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Guest Column

Going from the possible to the feasible: A study in evaluation methods

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I am always amazed when people say: "If you *do this,* then anything is possible." The "do this" can be anything to prove the point of the person making the statement and can be "eat your vegetables" or "do your homework" or whatever. Sometimes the "do this" can be substituted with "have this," like in the saying: "If you have love, then anything is possible." Even we engineers have a similar saying: "Given enough time and money, we can do anything!" Well, we can do anything within the laws of science, that is.

You're probably asking yourself: "What does this have to do with coating processes?" As consultants, our firm is frequently asked by our clients to provide them with options for coating their products. To do this properly, we start out evaluating "what is possible" and distill these options to "what is feasible." Knowing how to go through these stages of evaluation is the subject of this article and describes the service we provide these clients, dubbed a *feasibility study*.

What is a feasibility study?

A properly prepared feasibility study should answer the following questions:

- What options are feasible for coating my products?
- How much do these options cost to purchase?
- What are the manpower requirements for these options?
- What is the cost to operate these options?
- How much floor space will these options require?
- How do these operational costs compare with current finishing costs, and is there an acceptable payback or return on investment?

While these questions may seem fairly simple, developing the answers can be very complicated, even daunting if you don't know where to begin. The only way you can provide answers to these questions is to perform analysis of process specific information. Each of these analyses are discussed in the following sections.

Production analysis. A production analysis is designed to help "right-size" a finishing process by taking the production volume and physical dimensions of parts to be coated and calculating a conveyor line speed to meet these requirements. Production volumes are usually provided at current levels with anticipated growth for the near future (3 to 5 years down the road). This anticipated growth is normally provided as a flat percentage increase each year for the number of subsequent years the client is most comfortable using (like calculating compounded interest).

We use a spreadsheet model that we developed over the past 20+ years to determine how to best hang parts to maximize part target density on the conveyor. You can use whatever method works best for you providing that you take into account a product spacing that incorporates electrostatic wrap effects (usually 1.5 times the perpendicular dimension) and ergonomic issues that will allow proper touch-up and loading/unloading the product. The overall product window that you want to fill is most often determined by the height of the tallest part, the width of the widest part, and the length of the longest part. Using these maximum part window dimensions, fill the resultant "part cube" with smaller parts including appropriate part spacing discussed previously. Of course, you will have to calculate the hang centers of the parts based upon the pitch of the conveyor or hang points available on a load bar. Part of this model will calculate the total surface area and total mass (weight) of the products to be processed. This information is necessary for additional analyses (like calculating operational costs) and for eventually preparing a process specification to purchase the equipment. The goal here is to determine the total annual conveyor length necessary to process the volume of production parts for the target production goal, including future growth. Figure 1 shows a simple line study calculation as part of a total production analysis.

Armed with the calculated length of conveyor, you must now complete your production analysis by determining estimated conveyor line speed. To do this, start with the unit of time that the production volume was expressed in, such as parts per hour, parts per day, or parts per year. This total time will have to be "adjusted" to include process anomalies like recoating rejects or nonproductive time for color change or maintenance. This adjusted time is expressed as an "adjustment factor" in the final line speed calculation example shown in Figure 2.

If the resultant line speed calculates at greater than or equal to 6 feet per minute, then a continuous conveyor process is most efficient. However, if the calculation yields a line speed less than 6 feet per minute, then you need to evaluate an indexing process, batch process, or hybrid (both batch and conveyor) process.

Batch analysis. If the resultant line speed after performing the production analysis dictates you should evaluate a batch process, then you need to perform a batch analysis. This studies the effect of manpower and equipment availability to determine how much time and how many batches you can produce per unit time. Most manufacturing and industrial engineers will recognize this study as a machine loading and resource analysis whereby equipment cycle times and manpower availability combine to determine overall batch cycle time. We use a project management scheduling tool to perform this analysis to provide a Gant Bar Chart to determine equipment and personnel conflicts. An example of this is shown in Figure 3.

Each batch cycle shown in Figure 3 is made up of individual process steps that have their own time and manpower component. This relation is shown in Figure 4.

Finally, after you resolve the manpower and equipment conflicts, you will be able to determine the size of the batch equipment components by simply dividing the number of parts to be produced by unit time by the number of batch cycles available to determine the number of parts per batch. Use the number of parts per batch to determine the interior cavity of the batch equipment component. This calculation is shown in Figure 5.

Figure 1

Line study calculation as part of a total production analysis

Parts	Part size (inches) (H x W x L)	Parts per hanger	Hanger length (ft)	Hanger centers (ft)	Parts count for (Current year +5)	Hangers per year	Annual conveyor length
Handles	60 x 2 x 24	1	2	3	223,349	223,349	670,048
Blades	24 x 1 x 3	20	3	4	338,215	16,911	67,643
Decks	36 x 24 x 36	1	3	4	338,215	338,215	1,352,858
Wheels	12 x 5 x 12	8	2	3	995,500	124,437	373,312
Seats	25 x 6 x 24	2	2	3	89,340	44,670	134,010
			Total annual conveyor length (ft)				2,597,871

Figure 2

Final line speed calculation

Available production time:

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

Adjustments:

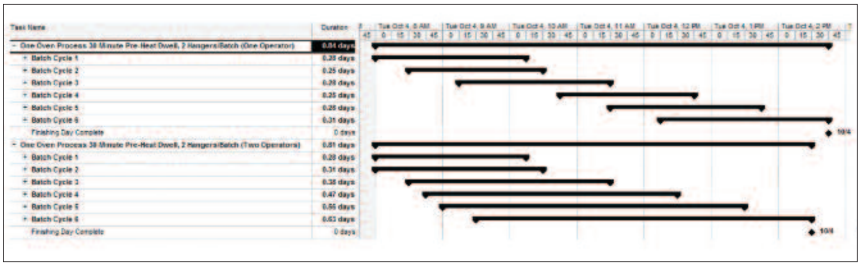
- Color change = +5%
- Rework = +3%
- Future production = +3%

$$\text{Design line speed (FPM)} = \frac{\text{Conveyor length}}{\text{Available production time}}$$

$$\frac{2{,}597{,}871 \text{ ft x } (1.11) \text{ adjustments}}{252{,}000 \text{ min}} = 11.44 \text{ FPM}$$

Figure 3

Project management scheduling tool



Manpower estimation. At this point of the feasibility study, we have developed enough information to determine the coating process steps and the right-sizing information for the equipment. Now it's time to determine the manpower requirements to staff the finishing process. Batch systems are the easiest to determine staffing requirements because it's obvious which process steps require manual intervention, and the batch analysis shows the personnel conflicts requiring more personnel. The example in Figure 6 shows manpower requirements comparing a batch process and an indexing process.

Determining manpower requirements for a conveyorized process is not as easy as determining manpower requirements for a batch process, however. Here you need to consider the level of effort it takes to load/unload the products to be coated on/off a moving conveyor line.

You also need to consider the level of effort it takes to perform any other manual operation the process requires, such as touch-up or manual coating operations or masking operations or manual blow-off. You can use past experience to help with manpower assumptions or perform testing trials simulating actual production conditions and parts.

Operational cost estimation. All the previous analyses need to be completed before you can start with evaluating the operational costs of the finishing process(es) you are looking at. In fact, understanding the operational costs for your process options is the key to transition from "what is possible" to "what is feasible."

Any operational cost analysis must include labor, energy, and raw material consumption at a minimum. This list of cost parameters can easily be expanded to include miscellaneous rework costs, waste/sludge disposal costs, clean-up and maintenance costs, contingency costs, and equipment depreciation costs. How much time and effort you expend in determining your operational costs will directly affect the quality and accuracy of your results. We developed a very accurate and robust operational cost estimator that provides the most comprehensive examination of total operating costs for organic finishing processes (both liquid and powder) available anywhere in our industry. This operational cost development effort is the culmination of focusing 100 man-years of experience and 25 years of hands-on knowledge of organic coating operational cost estimation in support of feasibility studies.

FIGURE 4

Individual process steps

FIGURE 5

Determining the size of the batch equipment components

$$\text{Finishing system batches} = \frac{\text{Total available time}}{\text{Total of equipment cycle times}}$$

$$\text{Product batch size} = \frac{\text{Production volume}}{\text{Finishing system batches}}$$

FIGURE 6

Manpower requirements comparing a batch and indexing process

System design	Load	Media blast	Pretreatment	Dry-off	Powder coating	Cure	Cool-down	Unload	Total
Batch system	2	2	2	0	2	0	0	2	10
Indexing system w/ 2 sprayers	2	2	2	0	2	0	0	2	10
Indexing system w/3 sprayers	2	3	3	0	3	0	0	2	13

Detailed operational cost estimation must include inputs such as part surface area, line speed, part silhouette size, conveyor weight, tooling weight, part weight, operating hours, number of color changes, estimated defect rates, operational labor, maintenance labor, clean-up labor, supervision labor, waste/sludge disposal, maintenance parts, paint/powder costs, specific gravity for powder or percent solids for liquid values, material utilization, coating thickness, pretreatment chemicals, energy source unit costs, thermal efficiencies by energy type, electric motor sizes, compressed air consumption, set points for all heat related process equipment, ambient temperature, oven exhaust rates, oven radiant heat losses, environmental room heat/cooling losses, flash-off losses, spray booth exhaust, solvent incineration losses, and more. Locating the formulas to use the above mentioned inputs to calculate actual operational costs are available from a variety of resources and engineering textbooks. A few "rule of thumb" estimates are available from industry sources to simplify the effort of calculating operational costs. Figure 7 shows a summary of a detailed operational cost analysis.

Floor space estimation. Floor space estimation can be performed after the production analysis and batch analysis have been completed, as these provide the required information. For instance, the production analysis will provide the resultant conveyor line speed for conveyorized systems that, along with the time for each process step, will allow you to estimate equipment component size. Conversely, the batch analysis will provide the resultant batch size, along with the product dimensions, to allow you to estimate equipment component size. Figure 8 is an example of both these estimations.

Once you have the individual equipment component sizes, you can estimate the overall floor space required to site the entire system by sketching these in their relative positions with appropriate spacing between the components. Of course, you can always obtain a layout drawing from a willing equipment supplier, providing you give him the required process information for accuracy.

Capital cost estimation. Estimating capital costs can be a easy as asking for a budgetary quotation from pertinent equipment suppliers. Be sure that you provide them with the particulars from all the previous analyses to ensure accuracy. Fortunately, we have an extensive database of past projects that we can draw from to provide estimated capital costs. Anyway, however you obtain your capital costs, be sure to include incidental costs to cover the purchase or manufacture of product fixtures or hangers, the placement of utilities, building modifications, etc. We normally add at least 15 percent to the capital equipment costs to cover these miscellaneous (contingency) costs. See the example in Figure 9.

Figure 7

Detailed operational cost analysis summary

Operating Costs (inputs)

Item	$	Units
Powder	$4.00	lb
Operator	$14.00	hr
Supervisor	$20.00	hr
Clean-up labor	$14.00	hr
Maintenance labor	$18.00	hr
Disposal	$0.00	lb
Gas	$0.80	Therm
Electric	$0.09	KWH
Runtime	2,000	hr/yr
Shifts	1	shift/day
Defects	4%	

Operating Costs (analysis)

Process	Manpower	Material costs	Energy costs	Labor & maintenance	Rework costs (4%)	Total operating costs	Limit count per sq. ft.
Batch system	10	$213,081.03	$61,649.06	$199,555.00	$22,972.44	$597,257.53	$0.4242
Indexing system 2 sprayers	10	$213,081.03	$72,512.42	$303,970.00	$23,581.58	$613,147.03	$0.4355
Indexing system 3 sprayers	13	$213,081.03	$72,512.42	$387,970.00	$26,942.58	$700,507.03	$0.4975

Figure 8

Production analysis and batch analysis

Process steps are time dependent and affect footprint:

- Cleaning and pretreatment in seconds
- Dry-off and cure in seconds

Batch system size:

- Estimate batch size based upon product size and quantity
  - Example: 10 parts per batch; Part size = 2 ft. x 2 ft. ; 2 rows of parts on carts plus spacing (1 ft. spacing); Batch size = 2 ft. wide x 14 ft. long (plus clearance)

Conveyor system size:

- Line speed x process time = equipment footprint
  - Example: 10 FPM x 30 min cure = 300 ft.÷ 4 passes = 75 ft. long (plus clearance)

Figure 9

Estimating capital costs

Process	Media Blast	Pretreat	Dry-off	Powder coating	Cure oven	Convey	Cool-down	Controls	Install	Misc (15%)	Total
Batch system	$320K	$75K	$100K	$100K	$200K	$75K	$0	$50K	$100K	$100K	?
Indexing system	$320K	$75K	$100K	$100K	$200K	$150K	$60K	$60K	$200K	$189.57K	$189.57K

Final report of results. This is the part of a feasibility study that requires expert evaluation of the process options, analyses, and obtained data to present a cogent summary that will allow the determination of "what is feasible" from all the "possible" finishing process options. Feasibility can be based on many criterion, depending upon the project goals and client objectives. For instance, one process may be the most appropriate way to obtain the stated product quality or performance. Another process may be the only one that can fit into the plant area dedicated for the finishing process. Capital funding availability may make one process the natural winner, while reduced operational costs may make another a better return on investment or offer a shorter payback.

If the study has been properly prepared, the results can be evaluated with any of these criterion. It often comes down to reducing the options and organizing/presenting the results for easy evaluation by the client. Figure 10 shows what issues generally affect capital procurement costs and what items affect operational costs. These are most often the items that are used to determine "what is feasible."

Summary

Organic finishing projects are no different than any other capital equipment projects. Understanding what options are available to attain your desired production, product quality, and coating performance goals is important to attain the best feasible options. Organic finishing systems, beyond the very basic ones, are sized and configured by using standard equipment components to provide a custom solution to your specific project goals. Feasibility for particular process options may be based upon capital cost, operational costs, manpower requirements, or floor space restrictions.

Without analyzing the "possible options" in these terms, it's impossible to determine the "feasible options" available for your requirements. Of course, expert assistance in this endeavor will ensure that you have the accurate information to make informed decisions and avoid costly mistakes. Considering that this equipment may have a 30-year lifespan, you may be living with these mistakes for a long time. We will be happy to discuss how our experience and tools can be used to mitigate risks in performing a feasibility study. **PC**

FIGURE 10

Issues generally affecting capital procurement and operational costs

Parameters affecting procurement costs:

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

Parameters affecting operational costs:

- Energy and manpower costs are accrued in $/hr. of operation (fixed costs).
- Coating and chemical costs are accrued in $/sq. ft. of products processed (variable costs).
- The bigger the system, the higher the energy and manpower costs. If runtime efficiency is low, then product cost is higher.

Editor's note

For further reading, see the "Index to Articles and Authors 1990-2011," Reference and Buyer's Resource Issue, *Powder Coating*, vol. 22 no. 6 (December 2011), or click on the Article Index at [www.pcoating.com]. Article can be bought online. Have a question? Click on Problem Solving to submit one.

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