Tank Optimization for the Job Shop

A pragmatic approach to maximizing the capabilities of both new installations and existing process lines. Each tank/system shall be reviewed in isolation and as part of the whole. Variables that affect throughput, quality, cost and maintenance requirements shall be discussed and categorized in order of importance. Tank optimization required for third party accreditation such as NADCAP or FDA Validation shall also be discussed in detail.

Introduction

In order to meet stricter requirements, all manufacturers must increase their efficiency. Process optimization is a key part of that.

Many of the concepts that actually make a real world difference in the plant do not occur at or in the tanks.

More specifically, change is seldom effective without a true change in attitude; a culture change.

Viewpoint

- We shall begin from the broad “macro” point of view by looking at ourselves, our market and Quality Management
- We shall then proceed to zoom into the “micro” point of view by examining specific process changes that can help to optimize the current process.

The Target Audience of This Paper

- There are:
- Less than 3,000 independent finishing operations in the U.S.
- Over 80% percent of finishing shops employ fewer than 75 people
- Nearly 40% of finishing shops employ fewer than 20 people

Industry wide change must include these companies

Management Buy-In and the Cost of Quality

- Nice equipment is great but not as important as a strong Quality Management Team working with trained, enabled employees.
- ***Lack of management buy-in to a structured Quality Management System is the biggest barrier to expansion.***

The Cost of Quality

- For every reworked part, the cost is at least 3-4X the original cost.
- First Run Lost: 1 X original cost
- Strip and rerun: 1-2X original cost, possibly more.
- Lost opportunity cost: 1X possibly more if rework is considerable or difficult.
- ***An ounce of prevention may not be worth a pound of cure but it is worth at least 3-4 ounces of it.***

Process Control Documentation

- Is there a written Process Control Document (PCD)?
- Does it comply with industry requirements?
- ***An undocumented process only continues to work if the operators are sufficiently knowledgeable and responsible to overcome the obstacles present to processing the job.***
- The moment when either their knowledge or responsibility level is insufficient for the task the process will fail.

Mil-A-8625 PCD Requirements

- Section 4.3.1 reads as follows:
- *"4.3.1 Process control document (PCD).*
- *The anodizer shall develop, maintain, and adhere to a PCD describing the anodizing process and procedures used to meet the requirements of this specification. As a minimum, the PCD shall describe the following:*
- *-All steps in the processing sequence.*
- *-Ranges for immersion time and temperature for each step in the process.*
- *-Chemical constituents used and allowable solution control ranges to be used for solution analysis (see 4.3.2) for each step in the process.*
- *-Ranges for temperature, current density and anodizing time (or voltage ramps and hold times) as applied to individual alloys or alloy series."*

PCD Self Audit

- Read the PCD in detail
- Compare it to the reality of your work instructions and actual shop floor activities.
- Compare those all to the spec, customer and regulatory requirements.
- All must be in harmony. Find the gaps and close them.

Solution Control

Some common errors in solution control are:

- Not having a Solution Control Log or having an incomplete one.
- Not having clear parameters for all solutions. Not having regular adds/decants on a schedule.
- Using solutions that are either weak or old in an attempt to "save money".
- Not accounting for contaminants.
- Not properly recording and using the data over time as a management tool.
- Not setting a target, using manufacturer's or spec's limits as shop limits.

Solution Control

- All solutions must be monitored for: Composition, Stability, Temperature and Etch Rates (if etching).
- Establish operating parameters based upon manufacturer tech data sheet, specification, and prior experience. There should be a target value for each parameter.
- Use shop limits inside of spec limits

Water and Rinsing

- Incoming solution makeup and rinse water should meet the International Water Standards, except pH should be 5.0 to 9.0.
- Total Solids: 500 ppm
- Chlorides: 25 ppm maximum
- Fluoride: 1.7 ppm maximum

- DI or RO water (50,000 ohms/cm min) should be used in the post anodize rinses if at all possible. This includes dye and seal rinses as well.

- Counterflow rinsing is an extremely efficient usage or water when compared to single stage rinses.

Cleaning

- The evaluation and selection of cleaners should be done **only** via one of two methods:
- Against the actual soils that would be encountered in a daily setting. Get samples from your customers of their cutting fluids and lubricants and run tests.
- Specification driven. In a spec-driven industry such as aerospace, very often a Qualified Products List (QPL) exists which directs you to use one of a certain approved cleaners.

Effective Concentration

- Upon makeup, immerse a test panel into a known oil and time how long it takes to achieve a water-break free surface. Document this.
- Periodically check this documented time against the actual solution time to clean.
- Set a point beyond which the cleaner is deemed ineffective and decant at that point. This concept can be applied to many tanks.

Etch Bath

- In addition to the basics of temperature, free caustic, and dissolved aluminum the bath must be monitored for stability. Accomplished via:
- Weekly etch rate monitoring on key alloys.
- Periodic testing for intergranular attack and end grain pitting.
- Effects upon surface roughness must also be monitored.

Etch Bath

- **Inter Granular Attack:** refers to preferential corrosion along grain boundaries or immediately adjacent to grain boundaries. The bulk of the grains remain largely unaffected.
- **End Grain Pitting:** Pitting corrosion is a localized form of corrosive attack that produces holes or small pits in a metal.
- **Surface roughness**: Etch processing should not cause an increase in surface roughness resulting in a final surface roughness exceeding Ra 80 microinch (2 micron) on surfaces Ra 80 microinch (2 micron) or less prior to processing.

Deox

- "Desmut" alone is insufficient.
- Iron-based deoxidizers work well. Avoid chrome if possible.
- Monitor for etch rate weekly and metals periodically.

Chromic Anodize

- Ramp at 3-5 Volts/Minutes
- Stepped ramp to final voltage promotes formation of pore structure
- New PFOS regulations make air compliance tougher
- Poly Balls and Wet Scrubber best alternative

Sulfuric Anodizing

- ***One cannot simply establish a voltage range for an alloy without consideration for the load size.***
- Given a rectifier of "X" ampacity, the voltage required to reach a given current density will decrease as the total current approaches 0 amps. The voltage required to reach that same current density will rise as the current load approaches the capacity of the unit.

Voltage/Amperage Ranges

- The answer is to establish coating rates on the principal alloy groups, *at several amperage ranges*.
- For Example: Assume 3000 Amp Rectifier,6061

Load Size	Voltage at 10 ASF
200 amps	11.8
500 amps	14.2
1000 amps	15.8
2000 amps	17.7
2500 amps	18.4

Coating Rates

- Distinct from establishing voltage ranges.
- The voltage range tells you the electromotive force required to achieve a given current density given a certain size load and certain alloy.
- The coating rate tells you how fast that current forms aluminum oxide per given alloy. The fewer amp/mins or hrs required the faster the alloy coats.

Rectifier Operating Ranges

- Rectifiers should not be run at 10% load or less. If this is unavoidable consider using dummy panels.
- A handheld Clamp-on Ammeter can be used to determine current going to a single spline. Observe proper safety precautions as needed.

Coating Rates Cont'd

- In our facility we have found the following:
- 6061: 720 amp/mins per sf = .001"
- 7075: 560 amp/mins per sf = .001"
- 2024: 810 amp/mins per sf = .001"

- Compare this to existing published rates of 900 amp/mins per square foot for 7075. You must make your own measurements.

Multiple alloy loads

- Aluminum racks are usually 6061 or 6063. Anytime you anodize any other alloy on these racks you are anodizing multiple alloys per load.
- Do not anodize 2xxx and 7xxx together
- Use your established relative coating rates to predict final thicknesses of mixed loads. Trial and error will fine tune method.
- Consider positioning faster coating alloys in center of bar. Slower ones on end.

Anodizing Additives

- **Marketed in three distinct ways:**
- As a means to improve low temp hardcoat quality.
- As a means to achieve hardcoatings with less chilling power.
- As an aid to "High Speed" Anodizing.

In Low Temp Hardcoat

- Assists in removing heat from the base of the pore by either increasing the rate of flow through the pore or by a catalyzed endothermic reaction.
- This is advantageous when hard anodizing difficult alloys such as 2024 because it reduces the chances of burning significantly.
- It also allows for harder coatings because the rate of dissolution is slowed by the endothermic qualities of the additive.

High Temp Hardcoat

- 6061 can pass taber at 60 Deg F
- Excellent alternative for shops with insufficient chilling power.
- Coating is clearer than traditional low temp hardcoat. Dyes very nicely.
- 2xxx and 7xxx will not pass taber at high temp.

High Speed Anodizing?

- Ignores the fact that the anodize process is composed of much more than the actual time in the anodize tank.
- It ignores the fact that we have limitations on rectifier size. If we shorten the time then we MUST increase the current proportionally. Add material handling issues and the burden actually INCREASES.
- It ignores the fact that higher current densities tend to exacerbate coating thickness variation within the load.

Fast vs Slow

- **Anodizing at 10 ASF.** Assume 1000 amp rectifier, .0005" thick coating. 6061 alloy.
- 360 amp mins to reach .5 mil
- 360/10=36 mins to reach .5 mil
- Assume 5 mins between loads.100 SF/41 mins
- 480 min in 8 hr day. 480/41=11.71 loads/day
- 11.71 x 100 SF/load=**1171 SF/day**

Fast Vs Slow Cont'd

- **Anodizing at 15 ASF.**

- 1000Amps/15 ASF=66.66 SF/load
- 360 Amp Min/ 15 ASF=24 mins/load
- Assume 5 mins between load.
- 66.66 SF every 29 mins
- 480/29=16.55 loads/day
- 16.55 x 66.66=**1103 SF/Day**

Maximizing Capacity

- ***In order to maximize line capacity, anodize max loads at the lowest possible current density required to produce an acceptable finish.***
- Loads at less than maximum ampacity can be run at higher current densities in an attempt to minimize tank time but the results will not be a dramatic improvement in capacity.

Minimizing Resistance

- Establish regular busbar and rack maintenance schedules
- In a new installation, consider cables instead of busbar.
- Mount the landing pad on the tank onto a universal type joint that will allow it to compensate slightly for angular deflection
- Mount the tank pad in such a way that the flight pad landing pad can be easily clamped to the tank landing pad.
- Use braided copper pads (such as those used in spot welding machines) as a shim to re-establish contact. Do not use copper under the solution level.

Key Points

- Lack of management buy-in to a structured Quality Management System is the biggest barrier to expansion.
- An undocumented process only continues to work if the operators are sufficiently knowledgeable and responsible to overcome the obstacles present to processing the job.
- Establish coating rates on the principal alloy groups, *at several amperage ranges*.
- In order to maximize line capacity, anodize max loads at the lowest possible current density required to produce an acceptable finish.