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Right-Sizing Your Finishing System Based on a Cost/Production Analysis

Right-sizing a finishing system can have different meanings. This article defines "right-sizing" as a technical process for outlining the system capacity necessary to meet the business objectives of the manufacturing organization. This process will also yield some of the physical characteristics of the system; i.e. the equipment size. A simple case study demonstrating the use of right-sizing is also provided.

Right-Sizing Overview. The objectives of the right-sizing process are to match the capacity for a prospective finishing system to the product throughput required to meet the organization's business needs. For this purpose, it is necessary to define the quality of finish required in the marketplace as well as the number and type of "widgets" that will have to be finished within a given time period. The finishing requirements and production analysis provide these inputs. The process also has to account for any fiscal constraints or target budget.

Once the inputs have been analyzed, the finishing process' desired throughput, quality of finish, physical/functional equipment characteristics, and approved budget will have been determined. These outputs, in turn, can be the basis for the Process Performance Specification included as part of vendor solicitations; i.e., requests for proposals. The right-sizing process is depicted in Figure 1. The following sections describe each process function shown in the figure.

Production Analysis. A production analysis is performed to determine the desired production rate at the desired quality. This analysis determines the total volume of parts to be coated per unit time (throughput). This analysis requires the following data:

- **Target throughput (i.e.parts/year)**
- **Available production time (i.e. minutes/year)**
- **Product presentation & conveyance, including part spacing**

Once the throughput for the finishing system has been determined, it must be compared to the production rates for the upstream and downstream manufacturing activities, such as fabrication and final assembly. If the calculated throughput is less than the upstream pace of manufacturing, then the finishing line will cause manufacturing bottlenecks. Conversely, if the finishing line's throughput is too large, then operations pay the cost of excess capacity.

Quality of Finish Requirements. The set of requirements for the quality of finish is another input into the right-sizing process. It is necessary to evaluate the finishing system's capabilities in terms of the finish that is desired to be obtained. For example, the desired finish may require a specified amount of corrosion resistance, mechanical flexibility, and a variety of colors. This, in turn, will impact the number of stages and dwell times comprising the system. These characteristics, as well as the time required to perform color changes, will impact throughput.

The desired quality of finish is generally specified by upper management in support of the organization's marketing and sales strategy.

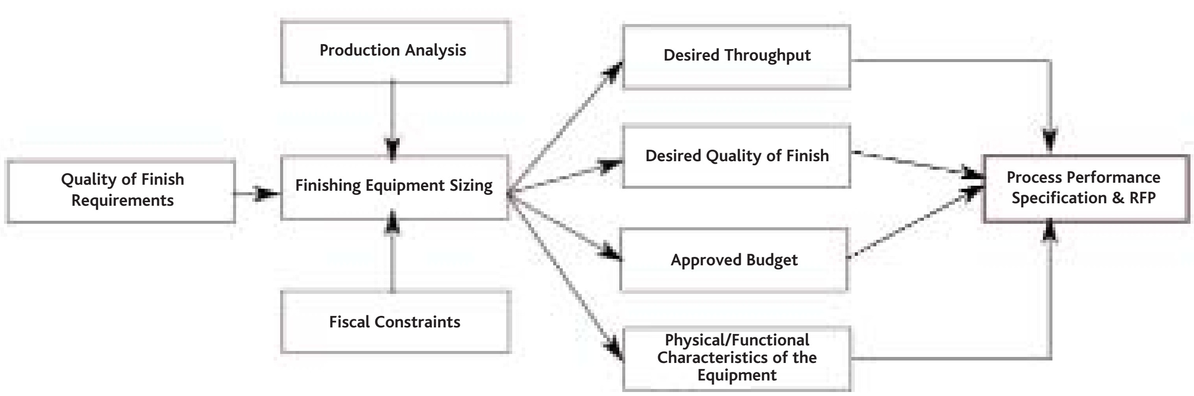

Figure 1. "Right Sizing" Process

This strategy usually involves the following criteria:

- **The importance of the product's appearance**
- **The anticipated lifetime of the product**
- **The conditions to which the product will be exposed during its lifecycle**
- **The impact of the product's finish with respect to the product's end use**

Fiscal Constraints. In most cases, right-sizing will involve capital and affect finishing costs; therefore, the right-sizing process must also consider the target budget for the prospective finishing system. Upper management provides this budget as part of its strategic planning.

Sizing the Finishing Equipment. Given the inputs, right-sizing can determine the desired quality and throughput requirements as well as the functional/physical characteristics of the prospective system's equipment components within a budgetary range.

Desired Throughput. The desired throughput is one result of sizing the finishing equipment. This result is specified using physical units such as conveyor line speeds (feet per minute), batch sizes and batches per shift, and pounds per hour, etc.

Desired Quality of Finish. The desired quality of finish is another result of the right-sizing process. This result is usually specified using industry standards such as ASTM testing methodologies. These methodologies provide quantitive values used to describe the desired finish. Using the specified test methodologies, these values are the pass/fail criteria for the finish's desired characteristics, such as corrosion resistance, color, gloss, solvent resistance, and flexibility, just to name a few.

Physical-Functional Characteristics of the Equipment. Right-sizing also results in the definition of the major physical/functional characteristics of the finishing system. These characteristics include, but are not limited to:

- **Major equipment components and their mechanical dimensions, number of finishing stages, load handling capacities**
- **Energy requirements; required heat and available utilities**
- **Materials and consumables such as chemicals and paint**

Approved Budget. Once the finishing equipment has been sized, there enough information to justify and approve the budget for the system's procurement.

Process Performance Specification and Request for Proposals. The desired quality and throughput, physical/functional equipment characteristics, and approved budget form the basis for the material and equipment specifications. These specifications are used as part of the technical description for the finishing system that the organization wants to procure. These specifications are codified in the following documents:

- **Finishing System Equipment Specification; this documents the system's finishing equipment, including heating needs and the available utilities**
- **Finishing System Material Specifications; this documents the materials the finishing system will use. These materials include such items as paint and substrates to be finished**

Since most right-sizing efforts support the procurement of a finishing system, the material and equipment specifications are used as the basis for the system's technical description included in requests for proposals (RFP) and bids. This inclusion in RFP's is the most important use of these documents and is the culmination of the right-sizing process. The fact that all the vendors will respond to exactly the same set of finishing specifications allows for direct comparison of their proposals. This direct comparison greatly simplifies the check for technical compliance and the selection of the optimum finishing system.

Case Study. The following case study demonstrates the right-sizing process. In this case, an organization is investigating the conversion from liquid paint to a powder-coated finish. Upper management has defined some general qualities of finish they feel will give their products (lawnmowers, in this case) a competitive advantage in the marketplace. Product design has identified powder coating as a viable option. Management has directed manufacturing engineering to investigate a potential powder coating system. The investigation must focus on the throughput capacity as well as the system's ability to obtain the desired quality of finish. Management is also concerned about production bottlenecks and excess capacity.

The first step of this investigation is to perform a production analysis. A required input to this analysis is the time available for the potential finishing system to support production in a given time frame. Available time must account for color changes, repaints, and future production, breaks, lunch, clean-up time, etc. The results of this calculation are usually expressed in minutes per year. In this case, the available finishing time is calculated as:

7 hr x 60 min x 2 shifts x 300 days = 252,000 (minutes per year)

The physical characteristics of the ware and the way it will be presented to the finishing equipment have to be taken into account. These inputs

Part	Part Size (inches) (HxWxL)	Parts Per Hanger	Hanger Length (ft)	Hang Centers (ft)	Parts Count for (Current Year + 5)	Hangers Per Year	Annual Conveyor Length
Handles	60x2x24	1	2	3	223349	223349	670048
Blades	24x1x3	20	3	4	338215	16911	67643
Decks	36x24x36	1	3	4	338215	388215	1352858
Wheels	12x5x12	8	2	3	995500	124437	373312
Seats	25x6x24	2	2	3	89340	44670	134010
		Total Annual Conveyor Length (ft)					2597871

Figure 2. Five-Year Production Goals for Finished Lawnmower Parts

Advantages	Disadvantages
Generally requires a smaller capital investment for the same functionality when compared to other types	Has difficulty supporting higher production rates
Lower operating costs	
Easier to maintain and operate	

Table 1: Batch System Characteristics

Advantages	Disadvantages
Easily supports higher production rates	Generally requires a larger capital investment for the same functionality when compared to other types
	Higher operating costs
	More difficult to operate & maintain

Table 2: Conveyorized System Characteristics

directly impact the calculations used to determine equipment's physical dimensions. Ware presentation has to provide clearances for safe conveyance and be oriented to promote maximum finishing efficiency. The ware's physical characteristics of interest are its length, width, height, weight, and heat capacity.

The remaining input into the production analysis is the amount of ware that will be processed through the finishing system under consideration. In the case of the lawnmower manufacturer, management provided the following guidance. In this case, the amount of ware is expressed as a theoretical total annual conveyor length. Note: the hang centers include part spacing on the conveyor, and the finishing system has to support the anticipated production goals for the next five years.

Having determined the finishing system's availability and target volume, the necessary production rate can be calculated as the conveyor design line speed:

- **Design Line Speed (FPM) = Total Annual Conveyor Length (ft.) / Available Finishing Time (min.) = 2,597,871 (ft.) / 252,000 (min.) = 10.3 FPM**

Given the design line speed, what type of system makes the most sense—batch, conveyorized, or a combination thereof? If the design line speed is less than 6 FPM, then a batch system can be considered or else a conveyorized system should be considered as the first option. Each type has its advantages and disadvantages. These are listed in Tables 1 and 2.

The following relationships are used to size a batch system:

- **Number of Finishing System Batches = Total Available Time (min.)/Sum of Equipment Cycle Times (min.)**
- **Product Batch Size = Production Volume/Number of Finishing System Batches**

The combination system, though not as common as the batch or conveyorized options, can provide solutions for unique situations at lower rates. One example: massive parts may require long cure cycles when compared to their pretreatment and paint batch cycle times; in this case, a conveyor loop might be used to transport the ware through the cure oven.

When determining the finishing system's equipment "foot print", the quality requirements must also be considered. For example, more color selections may require more application equipment, and higher corrosion resistance may require more pretreatment stages.

In this case study, the desired quality requires at least 500 hours of salt spray resistance; therefore, the pretreatment will use a five-stage washer with the following dwell times given in seconds:

- **500 hr salt spray = 5 stage washer (60, 30, 60, 30, 30) = 3.5 min.**
- **Stages 1 and 3 heated (90˚F –140˚F)**

Using the design line speed of approximately 10 FPM previously calculated, the dwell times result in the following stage lengths, respectively: 10 ft., 5 ft., 10 ft., 5 ft., 5 ft. Now it can be seen that slower line speeds result in shorter stage lengths while higher speeds result in longer lengths.

The desired quality of finish has to support multiple colors. Production planning anticipates five color changes per shift; however, there could be as many as eight. Given this situation, preliminary feedback from the powder application equipment vendors suggests the following:

- **5 per shift = 2 booths + 5 collectors**
- **8 per shift = 3 booths + 8 collectors**

At this point, it is clear that the right-sizing process has yielded key equipment configurations for the material handling, pretreatment, and application of powder in the prospective finishing system. The remaining components of the system, such as the dry-off and cure ovens, can also be characterized by this right-sizing process. This would be done by relating the heat load, heat capacities, and cure requirements of the powder to be applied to the desired throughput rate. The same approach applies to the heated stages of pretreatment.

As with all projects, the prospective finishing system has to fit within a certain budget. The parameters affecting the purchase price of a finishing system include:

- **Product size and weight**
- **Production rate (FPM, batch size)**
- **Finish quality (performance, appearance, function, etc.)**
- **System flexibility (color change, JIT, automation, etc.)**

In this case, the length of pretreatment equipment is anticipated to be 35 ft. Assume this equipment hypothetically sells for $2,500 per foot. The resulting cost = 35 feet x $2,500 per foot = $87,500. Given a unit cost for the powder booths and collectors, a similar cost calculation can be made.

Other parameters affect the operational cost of the prospective finishing system, including:

- **Energy and manpower costs accrued in $/hour of operation.**
- **Coating and chemical costs accrued in $/square foot of products processed.**

The bigger the system, the higher the energy and manpower costs. For example, an oven sized to handle 1,000 lbs/hr vs. 5,000 lbs/hr. of steel will require 37,500 BTU/hr vs. 187,500 BTU/hr.

Finally, if upstream production cannot keep up with the throughput of the finishing system , then the finishing costs per piece will be higher. For example, if the fixed costs for operating the prospective finishing line are $100 per hour, then finishing 100 pieces per hour = $1 per piece vs. 50 parts per hour = $2 per part.

SUMMARY

The purpose of this article is to provide an overview of the right-sizing process. A case study describing the investigation of a prospective powder coating finishing system is provided. This study is provided only to further describe and relate each process step to each other.

The major work products resulting from this process include equipment and material specifications. These documents help upper management make informed procurement decisions, including whether to proceed or not. These documents are also used to provide the technical characteristics included in request for proposals/bids for a prospective finishing system. These documents facilitate vendor selection since all prospective suppliers respond to exactly the same specifications.

Finally, these specifications form the basis for acceptance testing. Generally, these specifications are incorporated into the sales contract. When each functional point in the specification has been demonstrated to the buyer's satisfaction, then the final progress payment is made.

This process of "right-sizing" finishing equipment has been pioneered and refined by Powder Coating Consultants over the last 20 years. We have helped numerous clients define their finishing objectives and achieve their production and finish goals during this time. If you need assistance in performing the methods outlined in this article, please contact us at (800) 97 POWDER, and we will be happy to help you.

BIO

Michael Santolupo is an Associate of Powder Coating Consultants, Division of Ninan, Inc., an independent consulting firm located in Bridgeport, Conn. Santolupo has consulted in powder system design and specification, pretreatment chemical and powder material specification and selection, quality improvements, process control, cost reductions, and training in the powder coating industry. Santolupo was instrumental in pioneering specialized computer tools and math models used to provide clients with powder coating system operational cost analysis, production analysis, and vendor analysis data and information.

Santolupo has served in the powder coating industry since 1994, holds a Bachelor of Science degree in Electrical Engineering (BSEE) with continued studies in Computer Programming, and Powder Coating Technology. He has served on the Application Equipment Technical Committee of the Powder Coating Institute. Santolupo has written several technical and feature articles for Powder Coating Magazine. He is a contributing author to the award-winning Powder Coating: The Complete Finisher's Handbook, published by the Powder Coating Institute. Santolupo earned his Project Management Professional (PMP) certification from the Project Management Institute. He is also trained in Six Sigma practices.