Rapid Cycle Coating Techniques for Cell Manufacturing

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ABSTRACT

Metalizing for functional and decorative applications has long been an off-line batch process usually requiring climate controlled clean rooms and equipment costing in excess of $1,000,000. Large batch processing methods allow time for parts to absorb moisture and accumulate other types of contaminants [1]; cleaning procedures and base coats are often needed to achieve proper coating adhesion. In-line processing methods address these concerns and also increase yield and reduce the need for cost prohibitive part storage. We will discuss the advantages of using rapid cycle coating equipment designed for in-line, production floor deposition of EMI coatings for shielding and reflective/decorative coatings. Processes include thermal evaporation, sputter deposition, and arc vaporization.

INTRODUCTION

Commercial vacuum metalizing in the traditional sense has been a large batch process using vacuum chambers of 1 to 2 meters in diameter. Within the last ten years smaller rapid cycle coating systems [2,3] have been developed that increase manufacturing flexibility, process yield, and cost effectiveness in the production of high quality thin metal films. A review of the rapid cycle system and process design will show how thin film coating technology can be brought into cell manufacturing environments without increasing the skill level requirements for machine operators. Production experience has demonstrated that cell manufacturing processes and proper mold handling techniques can eliminate the need to base coat ABS and PC substrates. Process flexibility including thermal evaporation, cathodic arc vaporization, and sputter deposition of aluminum, copper, and nickel chrome makes it possible to adhere to rigid coating specifications and produce desired film qualities. Rapid cycle applications and cost effectiveness for in-line processing will also be discussed.

Various products today are being made using cell manufacturing models as opposed to performing all necessary processes for end products in separate areas and on separate schedules. Cell manufacturing can be defined as the continuous manufacture and assembly of sub-components into a finished unit that is tested in and shipped from the same specific cell area. The team of people working within the cell perform various tasks and, in most cases, have the opportunity to change activities; they are able to oversee the entire manufacturing sequence for the finished unit. We will discuss how rapid cycle metalizing has opened a window of opportunity to ship very diverse products directly from work cells.

METALIZING IN THE MANUFACTURING CELL

Manufacturing cells are expensive resources, and investments must be carefully planned and integrated. A typical cell using plastic injection molding and metalizing for automotive reflectors or cellular phones could contain the following components:

- Plastic injection molding press
- Robotic unloader and conveyor
- Rapid cycle metalizer located press side
- Specialized top coating if required
- Vibration welders for lens attachment
- Station for adding wire harness and circuitry to the assembly
- Turn on testing verification station
- Packaging and shipping area

Metalizing at the press saves time, space, and money. One could define a press side metalizer as a vacuum coating system designed to handle the output of the injection molding process in an integrated fashion. The scaled-down nature of the process allows for tailored vacuum coating solutions to be designed that meet the changing needs of today's manufacturing environment. The successful integration of the rapid cycle metalizer into the cell requires an understanding of not only the operation of the coating machine and other equipment, but also of the entire sequence of fixturing, coating, testing, and maintaining the process. Since all processes are interdependent, the integration effort must be a total investment in looking at the entire cell environment in order to succeed. Current large batch metalizers and large scale rapid cycle metalizers are difficult to integrate into the cell due to their sheer size, fixturing complexities, cleanliness requirements, and lack of flexibility in design options.

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Press side metalizers are proven cell capable for the application of reflective, decorative, and electronic shielding coatings. The smaller, more versatile metalizer has worked to bridge the separation between coaters and manufacturers of injection molded components.

METALIZER SPECIFICATIONS FOR THE CELL

Cells that include coating systems have been successfully built and are currently in production. The typical clean, dry, and empty rating of coating system performance is no longer an acceptable specification. The metalizer must be capable of operation by production personnel on the production floor in a dirty environment. Shift-to-shift performance under these conditions reflect the system's real world capabilities. The system must be simple to run, cycle 25% quicker than the one or more presses it services, and be able to run for 24 hours a day, 7 days a week.

OPERATIONAL DESIGN CONSIDERATIONS

The hallmark of a press side metalizer is one that maintains quick pumpdowns, has a stable coating process, and is built to cycle one million times a year. There are many engineering design considerations that need to be studied before developing such a system. A few of these are:

- Part conveyance and timing
- Ergonomics
- Resource planning and training
- Integration of a variety of processes
- Maintenance issues

Current and future part handling systems must be investigated. Relative part size and throughput requirements need to be analyzed in order to determine the appropriate size and performance requirements of the metalizer, a one-size-fits-all approach is destined for failure. Keeping the chamber size closely matched to throughput requirements helps to reduce the size of the pumps needed and reduces the system footprint. Valves, pumps, doors, and evaporation devices must be properly specified in order to perform consistently in the one million cycle per year arena.

Handling the constant part flow from the molding press requires many operator movements. System designers must study these movements to reduce bending, twisting, and additional hand motions performed by the operators. This ergonomic review is necessary to bring to the operators a degree of comfort that will translate into improved overall quality. Lightweight fixtures that are easy to load and manipulate are necessary to maintain timely product flow. These fixtures are commonly made from vacuum formed plastic and can take on the form of a disc or drum that is rotated past the evaporation source for coating exposure. As these fixtures cost hundreds rather than tens of thousands of dollars, new fixture investments are not as painful for parts with short life expectancies due to styling changes.

Press side metalizers should be capable of single person operation if they are to be integrated into the work cell as an inline component. System and component designs should be operator friendly so that minimal training is required for new personnel.

Many cell applications require that primary and sometimes secondary operations be incorporated into the cell model. Flash removal, top coating, vibration welding, and gluing or final assembly requirements are carefully weighed before a metalizer is recommended. Figures 1 and 2 show examples of cell layouts that incorporate additional operations and recommend press and metalizer placements.

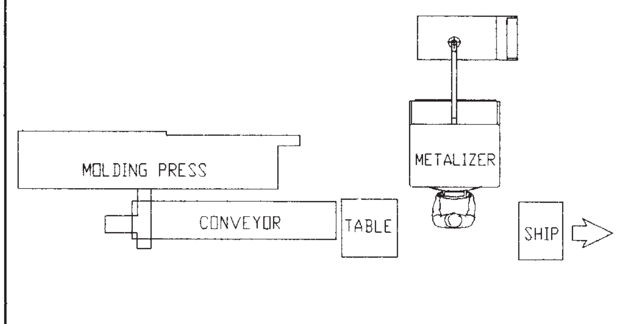

Figure 1. Cell Layout; No Top Coat Required

If the metalizer is working as part of a cell, maximum uptime is of the essence. Modular system design allows for quick disconnecting of pumping modules. Systems must be designed so that preventative maintenance tasks such as pump set removal and chamber liner change out can be performed quickly and easily. In larger shops where multiple maintenance entities are required to perform tasks, components must disconnect quickly in order to reduce maintenance time requirements.

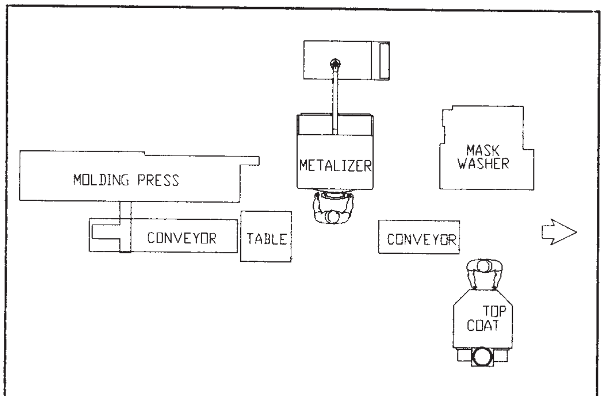

Figure 2. Cell Layout With Paint Top Coat

Figure 3 shows the necessary time required for a press side metalizer to match or exceed the output of the molding press operation. Smaller systems cycle in the 30 to 40 second range, with average sized systems running 45 to 58 second cycles. RFI/EMI shielding coating cycles average two minutes for the build up of 1 to 2 microns of aluminum or copper.

Coating operation	Time (sec.)
Install fixture; start cycle	4 - 6
Crossover: roughing to high vac. (.150 Torr)	10 - 16
Achieve coating pressure (.0005 Torr)	7 - 20
Apply coating	4 - 8
[*shielding]	[*20 - 90]
Vent chamber, open door, remove fixture	5 - 7

Figure 3. Reflective/Decorative/Shielding Coating Cycle

COATING PROCESS DESIGN CONSIDERATIONS

Tungsten filament resistance evaporation, sputter deposition, and patented cathodic arc vaporization technology [4] are currently being used in press side metalizers. Filament evaporated coatings include aluminum and nickel chrome, sputtered coatings include aluminum, copper, and chromium, and arc coatings include nickel chrome. Figure 4 shows how disc fixturing presents the parts to the evaporation source port for uniform coating while shielding the majority of the chamber from coating contaminants. One to two rotations of the fixture disc are necessary to apply coatings of desired thickness for reflective or decorative applications. Twenty rotations are typically required for electronic shielding applications.

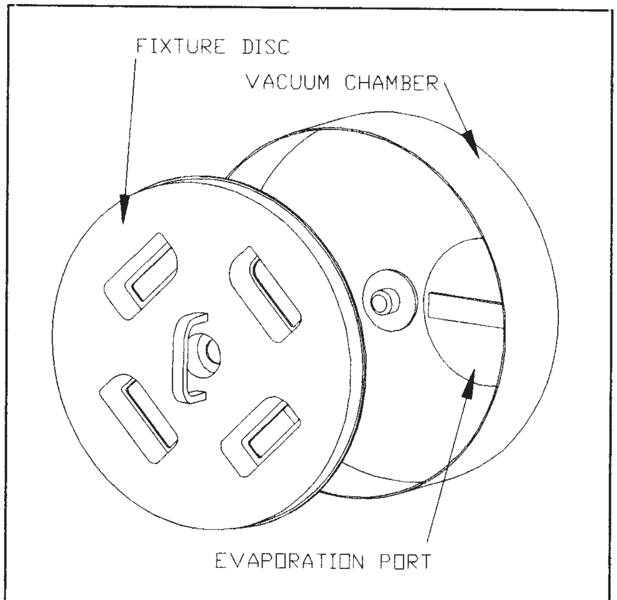

Figure 4. Fixture Disc / Evaporation Port Orientation

ADVANTAGES OF PRESS SIDE METALIZING

Cost savings, quality improvements and increased yields, elimination of basecoating, and process flexibility are several areas of advantage when using press side metalization equipment.

Reductions in storage turn warehouse space into production areas. Smaller press side metalizers take up less than 100 square feet and do not require exhaust stacks for pump venting. In many cases, the small footprint and operational simplicity allow the molding operator to also run the metalizer. Since parts are coated warm as they exit the press, contamination in the form of dust, water vapor, and fingerprints is greatly reduced or eliminated. As contamination is reduced, scrap volumes go down. When operators are able to see the metalized product of their efforts, ownership of the process is high resulting in increased quality. Overall yield increases as molded and metalized inspection stops the press before hundreds or thousands of sub-standard parts are molded. This keeps the molding process at its peak performance.

Traditional basecoatings can be eliminated on ABS, PC, and their blends by metalizing clean, warm parts from scratch-free molds without using extra mold releases. These contaminant-free parts do not require basecoating in order to achieve good coating quality and adhesion. Basecoat elimination directly contributes to the reduction or elimination of VOC emissions [5].

The tailored vacuum coating solutions of the press side metalizer provide both small and large molding shops with the flexibility required to deposit a variety of coatings using various techniques. Simple fixturing is the most obvious changeable component of press side metalizers; it makes it possible to run a variety of different parts simultaneously.

APPLICATIONS DISCUSSION

Press side metalizers are currently addressing the needs of many markets:

• Reflective:	automotive lighting products-*aluminum, chrome, nickel/chrome*
	flashlights-*aluminum*
• Decorative:	license plate holders- *aluminum*
• Shielding:	cellular telephones-*aluminum, copper*
	medical electronics-*aluminum*
	automotive electronics-*aluminum, copper*

With the relative cost of small press side metalizers being $150K to $400K, many new markets are emerging and existing ones continue to grow rapidly.

SUMMARY

Efforts to metalize press-side have grown through the cost savings, quality improvements, environmental friendliness, and simplicity of implementation that these systems have to offer. The true successful integration of this technology into cell manufacturing depends upon the delivery of equipment, fixturing, and coating processes that meet the requirements of the specific cell and can thrive in that cell's environment.

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