# FABRICATION OF DIPOLE VACUUM CHAMBER

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*Abstract*

Indus-2 dipole vacuum chamber is 3.6 meter long aluminum alloy chamber, which is fabricated from two thick plates of grade AA 5083 H321. These chambers will be installed in the 2.5GeV electron storage ring of synchrotron radiation source at centre for advanced technology Indore Each half of the chamber is complex in shape and it is machined by using CNC skin milling m/c. Manual TIG welding process is adopted in fabrication. Nineteen chambers, have been successfully completed and vacuum leak tested to the design target i.e. 4.0 x $10^{-10}$ mbar ltrs./ sec. This paper describes the fabrication aspects of dipole vacuum chamber.

## INTRODUCTION

3.6 meters long aluminum alloy dipole bending magnet vacuum chamber is fabricated with aluminum alloy grade AA 5083 H321, which has highest annealed strength and ductility compared to other non-heat treatable aluminum alloy. Each chamber consists of two halves i.e. top and bottom. These halves are machined on CNC skin milling m/c because of its complex shape and required precise dimensional stability. Roughness of 0.2 micrometer is achieved, which will be effective in minimizing the desorption rate. Welding lip of 2.5 mm. all around is provided in each half. Each chamber is an arc segment with 22.5º bending angle. Based on the design requirements, initially welding procedure was qualified and a prototype chamber was fabricated and tested. After that the regular production was started.

## MACHINING AND CLEANING

Machining of the dipole vacuum chamber was carried out in an Indian industry having specialization in manufacturing of aircraft components. The machine used is a bridge type 3 axes CNC milling machine having a large table to accommodate the vacuum chambers. The CNC programme of the machining of dipole chambers was made by using CAM software. This CNC programme was approved by cutting hard foam to check the final sizes. Two nos. of fixtures were made to final machine vacuum chambers. Each half of the vacuum chamber was final machined in two settings with suitable clamps so as to minimize the job spring back. Care was taken so that the welding lips of the job do not get damaged in the subsequent handling of the job before final welding of vacuum chambers. Dowel pins were provided in both the halves to align beam path of the vacuum chamber Special stellite coated milling cutters were used for machining of the vacuum chambers to obtain excellent surface finish. Extra care was taken during machining of UHV sealing areas Final machined job was properly wrapped to avoid scratches and dent marks. Cleaning of the chamber was done in various steps a) Vapor degreasing by trichloroethylene (at 87ºc). b) Cleaning in sodium hydroxide solution at room temperature. c) Immersed in nitric acid for 10 minutes at room temperature. d) Water washing, rinsing in demineralised water and dried in air. [1]

## WELDING OF CHAMBER

Higher thermal conductivity, aluminum oxide layer, high hydrogen solubility are the main feature while welding aluminum alloy, and this can cause gas porosity. [2]. One of the major sources of hydrogen is atmospheric moisture. This problem can be overcome by maintaining relative humidity less than 40% in welding area. In welding of dipole vacuum chambers aluminum alloy, AA5083 is used which has highest annealed strength and ductility compared to other non-heat treatable aluminum alloy. In this particular alloy mechanical properties are much less affected by base metal tamper or the thickness of the weldment, than are the heat treatable alloy. Weldability of AA 5083 is good and weld joints are free from hot cracking. The only problem with this alloy is heavier oxide film, but this problem can be overcome by proper surface cleaning.

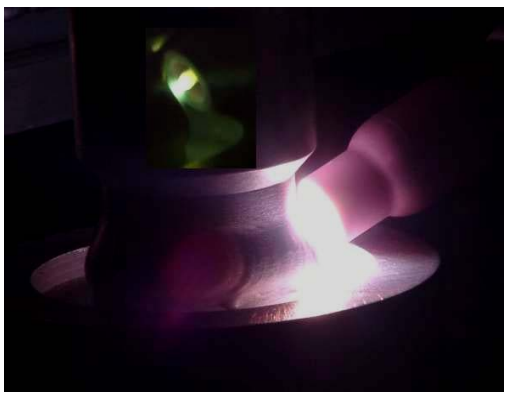

Figure 1: Welding of BPM port

Manual TIG welding process was adopted in the welding of dipole vacuum chamber before taking up production welding procedure was qualified and optimum values of welding parameters were set. Each dipole vacuum chamber consists of two halves i.e. top and bottom. Both halves of the chamber were hand scrapped and assembled using dowel holes within aligned accuracy. Qualified weld parameters including welding current, pulse frequency, etc. was carefully adjusted. High purity (99.99% pure) argon gas was used for both shielding and purging. End part of the weld bead was overlapped by 25-30mm. to avoid crater cracking. The exit port flanges and end flanges were welded in the last.

Table 1: Optimised TIG welding Parameters

| Welding Parameters | Values |
|---|---|
| Peak currant | 45-120 Amps. |
| Back ground current | 25-35 Amps. |
| Pulse frequency | 140 Hz. |
| Pulse Ratio | 80% |
| Type of arc | Hard arc |
| Filler wire | ER 5183(ø 2.0mm.) |
| Shielding Gas | 99.999% pure Argon |
| Shielding gas flow rate | 08 Ltrs./min |
| Relative Humidity | 35-40% @ 22º C |

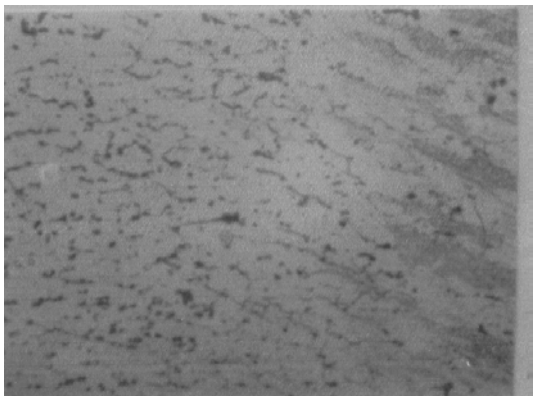

Figure 2: Fusion zone/HAZ/Base metal

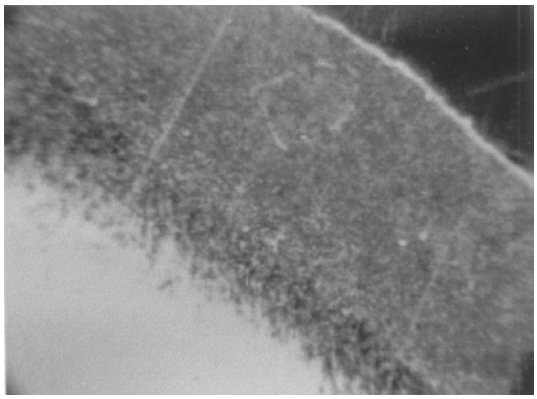

Figure 3: Fillet Weld with 5183 filler at 15X

Figure 4: Welded dipole vacuum chamber

## LEAK TESTING OF THE CHAMBER

Helium leak detector was used to check leak tightness of the weld joints. The helium leak rate of welded vacuum chamber was less than 2.0 x $10^{-10}$ mbar ltrs./ sec. It also passed the ultimate vacuum performance test to the design requirements.

## CONCLUSION

Workshop A , CAT; Indore has successfully fabricated Nineteen 3.6 mtrs. long dipole bending magnet chambers made of aluminum alloy grade AA 5083 H321 These chambers were tested at leak rate of $4x10^{-10}$ mbar ltrs./sec. Seventeen chambers also passed ultimate vacuum performance test as per the design requirements, other three chambers are in line for ultimate vacuum test.

## REFERENCES

[1] P. Ram shankar, S.N.Vyas et al., “Chemical cleaning of aluminum alloy vacuum chambers of Indus-2,” MSAI, Mumbai.

[2] Aluminum association Inc., “Welding aluminum,” 1991 edition.