A new approach to pulse anodising - Decreasing energy consumption – Increasing productivity

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1. Abstract

Most of the anodising job shops use DC or pulse anodising with pulses in milliseconds. The process time for forming a 20µm anodic oxide layer with these methods is normally in the area of 60 minutes. By using slow square-formed pulses, this process time can be decreased with up to 50% and at the same time, the total energy consumption in the anodising tank can be decreased with up to 30 %.

This paper is part of the work to be delivered in the project " Energy optimisation in the anodising process – an electrolytic process" sponsored by the Dansk El-distribution (Danish Power Distribution).

The present work will show how an existing anodising line can be optimised with a few simple guidelines. To provide the necessary contact several parts of the anodising equipment were improved before implementing pulse anodising. Several current densities and pulse periods were tested to find the parameters that provide the most optimal productivity and, at the same time, the lowest energy consumption.

The aluminium alloy was a 6063, and four different profiles were processed in order to investigate whether the geometry had some influence on the pulse parameters.

2. The new approach

Two Years ago the first paper in this project was presented at the Annual AAC Conference in Atlanta[1]. This paper contained the thoughts of introducing pulse anodizing in an existing production line. This paper will list the conclusions from the project.

For too long the pulse anodizing has been in the hands of the suppliers of rectifiers. There has not been enough convincing evidence to prove that pulse anodizing with slow pulses is much more effective than with fast pulses.

Slow pulses mean low frequency as accounted for in the early eighties by Yokoyama, Konno and Takahashi[2].

The anodizing industry has rejected it because to many have invested in new rectifiers without obtaining the energy saving as expected.

Additives and increasing acid concentration and temperature have been suggested as new ways to save energy. In this ways the anodizer is in the hand of the chemical supplier and the quality of the coating is much more insecure.

The new approach is in the simplest way to get back to the basic.

Anodizing and pulse anodizing

Back to basic in anodizing means that a current converts the aluminum surface into aluminum oxide. For the current to flow there has to be an electrolyte. This electrolyte is the one, which decide whether the quality will be good enough, or not.

Therefore this electrolyte should be as simple as possible. The specification for the Qualanod

Quality Label describes this electrolyte. The electrolyte contains not more that 200 g/l (18 wt%) sulfuric acid with a content of aluminum between 5 to 15 g/l at a temperature not above 20°C (68F) and with a current density of 1.5 – 2.0 amp/dm^2 (~ 15 – 20 a.s.f.).

To use pulses as a parameter for reduced energy consumption the anodizer has to be aware of two important things. What the anodizer needs to know is how much current the busbar can drive and if the agitation in the tank is well enough to cool in the period with high current density.

Lots of work has been done on the subject of using square wave-formed pulses[2,4]. The whole idea of using pulse anodizing is to have a higher average current density and hereby reducing the process time.

In short pulsating between two values of the current density, a high period (1) and a low period (2), gives the aluminum surface time to recover during the low current density period[2,4]. The time for these periods should be in the range of 10 – 240 seconds due to the fact of the two different dissolution mechanisms taken place during anodizing.

These two dissolution mechanisms take place with very different rates. The field-assisted dissolution takes place with rates up to 300 nm oxide pr. minute whereas the chemical dissolution is much slower with rates up to 0.1 nm oxide pr. minute[5,6].

3. Pulse anodizing in production

Constant current during the anodizing process will result in an increase in voltage due to the growing aluminum oxide layer. Higher current density will result in higher voltage response, see figure 1.

Figure 1 shows the four current density parameters for the anodizing process. The red curve is the DC anodizing, the blue PC 2.25/1 A/dm^2, the green PC 3/1 A/dm^2 and the yellow PC 4/1 A/dm^2.

The thickness of the oxide layer was 20 μm and the pulse time was 120 seconds for the high current and 30 seconds for the low current.

Conventional pretreatment was used and the alloy was customer specified, AA 6063. The loads were of the same customer parts, which were profiles with a medium complicated geometry.

The maximum voltage did not exceed 30 V at any time and as seen in the figure the increase is not linear.

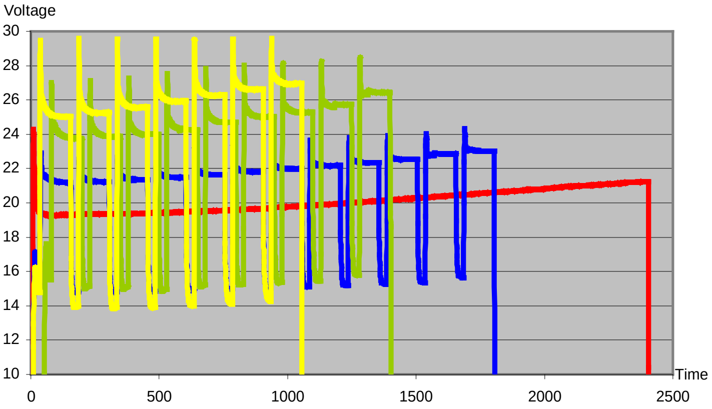


Figure 1, Voltage response forming 25 μm under different anodizing condition

The energy consumption is calculated in MWh/m^3, which gives an idea of the amount of energy used pr. micron formed oxide layer, see figure 2.

Electricity is priced by kilowatt-hours (kWh) V • A • time, therefore will a higher voltage normally be unfavorable. Using the square-waved formed pulses the process time will be reduced so much that the increase in voltage has no negative influence on the total energy consumption.

The voltage drop over various areas were logged every second during the anodizing process[1]. The energy consumption is calculated from the logged voltage drops and the current running trough the system.

The DC process uses 87 MWh/m^3 compared to the process pulsating between 4 A/dm^2 in 120 seconds and 1 A/dm^2 in 30 seconds with a total process time of 18 minutes.

The thicknesses of the oxide layers are identical as shown in figure 3. Though the thickness is higher than calculated even for the DC process.

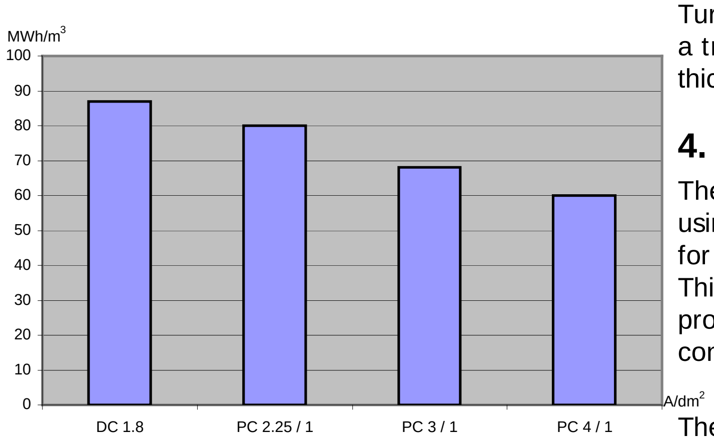
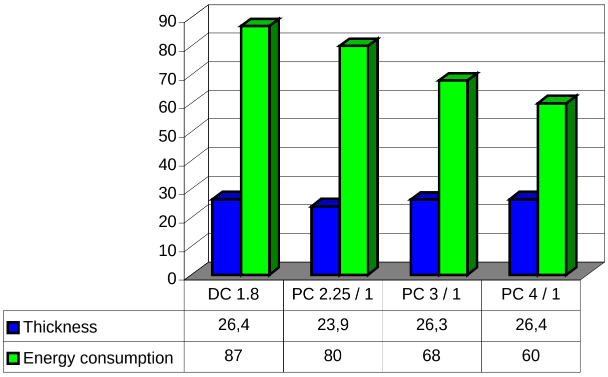
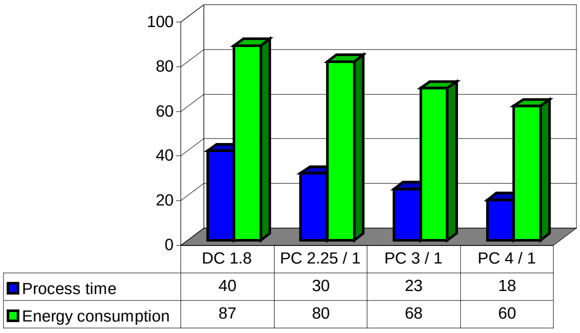


Figure 2, Energy consumption regarding anodizing parameters



	DC 1.8	PC 2.25 / 1	PC 3 / 1	PC 4 / 1
🟦 Thickness	26,4	23,9	26,3	26,4
🟩 Energy consumption	87	80	68	60

Figure 3, Thickness of the oxide layers formed by the four different processes



	DC 1.8	PC 2.25 / 1	PC 3 / 1	PC 4 / 1
🟦 Process time	40	30	23	18
🟩 Energy consumption	87	80	68	60

Figure 4, Process time of the four different processes

Turning to the process time, see figure 4, there is a tremendous reduction in time forming the same thickness of the oxide layer.

4. Conclusion

The energy consumption is reduced by 31% when using the pulse anodizing. This value is calculated for the high current density pulse process 4/1. This high current density can only be used in a production with a well agitated electrolyte and contact points that are well maintained.

The process time is decreased with over 50 % by the pulse process 4/1. The quality of the oxide layer is the same for all the four processes. The oxide layer withstands 1000 hours in a salt spray fog testing as ASTM B 117.

This reduction in time in the anodizing tank should be considered in the rest of the production line. Racking the parts could be done automatically to increase the amount of racks to fill the anodizing line with.

5. Acknowledgements

To the Danish Eldistribution, ELFOR, Jørn Borup Jensen.

6. References

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