Optimization of Current Anodizing Line in Small Contract Manufacturing Company

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Abstract

Titanium color anodizing is a process that consists in creating an oxide layer in the titanium surface to change the color of titanium components. As a highly used process in the medical implant industry, a small contract manufacturing company developed the process in-house. With the desire of incorporating anodizing as an independent service from the manufacturing service, this project developed a new fixture that reduces by 85% the processing time for the anodizing process in parts anodized using low voltages, which take to about half the titanium anodizing spectrum.

Introduction

This paper focuses on a small contract manufacturing company located in Hato Rey, Puerto Rico. This company provides contract manufacturing services which require regulations and monitoring from the Food and Drug Administration (FDA). They recently developed in-house capabilities for type III titanium anodizing, also known as titanium color anodizing, and are also looking to provide it as a service, not only for internal purposes. Titanium color anodizing is a process used to change the color of the surface of any titanium part using an electrolytic bath. Thus, they have the need to perform as efficiently as possible to ensure that the lead time of both the service and the manufacturing is affected by the increase in demand.

Background

The electrolytic bath needs to be carefully designed to consider the geometry and size of the parts that are to be anodized. All parts submerged into the bath must become part of the electrical circuit. Figure 1 shows an example of the required features for these baths. Direct Current (DC) flows the positive anode into the negative cathode. Some sort of mechanical agitation, i.e. ultrasonic or air flow, is required to reduce the thermal concentration in one specific spot during the anodizing process. The current travels through the surface of the titanium materials and creates the layer required. All the parts that are to be anodized at the same time must all be in contact with the anode in the circuit. This is why racking is crucial to understand the number of parts that can be processed at a given time. It is generally understood that the cathode and anode must have a 2:1 ratio. This is given in terms of surface area.

Problem

Developing the ability for bulk anodizing, in any capacity, is crucial to enhance the capabilities of the current equipment, without the immediate addition of more equipment or operators, thus reducing the amount of cost per part. Designing and developing a new fixture, to enable bulk anodizing, is considered the first step into enhancing said capabilities. This article aims to study the efficiency of a new titanium anodizing basket design and the viability of said design as a method of reducing production cycle time for the titanium anodizing process.

Methodology

A new fixture was designed and developed to increase the capacity of the titanium anodizing tank. The goal was to ensure that all parts can obtain the desired color while reducing the amount of setup time that is required by the fixture. Currently, the fixture used requires 2 minutes of setup time to rack the part and another 2 minutes to de-rack the parts. The time difference between the current and new design were measured and the data was inserted into a graph for visual conclusions. Furthermore, four sets of 25 samples were obtained for multiple colors within the titanium anodizing spectrum. The number of acceptable parts for each color was determined as a percentage of the parts processed and a commentary was added for the defects that were found.

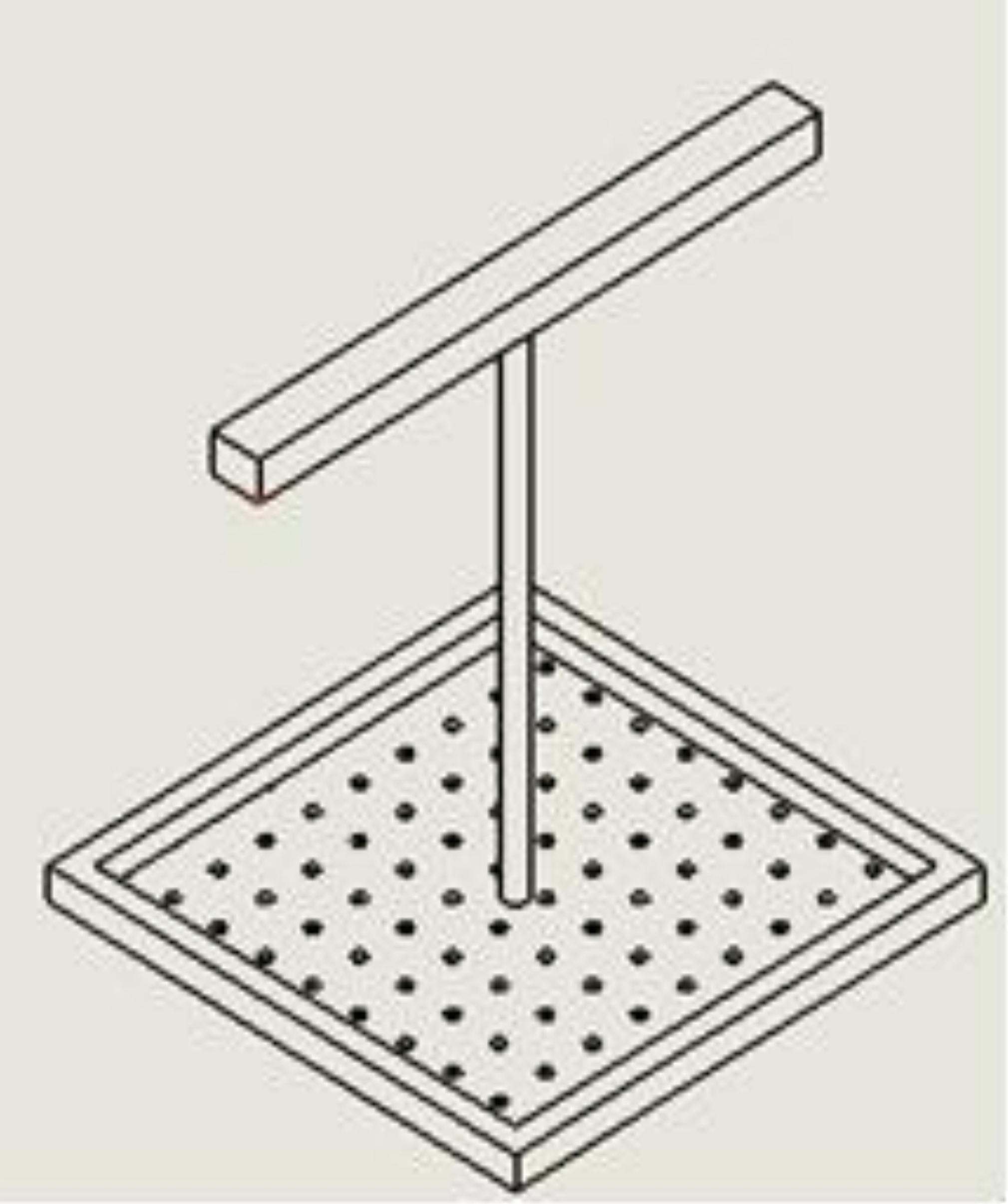

Figure 1: New Fixture Design

The bath used to perform the tests had a cathode surface area of 264.5 in^2. The individual part with the highest surface area has 0.192 in^2. This part was the worst-case scenario for this process. The current fixture allows for 20 parts to be processed at a given time. To this article, 20 parts can be processed every 385 seconds. The new fixture design, shown in the figure above, has a 100 in^2 bottom tray. This tray also has 100 holes of 0.25-in diameter, to reduce the surface area used. With this tray, considering the worst-case scenario screw, up to 600 parts could be processed at a specific time. This provides, in theory, a maximum of 600 parts every 220 seconds. This provides for an 85% decrease in terms of parts per second.

Results and Discussion

The table below provides the results obtained from the bulk anodizing results. The transition from Gold to Pink is a threshold in what is low voltage to high voltage. The first colors from the spectrum, i.e. the lower voltages, provided good results with all parts processed considered acceptable by the quality standards. None of the high voltages were considered completely acceptable due to an effect on the surface finish. In fact, Green is considered outside of the tolerable yield by the company, though it was considered that the color was achieved. In the case of Pink, Magenta, and Green, faded color means that an opaque coating or contaminant affected some of the parts. In Aqua and Teal, transitional color means that some parts were found to be transitioning from one color to another but did not provide the consistency required for acceptable results.

Table 1: Bulk Anodizing results

Color	Voltage	Number of Acceptable Parts	Main Defect Found
Bronze	17	100	N/A
Blue	24	100	N/A
Light Blue	32	100	N/A
Gold	55	100	N/A
Pink	62	92	Faded Color
Magenta	71	94	Faded Color
Aqua	82	97	Transitional Color
Teal	89	95	Transitional Color
Green	95	89	Faded Color

Figure 2 demonstrates the differences in time for each tank and the setup before and after the anodizing process. The Tank 4 value for the new fixture increased due to the additional surface area to be processed.

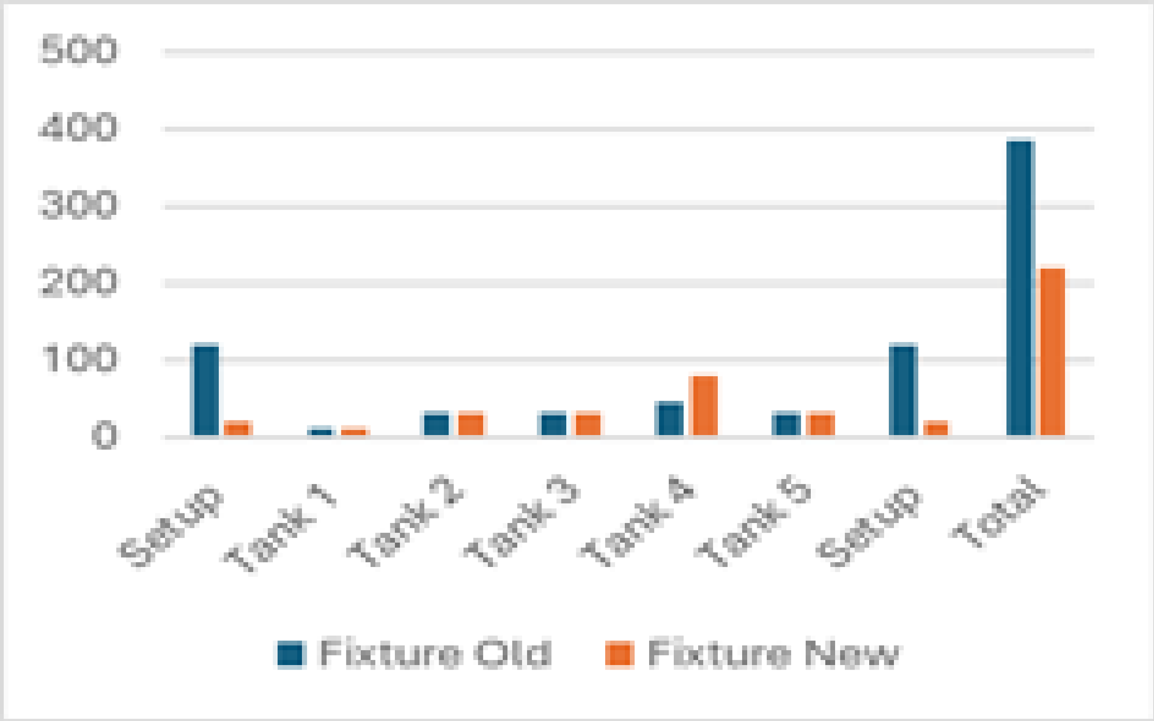

Figure 2: Time Difference for Fixturing

As seen in the results, low voltage parts can be processed with a low to no percent of rejected parts. When it came to high voltage colors within the spectrum, there seemed to be other factors affecting the results of the parts. Since grade 2 titanium was used for the basket, this could be a possible source of contamination for the parts, which were made of grade 23 titanium. Another aspect could be the chemistry's behavior when it is exposed to high voltages.

Conclusions

Overall, the findings in this article provide a better understanding of the fixturing possibilities, and possible enhancements that can be performed to improve the efficiency of a titanium color anodizing line. In all companies, but especially in smaller scale companies, any possible reduction in time can provide the company with more growth opportunities. For an immediate action, all lots to be processed in the low voltage side of the spectrum must be processed using the new fixture design. With such an implementation, around half the current processing time could be reduced up to 85% in cycle time. Thus, providing ample room for anodizing as a service using the same number of operators and equipment.

Future Work

There needs to be further study on the different parameters that affect the titanium anodizing process, especially to understand why defects arise in the high voltage side of the spectrum. The solution chemistry and the rinsing efficiency of the previous bath should be considered the next steps towards improving this yield. Another aspect that could be considered is a further iteration of the racking procedure where air flow, where possible contamination may arise, could be eliminated and still maintaining mechanical agitation onto the components to be anodized.