

CHAMBER UPGRADE FOR EPU48 IN TPS

I.C. Sheng[†], C.C. Chang, C.K. Chan, L.H. Wu, C. Shueh, Y.C. Yang, C.M. Cheng,
I.T. Huang, J. Y. Chuang, Y. T. Cheng, Y. M. Hsiao, National Synchrotron Research Center,
HsinChu, Taiwan

Abstract

Due to high total power and power density in Taiwan Photon Source (TPS) of EPU48 (Elliptical Polarized Undulator) in double minimum sector, we fabricate a new Aluminium vacuum chamber to increase sufficient room for synchrotron radiation to pass through without damage the storage ring chamber. A new method of in-site replacement of bending chamber is also presented, the result of this replacement procedure shows that it is very cost-effective as well as good UHV vacuum quality.

INTRODUCTIONS

Taiwan Photon Source (TPS) has successfully reached 500mA storage beam design goal in year 2015. Currently seven beam lines have also been constructed and is undergoing beam commissioning. As shown in Table 1, TPS has a tandem 4.8cm period length elliptical polarized undulators (EPU48) for beamline 41, which generates large total power ($13 \times 2 = 26 \text{ kW}$) as well as high power density ($16 \times 2 = 32 \text{ kW/mrad}^2$).

Table 1: Parameters of TPS Tandem IDs

Synchrotron Radiation	EPU48	IU22 (3m)
Period length(cm)	4.8	2.2
Number of Periods	83	137
Maximum B Field (T)	0.9	0.79
Maximum B Field (T)	0.62	0
Effective total length(m)	3.98	3.01
Deflection Parameters(K_y)	4	1.6
Deflection Parameters(K_x)	2.64	0
Total Power (kW)	13	5.4
Maximum Span Angle (mrad)	1.36	0.55
Horizontal beam size (mm)	13.63	5.53
Maximum Span Angle (mrad)	0.9	0.34
Gap value(mm)	13	7
Peak Power per Ω (kW/mrad ²)	16	46
second peak poer(kW/mrad ²)	10.72	
1st Critical energy(eV)	143	1677

The corresponding synchrotron radiation (SR) beam profile results in donut-like elliptical shape, in which the deflection parameters (K_x) controls the beam height. We later notice that for the current design, the gap of Aluminium vacuum bending chamber is not able to allow entire SR to pass through; Simulation reveals that damage of bending chamber will occur. The only solution is either to add an absorber to shadow downstream bending chamber, or to modify the bending chamber. After evaluating these two options, the final decision is to replace a bending chamber which has bigger aperture and more cooling channels. The most challenging issue in replacing the bending chamber is how to efficiently accomplish this mission within a week (since beamline commissioning is still on the way, any extra shutdown time will compress the existing schedule severely), of course, and it has to be cost effective.

THE ANALYSIS

TPS bending chamber is fabricated first machining with upper and bottom halves, then TIG welding together in-house. An exploding view of top and bottom bending chamber is showing in Figure 1 illustrates and yellow line indicates the path of SR. dashed red line indicates the electron trajectory.

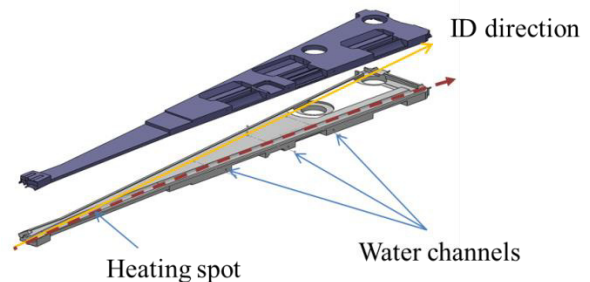


Figure 1: Exploding View of TPS Bending chamber and ID Beam Direction.

The SR first sees fish-eye like aperture (68mm x 30mm), which coincides with that of electron direction, as electron start to bend within dipole magnet, SR goes straight toward to the downstream bending chamber, which immediately is constrained by a 9mm gap. The distance from upstream EPU48 to this aperture is 13.3m whereas the downstream one is 6.7m.

Figure 3 shows that the combined EPU48 SR power density contours (3GeV, 500mA, $K_x=2.3$, $K_y=4$) and size relates to this 9mm gap.

[†] email address shengic@nsrrc.org.tw

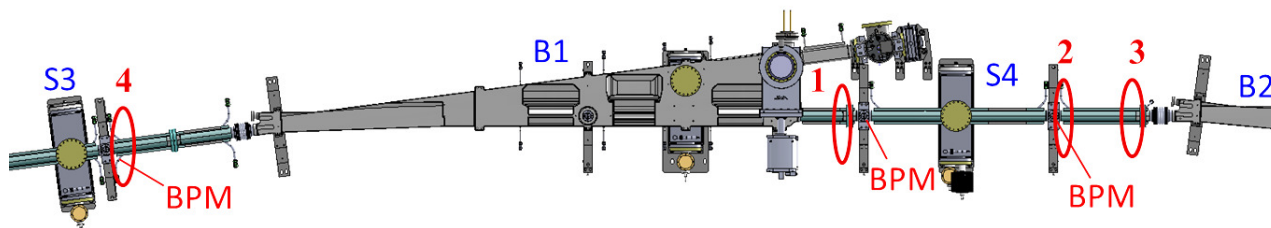


Figure 2: Cutting sequence of B1 bending chamber.

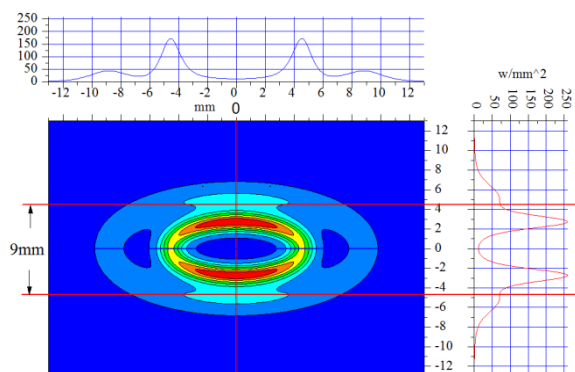


Figure 3: SR power density of tandem EPU48 at 3GeV, 500mA, $K_x=2.3$, $K_y=4$.

THE SOLUTION

We have evaluated several options, including limiting deflection parameter K_x , adding a smaller aperture (7mm) absorber at upstream of bending chamber. However it seems none of those are practical except to replace this chamber by opening up the 9mm aperture.

Figure 2 shows the resultant power density contour of tandem EPU48 at the beginning of 9mm chamber gap. The calculation shows that rest of 4.8kW (2.4kW each) power beyond 9mm height will be deposited on the belly of fish-eye aperture (heating spot, as shown in Figure 1), which will result in unacceptable temperature rise (1300 °C) at this location. Figure 4 indicates bending chamber's sectioned view of temperature contour as original bending chamber receives SR at normal operation.

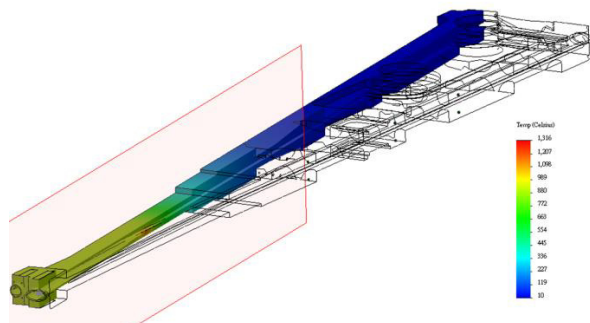


Figure 4: Section view of temperature contours as tandem EPU48 hits original bending chamber.

Along the ID path, we modified the bending chamber by opening up the aperture so that it tapered from 68×24mm to 68×18mm, we also add additional 6 water

channels (3 each on top and bottom) across the bending chamber to enhance the cooling. At the worst beam missteering scenario (as beam deviates 0.2mrad, or equilibrium to 2.66mm offset) only few hundred watts will deposit along the tapered surface and result in only maximum of 40 °C temperature increase.

The TPS storage ring is a 24 cells design, each cell consists of two bending chambers welded together with straight chambers, the cell length has 14m long. Instead of replacing entire 14m storage ring chamber cell (two bending chambers with few straight chamber welded together, which is not only time consuming (42 days) but also unpractical due to crowded space in beam line area (We can lift up the 14m chamber cell by crane but no room to transport it to the laboratory). We decide to saw cut the separate two bending chambers by cutting it in-situ; replace only the upstream bending chamber (B1) which is needed.

A special plug is developed to prevent dust contaminating the chamber during saw cutting. The plug is inserted from BPM ports and filled the small gaps with lime-free paper and alcohol.

THE PROCEDURE



Figure 5: Chamber Plug for Saw Cutting.

Figure 4 illustrates the top view of bending chamber and associated straight chambers, red circled with number indicates the order of the place to saw cut.

The replacement procedure is the following:

1. Remove top concrete ceiling by crane.
2. Remove upper half of the magnets by crane.
3. Disconnect all water and gas pipes.
4. Disconnect BPMs cables, IPs, NEG and IGs from existing B1 bending chamber.
5. With clean booth placed on the cutting area, we first cut places 1 and 2 so that this IP section can be removed immediately.
6. Cut place 3 and TIG weld a new flange.
7. Cut place 4 and the existing B1 bending chamber is able to be removed by crane. Since left hand side of place 4 has a gate valve therefore no flange welding is required.
8. Move new B1 bending chamber in place. The new chamber has total length from place 4 to place 3 in Figure 4, flange to flange, and bolt both places.

9. Put back IPs, NEG and IGs, reconnect BPMs cables, pumping down B1 and B2 bending chambers, leak check, NEG activate. Final leak check.
10. Put back top half magnets by crane.
11. Put back concrete ceiling by crane.



Figure 6: In-situ Flange Welding on Bending Chamber.

Above procedure took total 5 days, 3 days for vacuum group to complete procedures from 3 to 9 in the tunnel. All the new chambers have been cleaned, baked out and leak checked in the lab. Since there is no room to place heating tape, no in-situ baking out is possibly performed in the tunnel. The reason being is suggested by [1,2], many other accelerator facilities have also done no in-situ baking out and the results are still promising [3]. We believe that baking out can only desorbed limited number of chamber particles; most of gas particles are excited by beam cleaning process before they are absorbed by IPs.

The estimated beam dose to reach UHV in TPS is around 30Ah[3], Figure 7 illustrates that after the bending chamber is replaced (SR21), even the average pressure is high in the beginning of installation, as average beam dose reaches over 300Ah, both the SR21IG5 pressure (red circle symbol) coincides with storage ring average pressure.

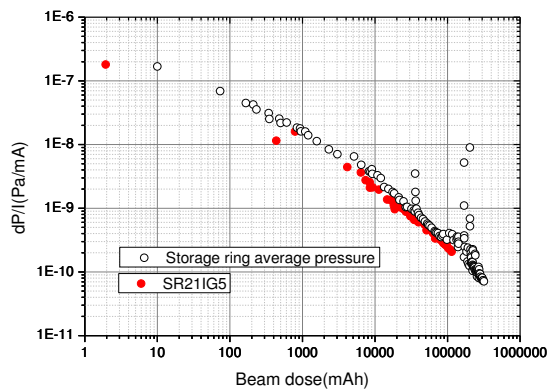


Figure 7: TPS beam dose.

A time-elapsd video is also recorded in YouTube [4].

CONCLUSION

TPS has upgraded corresponding bending chamber for EPU. Due to constrained budget and maintenance time allowed, an in-situ methodology to replace new bending chamber is developed. Total working time in the tunnel is less than 5 days and only 3 days for vacuum group to cut, replace, pump and leak check. Many other synchrotron facilities have also advised that in-situ bake out can be

omitted. It is understandable that in order to reduce vacuum pressure, beam cleaning is much more efficient because synchrotron light has much higher photon energy to desorb more molecules instead of bake out (baking temperature $\sim 150^\circ\text{C}$)

ACKNOWLEDGEMENT

The authors would like to thank Dr. C.T. Chen for valuable discussions and suggestions.

REFERENCES

- [1] J. Miertusova, "Storage Ring Bake-out Efficiency from the Accelerator Parameters Point of View" *Proceedings of EPAC 1998*.
- [2] Yasunori Tanimoto, Yoichiro Hori, Takahashi Nogami and Takashi Uchiyama, "Upgrade and Current Status of the PF Ring Vacuum System" *Proceedings of EPAC 2006*.
- [3] <https://goo.gl/J3NBKx>
- [4] <https://www.youtube.com/watch?v=eae-oWT9hqg>