

## HARD ANODISING OF INTERNAL BORE OF CYLINDRICAL ALUMINIUM ALLOY FOR ENGINEERING APPLICATIONS

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### ABSTRACT

Hard anodising of internal bores of aluminium guide disc used in shock absorbers cannot be carried out by the conventional method of anodising. So special type of jig has been fabricated to hold the rings one over the other and the electrolyte is flowed through the internal bore without seepage of the electrolyte. The influence of the parameters such as temperature, current density, flow rate and the properties such as hardness, coating ratio and thickness were studied using different electrolyte systems.

**Key words:** Hard anodising, engineering application, Al alloy

### INTRODUCTION

In the past few decades various hard anodising processes have been developed wherein an extremely thick, wear and corrosion resistant oxide coating has been produced on an impressive range of aluminium alloys. These hard coatings over the stronger aluminium alloys can be substituted for steel alloys in many design applications where superior strength of steel is not of importance from design angle. Unlike electroplating – in general – hard anodising is wellknown for its superior throwing power. Production of uniform hard coatings on complicated parts can be achieved with adequate agitation of the electrolyte throughout the surface of the work piece. In this way, overheating and localised burning can be eliminated.

It is reported [1] that for hard anodising of internal bore of 25 mm dia tube, the relative electrolyte flow to the anode surface must be at the rate of 3 to 21 metre/min. for every 0.3 m length of the tube.

Most of the hard anodising processes are based on 9 to 15% (V/V) sulphuric acid solutions [2]. The anodising bath is operated at a temperature +5°C and less. For hard anodising alloys containing copper over 5% and silicon over 9%, AC superimposed over DC current is used. Addition of 1 to 2% oxalic acid to sulphuric acid is also employed for hard anodising [3] and it helps the prevention of burning due to local heat at places where proper circulation of anodising electrolyte is a bit difficult.

Addition of various organic components such as polyhydric alcohols, aliphatic hydroxy carboxylic acids, dicarboxylic acids to sulphuric/oxalic acid are reported [4,5]. some of these additions give harder film at slightly higher operating temperature than conventional sulphuric acid process. The saving in cost of cooling the anodising electrolyte and capital investment on chilling plant have to be weighed against recurring expenditures like cost of anodising electrolyte containing organic compounds and its analytical control during operation. These organic compounds get decomposed at the electrode to give side products; which may not be beneficial and sometimes, they corrode the materials of construction [6]. There are other restrictions. The power consumption is more due to higher starting and final anodising voltage. The bath can tolerate only a few grams of aluminium per litre and they are more sensitive to chloride ion contamination than sulphuric acid bath.

### EXPERIMENTAL

#### Design of PVC jig for hard anodising

Hard anodising of cylindrical aluminium pieces of length 13.5 mm and dia

36 mm with 11 mm bore at the centre is carried out requiring anodising inside the bore. The best way of anodising a number of cylinders at a time was to pack them one over the other in a leak proof PVC jig, with a lead coated copper rod as cathode, placed at the axis of the tube thus formed by the bores of the cylinders. By circulating the electrolyte through the bores, all the bores of the cylinder could be anodised at a time.

The PVC jig consisted of three parts: top lid (1) body (2) and bottom lid (3). The top lid (1) as shown in Fig. 1 is provided with fine thread for screwing it to the body (2). The PVC outlet pipe (6) is welded at an angle perpendicular to the body of the lid. The top lid is bored to sufficient depth for the flow of electrolyte. Two neoprene washers are provided to the top lid. A washer (7) each is placed on the top end of the thread span. At the bottom side of the lid, a hole is drilled at the centre and a teflon bush (11) with 3 mm hole at its centre, is fixed and it can take through the hole in the bush a 3 mm dia lead coated copper rod can be inserted. Another hole of 1 mm dia is drilled in the teflon bush to take the aluminium spring (12). The Fig. 2 shows the body. This is bored to close dimensions so that the aluminium cylinder can be slid into the body. The ends of the body are provided with corresponding internal threads to take the top and bottom lids.

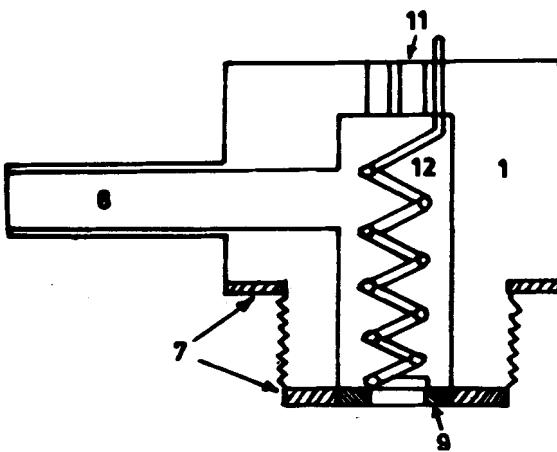


Fig. 1: Top lid of the jig

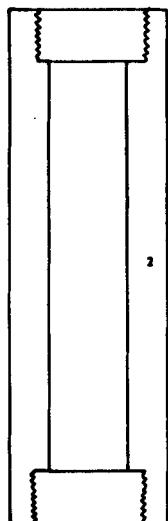


Fig. 2: Body of the jig

The fig. 3 shows the bottom lid. It is provided with external thread for screwing it to the body. An inlet PVC pipe (5) is welded similar to 6 above. The lid is bored to sufficient depth for the flow of electrolyte. Two neoprene washers (8) are provided to the lid as shown. At the top side of the lid, a hole is drilled at the centre and a teflon bush with 3 mm dia hole is fixed.

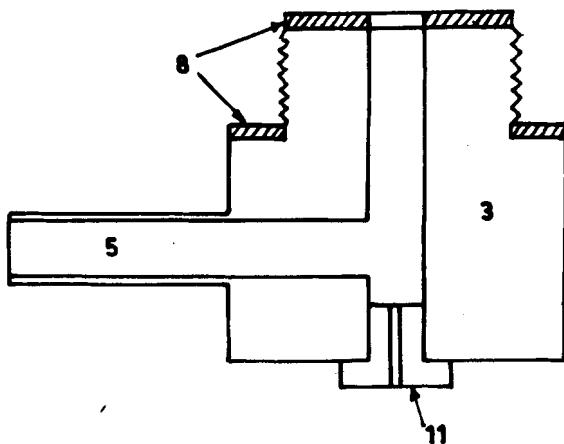


Fig. 3: Bottom lid of the jig

#### Sequence of operation for hard anodising of aluminium cylinders

The aluminium cylinders were degreased in trichloroethylene, soak cleaned in 15 gpl sodium carbonate + 5 gpl sodium phosphate solution at 80°C for 2 minutes, washed in tap water, desmutted in 15% V/V nitric acid for 2 minutes, washed in tap water and rinsed in deionised water.

All the components of the PVC jigs are washed well in tap water and rinsed in deionised water.

The bottom lid with its washers was screwed to the body. The lead coated copper rod was inserted through the teflon bush. The aluminium

cylinders were pushed into the body. The jig can take ten numbers of cylinders in question. An aluminium circular washer (9) with 11 mm hole at the centre - corresponding to bore dia - was placed over the top of the cylinder, to give electrical contact. The neoprene washer was placed around this washer. Now the aluminium spring was inserted into the hole in the top lid, followed by one lead coated copper rod in the teflon bush of the top lid. The top lid was screwed lightly to the body.

25 litres of the anodising electrolyte was contained in a PVC tank provided with lead cooling coil, and PVC air agitation tubes. Brine solution was circulated through the lead cooling coil. The air from a rotary air compressor through the PVC tubes maintained uniform temperature. The anodising electrolyte at required temperature was pumped through the PVC jig by means of an ebonite pump with entry at inlet pipe (5). The aluminium spring is connected to the positive terminal and lead coated copper rod to the negative terminal of a three phase rectifier.

After anodising, the cylinders were taken out from the PVC jig and washed well and dried.

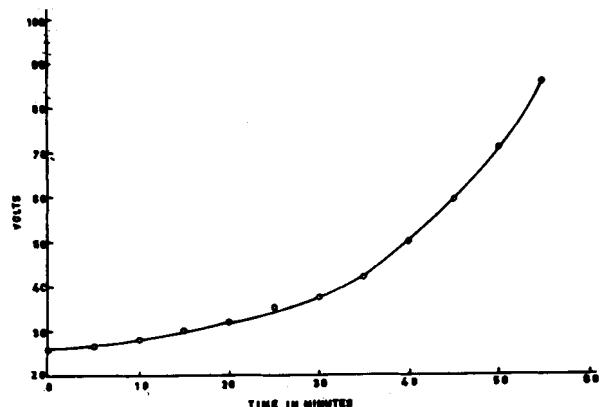
The bath containing 165 gpl sulphuric acid and cooled to  $3^\circ \pm 1^\circ\text{C}$  was employed at current densities of  $4 \text{ A}.\text{dm}^{-2}$  and  $5.2 \text{ A}.\text{dm}^{-2}$  for a period of one hour. Periodically the voltage was increased to impress the chosen current density. Since it is reported that a difference in temperature of  $2^\circ\text{C}$  between the bath and the delivery side of the PVC jig may give soft oxide film, a temperature difference of  $1^\circ\text{C}$  was maintained with a minimum flow rate of 3 metres/min. and 4.5 metres/min. respectively at the current densities studied.

Since it is difficult to determine the hardness, thickness etc. of the oxide film produced inside the 11 mm dia bore of the cylinders, samples were prepared under similar experimental conditions with H<sub>3</sub>O alloy sheet, adopting the following approach. Two pieces of PVC rods of dia. 36 mm-60 mm length with 11 mm dia hole, were slid into the PVC jig. At the top of the rods a PVC rod of dia 36 mm and length 15 mm with 10 mm square hole at the centre was placed. The H<sub>3</sub>O alloy sheet of dimensions, 35 mm x 10 mm x 2 mm was folded at right angles to have 15 mm length on one side. This shaped plate is placed over the top of the PVC rod such that 15 mm x 10 mm side is fixed to one side of the 10 mm square hole. By giving electrical contact with aluminium washer (9) and aluminium spring (12), using lead coated copper rod as cathode the alloy sheet was hard anodised.

Over the specimens prepared above, hardness of the oxide film was measured with C E Johnsons hardness testing machine using a diamond pyramid indentor with a load of 200 g. The hardness values reported in VPN units were the average of five measurements. The thickness of the film was measured with Dermitron Model 9 D using a Probe D with scale 000-1010.

#### RESULTS AND DISCUSSIONS

The fig. 4 shows the voltage-time curve obtained while anodising H<sub>3</sub>O alloy in 165 gpl sulphuric acid - a commercially adopted solution - at  $\pm 1^\circ\text{C}$  using  $4 \text{ A}/\text{dm}^2$

Fig. 4: Voltage-time curve for anodising H<sub>3</sub>O alloy in 165 g/l sulphuric acid at  $3 \pm 1^\circ\text{C}$  using  $4 \text{ A}/\text{dm}^2$

The Table I gives the various electrolytes used and the results obtained.

Table I: Influence of current density, temperature and flow rate on the hardness and thickness using different electrolyte systems

S.No.	Electrolyte	C.D. A.dm <sup>-2</sup>	Temp (°C)	Anodising voltage		Hardness (VPN)	Thickness (μm)	Flow rate (metre/min)
				Initial	Final			
1.	165 gpl H <sub>2</sub> SO <sub>4</sub>	4	3 ± 1	24	86	440	58	3
2.	6% V/V H <sub>2</sub> SO <sub>4</sub> + 4% W/V oxalic acid [7]	5.2	3 ± 1	29	98	450	72	4.5
3.	6% V/V H <sub>2</sub> SO <sub>4</sub> + 4% W/V malonic acid	4	10	28	73	400	70	3
4.	5% W/V oxalic acid + 4% W/V malonic acid [8]	4	20	29	129	500	60	5

The hardness and thickness values obtained in 165 gpl sulphuric acid bath flow rate comparable with the values obtained by anodising in the same bath under stationary condition having good agitation (3 metre/min). The higher current density of 5.2 A.dm<sup>-2</sup> gave thicker oxide film. The 6% V/V sulphuric acid + 4% W/V oxalic acid bath gave fairly hard oxide under flow condition. This bath with malonic acid in place of oxalic acid gave a higher final anodising voltage compared to oxalic acid—sulphuric acid mixture. The oxalic-malonic acid at 20°C gave maximum hardness of 500 VPN. Due to high anodising voltages involved the flow rate had to be increased to 5 metre/min

## CONCLUSION

From the above results it can be concluded that the PVC jig designed can be successfully used for hard anodising internal bores of cylinders by circulating the anodising electrolyte through the jig at a flow rate of 3 to 5 metre/min.

## REFERENCES

1. W J Campbell, U.S. Patent, 716554 (1954)
2. Hard anodising of aluminium D.T.D. specification. *Electroplating and Metal Finishing*, 10 (1957) 119
3. H J Wiegner and H A Mears, *Proc AES*, 45 (1958) 105
4. J M Cape, *Metal Industries*, 91 (1957) 109
5. K H Dale, *Plating*, 59 (1972) 843
6. J M Cape, *Metallurgia*, 60 (1959) 181
7. A W Brace, *The technology of anodised aluminium*. Chapter II, Robert Draper Ltd. Teddington, 1968
8. V L Narasimhan, K R Narasimhan and B A Shenoi, *Metal Finishing*, 65 (1967) 60