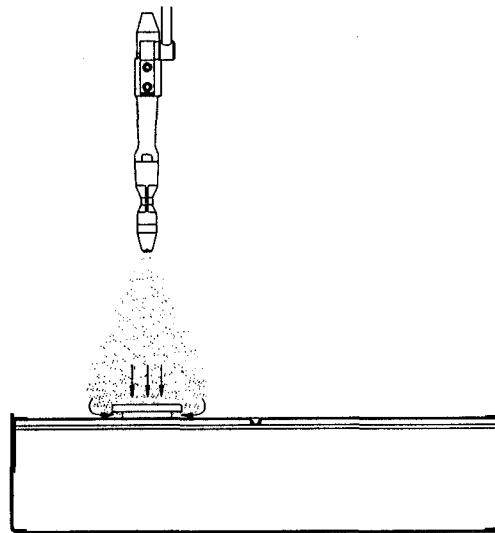
Masking

The belt material for the spray booth conveyor can either be of a solid rubberized material or of a stainless steel wire mesh material. Utilizing a solid belt offers the ability to "mask" the underside of the part, something that would be difficult, if not impossible, to achieve if the parts were hung vertically. The only section of the actual brake pad assembly that requires paint is the top of the "backing plate", which is facing up as it is coated. A small amount of paint or "wrap" is required on the opposite, or underside of the backing plate. Most of the underside is the actual abrasive brake material, however, some metal is still exposed and requires coverage. The abrasive surface of the brake pad is actually face down on the belt. In an overhead vertical powder coating application the abrasive surface would see enough paint to require a post machining or grinding process. In a flat-line application, with the abrasive surface laying face down on the flat belt, effective masking is achieved and the post machining or grinding process is not required (see fig. 2).

Grounding

Effective masking achieves the desired result of no powder where it is not required. An effective earth ground is essential in achieving complete and uniform coverage where powder is required. On an overhead vertical line this is accomplished through an earth ground on the conveyor. As long as the part hangers are kept sufficiently clean, the part being coated will maintain a path to ground. Since the brake pad in a flat-line coating

application is being conveyed on a flat belt, this becomes somewhat of a challenge. One method of grounding is to suspend a ground bar with whiskers that are aligned with each row of parts. The ground bar is positioned before the guns such that the whisker is still making contact with the part as it is being coated. The only drawback to this method is that the ground bars are eventually coated with powder and need to be cleaned periodically. A more effective method is to use a flat belt made of a conductive or semi-conductive material. Provided the belt is properly grounded, and the belt is kept sufficiently clean, the part being coated will maintain an adequate path to ground.



(fig. 2)

Powder Application & Cure

As the brake pads transition from the ramp-up conveyor onto the conveyor traveling through the powder spray booth, the actual line speed can range anywhere from 3 fpm to 16 fpm, depending on what the customer has specified. Powder is applied overhead with automatic powder spray guns. Depending on the complexity of the part shape, the powder spray gun can either be a corona-charging or tribo-charging style of gun. Also, depending on the part shape complexity, the guns may either be fixed, or oscillating back and forth. No manual touch-up is required. Any powder that lands on the belt is collected and re-sprayed. The conveyor is dedicated and contained within the spray booth. A dedicated spray booth conveyor is essential in eliminating the potential for contamination of other processes. As the brake pads leave the spray booth, they transition onto the conveyor that travels through the IR (infrared) curing oven. The same conveyor that travels through the oven then carries the parts through a cooling zone. Finally, the parts exit the cooling zone

and are loaded manually into storage bins. The only time the brake pad is touched by human hands is once at the beginning of the coating process and once at the end of the coating process. The entire flat-line powder coating process requires less floor space than a conventional “overhead” vertical coating line in that the miles of overhead conveyor are no longer required. Also, the total cycle time of an IR oven is far less than that of a conventional gas fired oven and as a result requires far less floor space.

Two-Dimensional Parts

The flat-line powder coating of two-dimensional parts such as “blanks” as well as continuous steel and aluminum “coil” is quickly becoming an emerging technology. Blanks are flat metal sheets (sheared to length from coil stock, and punched with all of the required holes and notches) that are powder coated before they are formed. This type of substrate is also known as “post- formed”, but more commonly referred to as “pre-coated”. The flat-line powder coating of blanks and coil offers all of the advantages gained by powder coating three-dimensional parts horizontally as well as higher transfer efficiency, and higher production rates.

Blanks

Although there are presently only a handful of powder coating blank systems in the world (and even fewer powder coated coil systems), this process is beginning to gain wide acceptance in Europe, South East Asia, and the United States. Most of the players in the United States producing powder coated blanks are household appliance manufacturers, powder coating blanks for washer, dryer, oven and even larger refrigerator panels. Making the transition from powder coating three-dimensional parts hung vertically to two dimensional parts conveyed horizontally is a major step, as well as a substantial investment. However, the manufacturers that have done so, recognize that powder coated blanks offers them the following benefits:

◇ STORAGE

A single pallet (approximately 400 pieces) of powder coated blanks requires far less storage space than the same number of formed panels. Since a powder coating blank line is a high speed process and requires no special gun set-up for a particular shape, a manufacturer can coat a complete unit for immediate forming and assembly.

◇ PRODUCTION RATES

Current blank line installations are coating at line speeds of anywhere from 30 fpm to 75 fpm. Powder coating equipment technology is available today that will apply a uniform coating at close tolerance (coating thickness) in excess of 100 fpm.

◇ AUTOMATION & FLOOR SPACE

The entire process, more importantly the powder coating system becomes more automated with blank line powder coating. No manual touch-up or sophisticated gun moving equipment is required as with conventional overhead lines. The loading and un-loading of parts is done automatically as opposed to manually, and since the parts are flat, these stations are more compact than three-dimensional part load and un-load stations. The IR oven not only reduces total cure time, but requires far less floor space than a conventional gas fired convection oven.

◇ TRANSFER EFFICIENCY

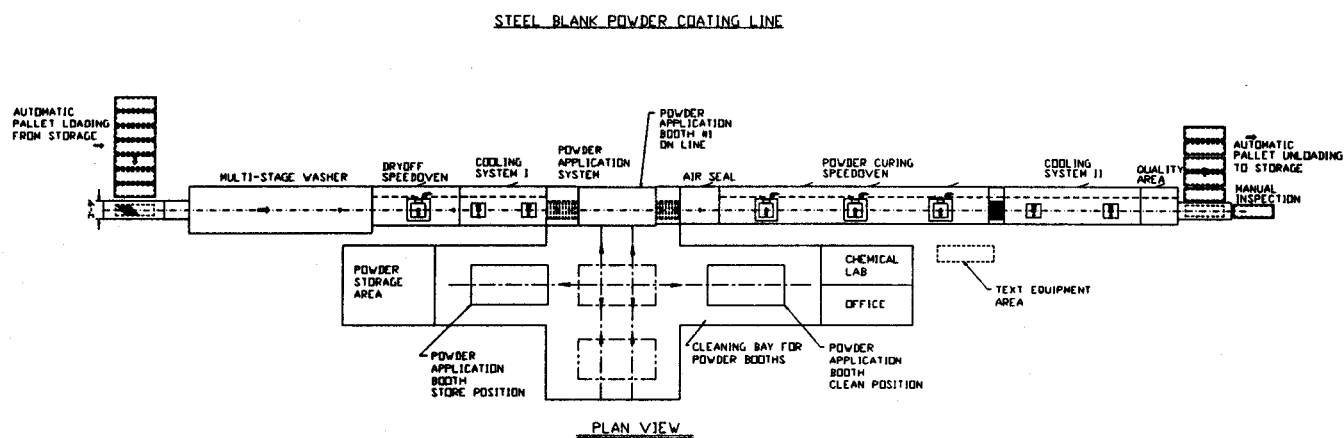
Transfer efficiency is possibly the most important benefit of all, because it translates into direct material cost savings for the customer. A flat part is much easier to coat since there are no recesses or corners to coat, so less powder is applied initially. Part spacing is also kept at a minimum, so more powder goes ON the part rather than past the part, resulting in higher FIRST PASS transfer efficiency. All of these factors result in transfer efficiencies in the low to mid ninety percentile range.

The Process

A typical blank coating line (see fig. 3) begins with a pallet of blanks being brought over from the stamping process and loaded onto the "de-stacker". The de-stacker is a highly sophisticated, high speed loading device equipped with suction cups that load a blank onto the washer conveyor. The washer conveyor is typically of a driven roller configuration so that spray nozzles can be positioned to clean the underside of the part as well as the top of the part. After the necessary cleaning and rinsing stages, the part continues on to a dry-off zone, and then enters what is commonly referred to as the "dry- in-place" zone. This is where either a chromate or non-chromate sealer is applied. Before entering the spray booth, the part continues on to another dry-off zone and then a cooling zone.

The blank transitions from the cooling zone onto a separate conveyor inside the spray booth. This conveyor is essentially two separate conveyors with one common drive. The

first section is a semi-conductive flat belt conveyor where the top side is powder coated. The blank then transitions onto a disc conveyor, still inside the spray booth, where a dust coating is applied to the underside. This dust coating is also known as a “slip coat”. This slip coat is actually a form of lubrication and allows the part to pass through the forming equipment without sticking.



(fig. 3)

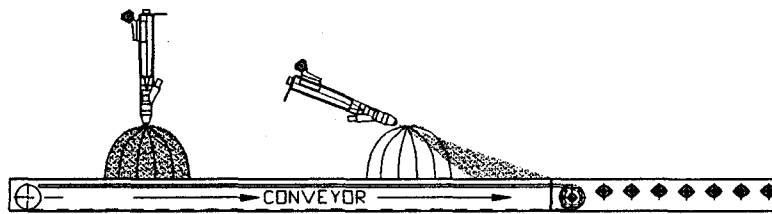
As the coated blank leaves the spray booth, it enters into the combination electric IR/gas convection oven. The part passes through the separate cure stages in a total time of approximately 90 to 180 seconds. As the cured blank leaves the oven it enters a cooling zone. The final stage is the “stacker”. This device looks identical to the de-stacker and performs essentially the same operation in reverse. At a line speed of 75 fpm, the total cycle time from de-stacker to stacker is approximately 5 1/2 minutes.

Single Side vs. Double Side Coating

As previously mentioned, the finished or appearance side of the blank is typically the top side, and the unfinished or dust coat side of the blank is typically the underside. There has been some discussion as to whether or not both sides can be coated with a finish coat. This may present somewhat of a material handling challenge if attempted with blank coating. It is, however, quite possible with powder coated coil. Since coil is suspended from the point that it enters the spray booth, to just past a point in the oven in which the powder begins to gel, a finish coat can be applied to both the top and bottom without the risk of any support marks or adhesion of the ware to a conveyor. Even with a “two-coat/two-fire process”, and turning the part over between coating applications there is the potential for re-gel of the first coat if attempted with blanks.

Tribo vs. Corona for Powder Coating Blanks

There are essentially two types of powder charging guns on the market today. One is based on the corona charging principle. An electric field emanates from an antenna near the tip of the gun. As the powder particles pass through the electric field, they become negatively charged. This type of gun is quite effective for relatively low-speed, vertically hung part applications. However, it does have some limitations when used for the high speed powder coating of blanks (see fig. 4). In order for a powder particle to become charged, it must pass through the electrostatic field in front of the gun. This requires the gun to be positioned perpendicular or near perpendicular to the part. The main limiting factor for a corona charging gun is line speed. At line speeds of just above 30 - 35 fpm, a "boundary" layer of air begins to form above the blank as it is conveyed on a flat belt. This boundary air tends to distort the gun's fan pattern. This adverse effect is also known as "brooming". The logical solution for this problem would be to angle the gun in a "lag" position so that the powder would flow in the same direction of part travel. However, with the gun in this position, the electrostatic charge is seeking the shortest path to ground, which is straight down to the part. The end result is that the powder particles are no longer passing through the electrostatic field.



(fig. 4)

The "tribo-charging" principle is based upon the known phenomena of frictional charging. As the powder particles pass across the interior cylinder of a tribo gun at a relatively high velocity, the negative electrons are stripped away, and the powder particles become positively charged. Since the particles are charged in this manner, and are not required to pass through an electrostatic field, the gun is allowed a much greater freedom of position in relation to the part. This results in the tribo gun being a much better fit for the high speed powder coating of blanks. In addition to positioning the gun so that powder flow is in the same direction as part flow, powder flow rate pressures can be adjusted such that the powder particles and the ware are traveling at co-speed (see fig. 5). This allows for a highly uniform distribution of powder within a close tolerance at a relatively high speed.



(fig. 5)

FLAT-LINE CONVEYORS

Much of the technology that is applied to the design of the actual conveyor mechanism for flat-line powder coating already exists and has for some time. In addition, some of the current technology for cleaning the conveyor belt has been developed from similar applications. However, being that so much technology already exists, the difficult task is in determining the right mechanism, device or combination thereof for a particular process.

Design

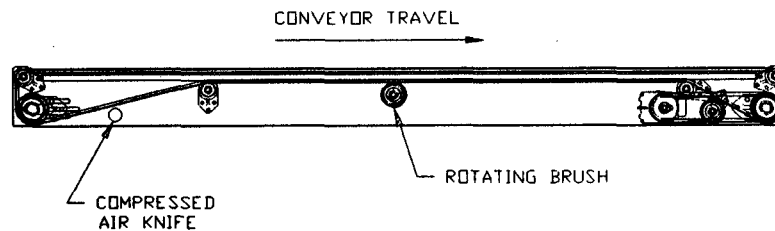
For example, when choosing the proper type of belt material, consideration must be given to pulley size. Optimally, a smaller pulley is desirable, especially if the ware being coated is small. This will allow for smooth transitioning of the part without the use of additional, smaller, transfer conveyors. Pulley size is directly related to belt ply (in the case of a solid belt) and belt life. A belt should never travel around a pulley that is smaller than what is recommended by the belt manufacturer. Doing so will result in reduced belt life as well as unwanted stress on the conveyor mechanism. The belt material must also be resilient enough for the shape, as well as the total weight of the parts being conveyed.

Application must also be considered when choosing the right belt material. All powder coated blank applications, as well as many three-dimensional part applications require adequate grounding of the part, effective masking of the underside, and perfect repeatability of part positioning. Perfect positioning means that the belt cannot sag, causing the "part to gun tip" distance to change. It also means that the belt must track straight and not wander from side to side. Belt sag can be eliminated by allowing the belt to ride on a flat surface between the entrance pulley and the exit pulley. Perfect tracking can be achieved by attaching a v-belt on the underside of the conveyor belt. Provided the pulleys are large enough, a groove is machined in the center of the pulley to accept the v-belt. This results in positive tracking of the belt, and eliminates side to side wandering. Crowned rollers and off the shelf add-on tracking devices are fine for simple bulk handling situations, but are not recommended for precision powder coating applications. Effective grounding of the part being coated can be achieved through the use of a conductive or

semi-conductive belt material. The belt is then grounded with a heavy duty grounding brush that is connected to earth ground. Effective masking of the underside of the ware requires a smooth, non-textured, CLEAN belt surface.

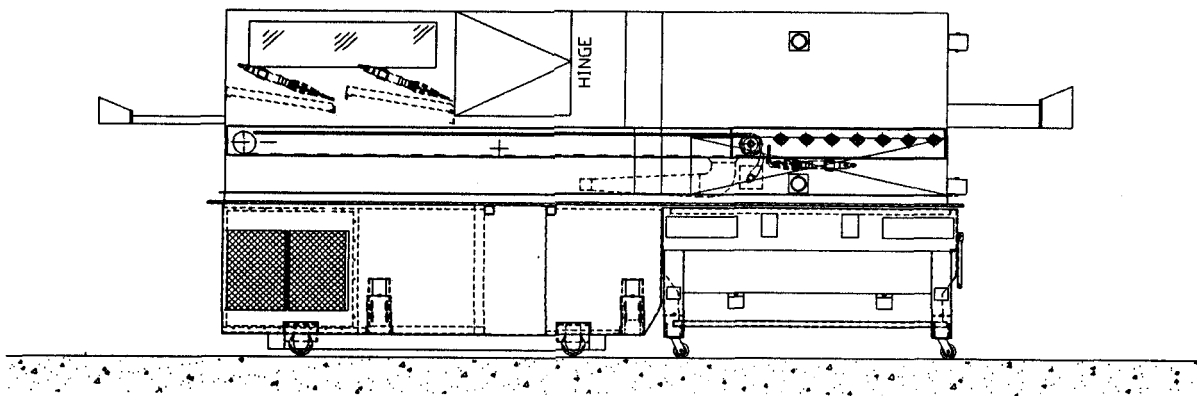
Cleaning

There are a number of effective devices or combinations of devices that will effectively clean a flat belt conveyor. Cost, space, and available utilities should be considered when choosing a device or combination of devices for cleaning a flat, solid belt. One effective, low cost, space saving combination is an air knife with a rotating cylindrical brush (see fig. 6). As the belt travels to the underside of the conveyor, and while it is still over the cartridge filter collector, a rotating brush spinning opposite the direction of belt travel will remove the bulk of powder that is on the belt surface. Just before the belt returns to the top side of the conveyor, a compressed air knife removes the rest of the powder still on the belt. Although brush life is extremely good, space requirements are minimal, and initial cost of both devices is low, they do accrue a certain amount of daily operating cost. The air knife consumes approximately 130 cfm of compressed air at roughly 30 - 40 psi for every 36" of belt width.



(fig. 6)

Another effective combination is a tensioned urethane blade followed by a vacuum head (see fig. 7). The tensioned urethane blade first removes the bulk of powder on the belt and is positioned over the cartridge filter collector. Still positioned over the collector is a vacuum head. The leading edge of the vacuum head is equipped with a nylon bristle brush, while the trailing edge is equipped with a urethane blade. This is an extremely effective method for cleaning a belt in that the belt is wiped, brushed, vacuumed and then wiped. Brush and wiper blade wear is good, and the cost of electricity to run the vacuum blower is relatively low. These devices, however, require quite a bit more space than the air knife and rotating brush combination. Although it is not figured into the space required of the conveyor inside the booth, the vacuum unit (vacuum source for the vacuum head) requires additional overall system space.



SIDE VIEW

(fig. 7)

Color Change

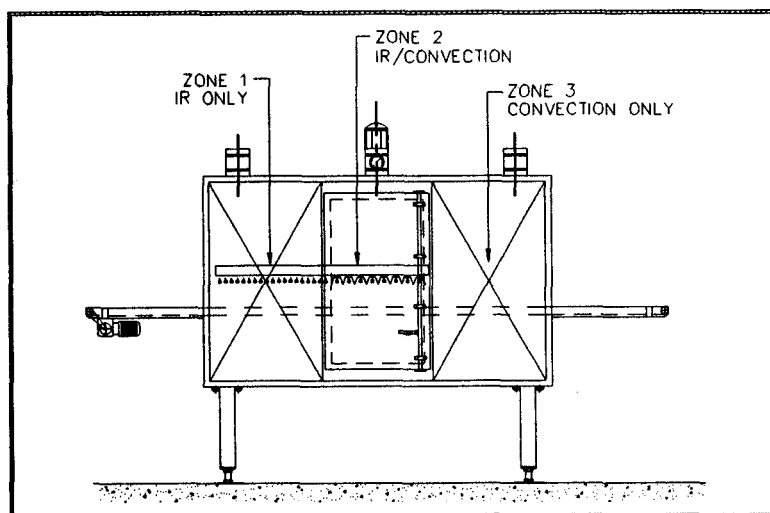
A clean belt is essential to the appearance of the underside, or “masked” side of the part. As a clean belt is instrumental to a quality, finished part, a quick and easy to clean powder system is essential to high productivity and lower operating costs. With a conventional overhead vertical application, the conveyor is positioned externally, above the spray booth. In a flat-line powder coating spray operation, however, the conveyor is now an integral part of the spray booth and should be calculated into the total time required for changing colors. Switching conveyors (for respective colors) is certainly quicker than the time required to clean conveyors, however, the initial cost of additional conveyors must be weighed against the daily cost of cleaning conveyors and the associated “down time”. In order to determine the economics of a given flat-line powder coating operation, careful consideration should be given to cost of labor, number of colors, and frequency of color change. Once these are defined, the following options may help determine which equipment configuration is the most cost effective for a given operation. They are listed in order from higher cost and less time required to change colors, to lower cost but more time required to change colors.

1. Multiple roll-on/roll-off booths with dedicated conveyors for each color.
2. Single roll-on/roll-off booth with additional removable conveyors for each color.
3. Single roll-on/roll-off booth with removable conveyor and additional belts for each color.

CURING / INFRARED vs. CONVECTION

Infrared (IR) curing is by far the only choice for curing flat-line powder coated parts, especially for two-dimensional parts such as blanks that are coated at higher line speeds. Compact size, faster cure rates, and shorter cycle times are all benefits that cannot be attained with conventional gas fired ovens. Although a typical IR oven used for curing blanks at high speeds requires some convection in it's final stage, the oven as a whole still requires less space than a gas fired convection oven would at lower, more conventional speeds. An IR oven has the ability to bring a part up to peak metal temperature much quicker than a gas fired convection oven. This is what is meant by faster cure rates. Since cure rates are faster, total cure cycle time is much shorter in an IR oven. Total cycle times as low as 90 - 180 seconds are not uncommon in an IR oven, as opposed to 12 -15 minutes in a gas fired convection oven.

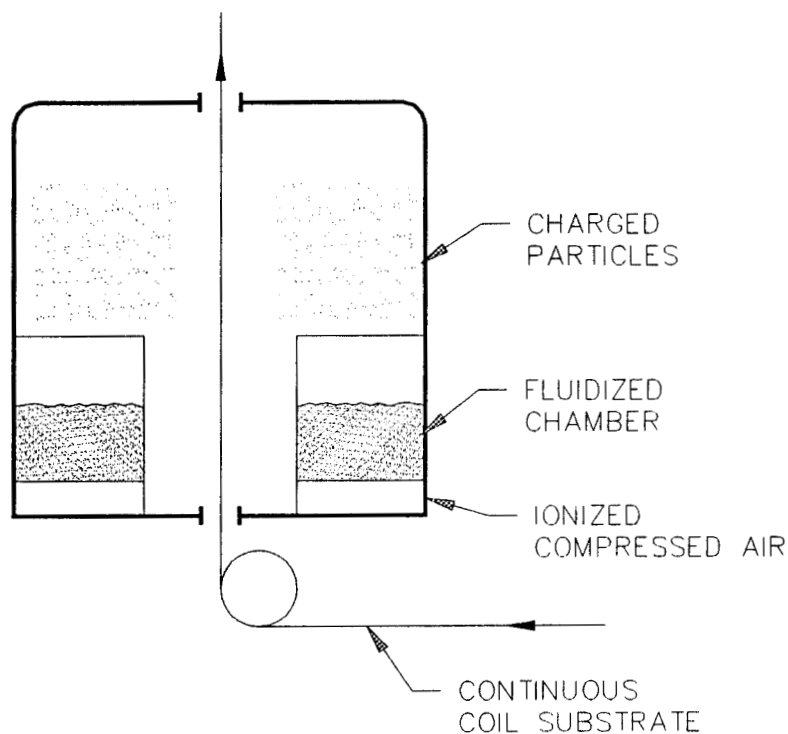
A typical combination IR/gas convection oven consists of three stages or "zones" (see fig. 8). The first zone is strictly IR only and is sometimes referred to as the "pre-heat" zone. In this zone the part is quickly brought up to peak metal temperature, and the powder material begins to gel. The second zone, sometimes referred to as the "equalization" zone, combines IR and indirect natural gas convection. In this zone, the powder continues to cure, as well as bond to the metal substrate. The third and final zone, sometimes referred to as the "holding" zone, is strictly gas convection. This is where the final cure takes place, and coating hardness is achieved.



(fig. 8)

ELECTROSTATIC FLUIDIZED BED / A COATING ALTERNATIVE

An electrostatic fluidized bed or chamber is a readily available coating alternative that is suited more for CONTINUOUS, two-dimensional substrates. A typical fluidized chamber (see fig. 9) consists of essentially two sections. The top section is the actual coating chamber that contains the cloud of fluidized powder. The bottom section is commonly referred to as the fluidizing plenum. The plenum is essentially a box with one side, typically the top, being of a porous plastic material. As the plenum is supplied with compressed, ionized air, it passes through the porous material causing the particles to become charged as well as suspended in a "fluidized" state. The continuous substrate is suspended inside the coating chamber as it is being conveyed. Film build is typically controlled by the speed of the substrate as it is conveyed through the fluidized chamber. Film build can also be enhanced through pre-heating of the substrate. As stated previously, this type of coating process is well suited more for substrates such as continuous metal and paper coils, woven and non-woven fabrics, as well as metal wire and cable.



(fig. 9)

SUMMARY

Flat-line powder coating offers several advantages that cannot be attained with the conventional process of coating vertically hung parts. The flat-line powder coating of three-dimensional substrates results in ease of material handling (more automated), greater line density (higher production rates), and effective part masking. In addition to these benefits, the high speed powder coating of two-dimensional substrates offers even higher production rates and requires less storage and floor space for finished parts and processing equipment. Possibly the most important benefit of all is powder material cost savings due to higher transfer efficiencies.