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Previously, 15 years working as a process engineer and production supervisor for Knape & Vogt Mfg Co in Grand Rapids, MI. Experience with manual and automatic barrel and rack lines running: copper, nickel, chrome, zinc plating, brass and copper plating, anodizing, powder coat, e-coat and liquid coatings as well as all things environmental associated with these processes.

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Maximizing the Capacity of Existing Finishing Lines

Production Capacity Tool

Many of us are faced with trying to maximize the capacity of our existing finishing lines. This article will discuss several areas to consider as well as an Excel spreadsheet tool to help predict current and future capacity. We will consider three main areas; hoist capacity, process tank capacity, and racking capacity first by observing and secondly utilizing a relatively simple spreadsheet tool.

Determining Capacity by Observation

To get a general idea if there is additional capacity in your finishing line make the following observations:

1) **Hoist Capacity:** If you observe the line and the automatic hoists (or the manual operators) are productively moving all the time, then you are likely maxed out on hoist capacity and the number of loads per hour cannot be improved without adding a hoist. On the other hand, if the hoists have idle time you have more than enough hoist time to improve on the existing capacity. Be careful to observe the line several different times of the day *i.e.*, before breaks, after breaks, during breaks and in between break times.

(The Production Analysis Capacity spreadsheet can be used to calculate a theoretical value to be explained later in the article.)

2) **Process Tank Time Limitations:** If you appear to have enough hoist time, the next area to check is the process tank availability. The most probable bottlenecks in a finishing line are the tanks with the longest process times, which are typically the plating or anodize tanks. If you have hoist time and the anodize or plating tanks are full when you observe the line, you are likely process tank limited. The best check on how well the line is working to capacity is to make sure anodize and plating tanks are full – this should be done every time you walk by the finishing line. If these tanks are not full, something needs to be done, perhaps a push by the boss. It is possible that a cleaning tank is the process limitation, but the Excel tool will aid in determining if any other capacity problems exist.

   It is also possible that the process times can be reduced. It is very common for process times and temperatures to be set based on "*this is how we have always done it" i.e.*, process times, temperatures, chemistry – maybe one bad day back in 1976 there was a problem and the time was increased. There are lots of stories, but press your chemical suppliers, typically one load per hour can easily justify a little more chemistry or a little more heat.

   Another common factor in plating or anodize tank capacity is the rectifier size. Many lines are running at a very low amps per square foot setting because the rectifier does not have enough amperage to run at the optimum settings and/or there is a fear of burning the parts. Again, this is often based on the *how we have always done it* philosophy. Anodize tanks are meant to run at 15 ASF – figure out a way to make it work and shorten the times and the same goes for plating tanks. Most finishers are very good at maximizing the parts on the racks – this is often done without considering if the rectifier/saddle/buss work/work bar combination can handle the higher amperage needed to run more parts

3) **Rackers and Unrackers:** Most of the lines I observe have both idle hoist time and their longest process tanks are not full. The capacity of the line is often dictated by those who load and unload the racks. Of course, these folks are the least experienced and physically the hardest working people in the plant. The most difficult and time-consuming area of line design is how to make the part handling as efficient as possible. This is another great topic for an article, but the best principle for design is *the only productive work is placing parts on and off the rack, everything else is a waste and must be minimized*. It sounds too simple, but too many plants spend too much time moving carts, racks, walking to and from parts, finding a rack for a part change, bending and reaching above safe levels – the list goes on and on.

If you want to know if your line is running at capacity, it is a pretty simple observation. First, look at the plating or anodize tanks – are they full? Are the hoists always productively moving, or is there idle time? Are the rackers/unrackers busy all the time? You can tell pretty quickly whether there is more capacity in the existing line.

Determining Capacity by Utilizing a Spreadsheet Tool

A simple straight line anodize system will be used as an example, but the tool works just as well for any type of finish – see the spreadsheet below for the finishing line example used in this article. Please note the observations below the anodize spreadsheet.

ABC FINISHING COMPANY
Process Line Layout

	ANODIZE		RECTIFIERS		
Station No.	Tank Description	Time (min)	ASF	Volts	Amps
1	Load Cart Station				
2-5	Queue Stations (4)	30			
6	Alkaline Cleaner	6			
7	Rinse				
8	Rinse cf				
9	Alkaline Etch	3			
10	Rinse				
11	Rinse cf				
12	Deoxidize	3			
13	Bar Wash Rinse				
14	Rinse cf				
15	Anodize Type II	40	15	24	3000
16	Anodize Type II	40	15	24	3000
17	Anodize Type II	40	15	24	3000
18	Anodize Type II	40	15	24	3000
19	Anodize Type II	40	15	24	3000
20	Anodize Type II	40	15	24	3000
21	Rinse				
22	Rinse cf				
23	Nitric Dip				
24	Rinse				
28	Black Dye	12			
29	Rinse				
30	Rinse cf				
31	Dye Seal	12			
32	Dye Seal	12			
33	Rinse				
34	Rinse cf				
35	Hot Water Seal	12			
36	Hot Water Rinse	3			
37-40	Queue Stations (4)	30			
41	Unload Cart Station				

Observations

There appears to be idle hoist time

The amps per square feet run for the line averages 10 ASF for the racks

The chiller is idle at least half the time

The anodize tanks are not ever full of part loads there is usually two empty positions

The rackers are very busy, but spend a great deal of time moving carts back and forth to the raw and finished work areas

The completed spreadsheet tool for the anodize line example is below. The items highlighted are items which are specific to the anodize line application. It looks complicated, but it is really very simple and can be completed very easily – a very simple mind (mine) developed the sheet. Just take it one step at a time and you will be very pleased with the results. I will attempt to explain it very well. Once you feel you understand the logic, there is a link which will give you access to the actual spreadsheet. You can complete the highlighted areas on the spreadsheet and determine theoretically where your capacity stands and how you can improve it. The general rules for completing the tool (if there are multiple finishes) are to use the finish process with the longest times and most number of steps. You can program where you don't run these long processes back to back, but the reality is you usually have a long run of these parts and you need to plan for maximum capacity during the worst case.

Click here to download Production Capacity Tool

PRODUCTION CAPACITY ANALYSIS - EXISTING ABC FINISHING COMPANY ANODIZE LINE

Customer:	**ABC Finishing Company**		**Project No:**	**STERC Article**		
Project Name or Location:	**Grand Rapdis, MI**		**Rev Date:**	**4/9/2018**		
Existing Number of Hoists:	**3.0**					
Hoist Type:	**1000# Overhead Hoist**					
Loads Per Hour:	**6.0**		**Operation hours**			
Cycle Time:	**600**	**seconds**	**Days/year**	**250**		
Load Size:	**8" DOT x 48" Deep x 120" Long**		**Hours/shift**	**6.8**	**85% Efficent**	
Rinse Tank Size:	**20" DOT x 60" Deep x 132" Long**		**Shifts/day**	**2**		
Maximum Surface Area per Load:	**150 square feet**					
Rectifier Size:	**24 Volt 3000 Amps**					

NUMBER OF HOISTS

	Number	Time (sec.)	Total Time (sec.)
Lifts	23	10	230
Lowers	23	10	230
Line Length (ft.)	185		
Factor	5		555
FPM	100		
Total Up Drain Dwells	3	12	36
Total Rinse Dwell Time between 5-60 seconds	4	45	180
		Total	1,231 sec.
		Cycle time	600.0 sec.
	Calculated Hoists Reqd.		**2.1**

PROCESS CAPACITY

Process	Process Time (Minutes)	Fill Time (Seconds)	Total Time (Seconds)	Cycle Time (Seconds)	Bays Reqd.	Bays Reqd. Rounded Up	Number of Tanks on the Existing Line
Load	2	60.0	180	600.0	**0.3**	**1**	1
Queue	30	60.0	1,860	600.0	**3.1**	**4**	4
Alkaline Clean	6	60.0	420	600.0	**0.7**	**1**	1
Etch	3	60.0	240	600.0	**0.4**	**1**	1
Desmut	3	60.0	240	600.0	**0.4**	**1**	1
Anodize Type II	40	60.0	2,460	600.0	**4.1**	**5**	6
Black Dye	12	60.0	780	600.0	**1.3**	**2**	1
Dye Seal	12	60.0	780	600.0	**1.3**	**2**	2
Hot Water Seal	12	60.0	780	600.0	**1.3**	**2**	1
Hot Water Rinse	4	60.0	300	600.0	**0.5**	**1**	1
Unload	2	60.0	180	600.0	**0.3**	**1**	1

*****One black dye tank is enough because half of the work is clear**

ANODIZE TIME CALCULATION

Type II		
THICKNESS - ENTER ONE VALUE	0.50	MILS
CURRENT DENSITY - ENTER ONE VALUE	10.00	A/SQ.FT.
CALCULATED TIME IN MINUTES =	36.00	
CONSERVATIVE TIME IN MINUTES =	40.00	

ompleted Spreadsheet Tool for a Straight Line Anodize

Let's start at the top and fill in the highlighted details for our specific application ABC Finishing Company – Anodize Line: Fill in all items highlighted in grey.

Customer: ABC Finishing Company

Project Name or Location: Grand Rapids, MI

Existing Number of Hoists: 3

Hoist Type: 1000# Overhead Hoist

Loads per Hour: 6

Load Size: 8" x 48" x 120"

Rinse Tank Size: 20" x 60" x 132"

Maximum Rack Surface Area: 150 square Feet

Rectifier Size: 24 Volt 3000 Amps

Operating Hours:

Days per Year: 250

Hours per Shift: 2

Shifts per Day: 16 hours with a 85% efficiency factor = 6.8 hours per shift

Number of Hoists (use the process with the most number of tanks)

Lifts: 23 **Actual Time:** 10

Lowers: 23 **Actual Time:** 10

Line Length: 185 feet

The lifts and lowers are simply the number of process steps in the line. Please use the actual lift and lower times which you observe watching the hoists on your line. Use the time between when the hoist stops traveling to lower and then when the hoist starts to move away after the lower and the opposite for the lift time.

Total Up Dwell Drain Time: 3 tanks for 12 seconds each

Example: An up dwell drain time is above the tank – need to count the number of these and the time for these (this is a total time – example above the etch, anodize and final rinse we have 3 dwells of 12 seconds for a total dwell time of 36 seconds as per example). This is very important time as the hoist cannot accomplish anything else during dwell times, it just waits.

Total Rinse in tank Dwell Time Rinse tanks with times between 5-60 seconds:
Four rinse tanks at 45 seconds each for a total of 180 seconds

Example: Anytime a rinse or process tank is more than 0 seconds, but less than 60 seconds, the total time must count (add up all the process times which are specified in this range – for example, you have four rinse tanks you specify are 45 seconds versus in/out or longer than a minute, these add up to 180 seconds in the dwell time). You must design these out of your process, if at all possible. In/out is the most efficient use of the hoist in a rinse. As an equipment person, I would argue most of the rinsing action occurs in the movement of the parts in the rinse. If you are uncomfortable with in/out, specify over 60 seconds or even better any time the system needs, as it is not critical. If you do not specify a time, the hoist can be most efficient and focus on the critical time processes. For example, a cleaner rinse is not usually a critical time as there is no damage to the part.

Process Capacity – data from your line

List all the process tanks – see above

List all the process times – use the longest process times if this varies by part or process

The fill time is the time it takes to remove one load out of a tank and replace it with another load. If you have two hoists this can be pretty quick, it is important to have one waiting for anodize in the example, *i.e.*, with multiple hoists, one hoist pulls out of anodize and the second hoist fills it as soon as possible. This needs to be from your line as accurate as possible. An automatic hoist without up dwell takes about 60 seconds to accomplish the emptying and filling of a tank. lift: 10 seconds; transfer: 7 seconds; lower: 10 seconds; then transfer to another load: 7 seconds; lift the load: 10 seconds; then transfer again: 7 seconds; and lower: 10 seconds.

Number of tanks spaces on the existing line – current number of process tanks (bays) should be listed

Anodize Time Calculation

The thickness necessary for anodize with Black Dye (the longest time)

The design amps per square feet of your system

Round up the time just to make sure you have enough capacity. This is used in the process capacity above.

The Power of the Tool

One of the powers of the tool is to see how your existing line capacity is constrained or not constrained. Here are some examples:

In this example:

1) We have almost one extra hoist – have 3 and only 2.1 are needed so there is plenty of hoist capacity (Found in the Number of Hoist section at the bottom).
2) We have more than one extra anodize tank, 4.1 calculated versus 6 actual tanks (found in the process capacity section under anodize tanks).
3) We are only running the anodize tanks at 10 amps per square feet (found in the anodize time calculation).
4) Based on our observations at the bottom of the ABC Finishing Company Process Line Layout, the anodize tanks are not full, the hoists are idle, and the chiller only cycles about half the time. These confirm that we can get more throughput on this line. The question becomes how can we estimate how much more throughput?

The second power of this tool is that, by changing the inputs, you can see the effect on the capacity of the machine.

1) Change the amps per square feet on the Anodize Time calculation from 10 to 15. The calculated process time goes from 36 minutes to 24 minutes. Now we have even more anodize tank capacity. We could increase the throughput through anodize by (36-24)/36 or 33% if it were full. Try it and see if it can work for you. Even to go to an 11 ASF number versus the 10 ASF significantly decreases the time – see example below.
2) If you are one of those companies who have a lot of dwells in rinse tanks between 5 and 60 seconds. Does it really matter if you are in/out in the rinse? Or can it be more than 60 seconds, as it is not critical, to allow the hoist to make another move instead of sitting doing nothing. If we change all the 4 rinse dwells to 0, the number of hoists is reduced from 2.05 to 1.75 hoists and we can gain another 15% of the hoist capacity. The problem may be worse in a multiple hoist system because all the hoists could be waiting for the one sitting at the rinse tank to move.
3) You can change any of the process times which could be a constraint on your line. I have seen many lines where the alkaline cleaner could be a constraint. If the time in the cleaner tank in our example was more than 8 minutes - it would be the process constraint, surprisingly even more than the anodize time.
4) The biggest value is play with the loads per hour number in the top section to see what needs to be added to increase the productivity. For instance, if you want to increase the loads per hour from 6 to 9 what needs to be added for a 50% increase? You can see the areas which need to be improved highlighted in yellow. See the example below:

PRODUCTION CAPACITY ANALYSIS - 50% PRODUCTION INCREASE FROM 6 TO 9 LOADS PER HOUR

Customer:	**ABC Finishing Company**		**Project No:**	**STERC Article**	
Project Name or Location:	**Grand Rapdis, MI**		**Rev Date:**	**4/9/2018**	
Existing Number of Hoists:	**3.0**				
Hoist Type:	**1000# Overhead Hoist**				
Loads Per Hour:	**9.0**		**Operation hours**		
Cycle Time:	**400**	**seconds**	**Days/year**	**250**	
Load Size:	**8" DOT x 48" Deep x 120" Long**		**Hours/shift**	**6.8**	**85% Efficent**
Rinse Tank Size:	**20" DOT x 60" Deep x 132" Long**		**Shifts/day**	**2**	
Maximum Surface Area per Load:	**150 square feet**				
Rectifier Size:	**24 Volt 3000 Amps**				

NUMBER OF HOISTS

	Number	Time (sec.)	Total Time (sec.)	
Lifts	23	10	230	
Lowers	23	10	230	
Line Length (ft.)	185			
Factor	5		555	
FPM	100			
Total Up Drain Dwells	3	12	36	
Total Rinse Dwell Time between 5-60 seconds	0	45	0	
		Total	1,051	sec.
		Cycle time	400.0	sec.
		Calculated Hoists Reqd.	**2.6**	

PROCESS CAPACITY

Process	Process Time (Minutes)	Fill Time (Seconds)	Total Time (Seconds)	Cycle Time (Seconds)	Bays Reqd.	Bays Reqd. Rounded Up	Number of Tanks on the Existing Line	What can we do to make up the difference?
Load	2	60.0	180	400.0	**0.5**	**1**	1	**We are using carts so no issues - may have to add people**
Queue	30	60.0	1,860	400.0	**4.7**	**5**	4	**This is close enough for now**
Alkaline Clean	6	60.0	420	400.0	**1.1**	**2**	1	
Etch	3	60.0	240	400.0	**0.6**	**1**	1	
Desmut	3	60.0	240	400.0	**0.6**	**1**	1	
Anodize Type II	36	60.0	2,220	400.0	**5.6**	**6**	6	**maximizing the anodize capacity - can increase ASF to reduce time**
Black Dye	12	60.0	780	400.0	**2.0**	**2**	1	**as long as the black dye percentage of work is < 50% ok**
Dye Seal	12	60.0	780	400.0	**2.0**	**2**	2	
Hot Water Seal	12	60.0	780	400.0	**2.0**	**2**	1	**as long as the clear work is < 50% ok (convert to dye seal)**
Hot Water Rinse	4	60.0	300	400.0	**0.8**	**1**	1	
Unload	5	60.0	360	400.0	**0.9**	**1**	1	

ANODIZE TIME CALCULATION

Type II		
THICKNESS - ENTER ONE VALUE	0.50	MILS
CURRENT DENSITY - ENTER ONE VALUE	11.00	A/SQ.FT.
CALCULATED TIME IN MINUTES =	32.73	
CONSERVATIVE TIME IN MINUTES =	36.00	

I hope you have enjoyed the exercise of evaluating our anodize line example to determine if there are possibilities to increase the capacity of this line. It is important to make observations of the capacity in people, hoists and process and then use the process capacity excel spreadsheet to compare to your observations. You can make these observations anytime by simply walking the line and evaluate how your finishing line(s) are running in any moment in time. If those main process tanks are full you can move on to managing your company. We have also provided a link to the actual Production Capacity spreadsheet for you and your team to evaluate your process lines. Good luck in your efforts to increase capacity in these good economic times!