Abstract

The European XFEL is a 3.3 km long X-Ray laser facility, powered by a 17.5 GeV superconducting linear accelerator, is located at DESY in Hamburg. For its diagnostics ultra-high vacuum components with high mechanical precision and strict requirements on particle cleanliness had to be developed, designed and produced. For the screen system of the facility, enabling to observe the size and shape of the electron beam, massive vessels, precisely milled out of stainless steel blocks 1.4435 (316L) have been produced. For these chambers all flange-connections are milled into these blocks. This paper will report on micro damages in these integrated knife edges and will present simulations of the damage mechanisms. It will also describe the influences of material properties of two different stainless steel brands, effects on the “knife edge” due to the penetration into the gaskets as well as the non-elastic deformation of the sealing area. The dependence of tightening forces under special conditions, like the very clean conditions in particle-free applications due to the non-lubricated area. The dependence of tightening forces under special conditions, like the very clean conditions in particle-free applications due to the non-lubricated area.

Introduction

Particle accelerators are used as standard as well as and special diagnostics, also for the European XFEL (E-XFEL) at DESY, Hamburg. A scintillation screen monitor system has been designed for diagnostic purposes in particle beams. For this system two different types of special vacuum chambers have been fabricated. More than 50 vacuum chamber with weights over 50 kg have been fabricated out of massive blocks. The geometry of these chambers had to be chosen as to match the requirements of independence and stability; therefore a massive stainless steel (SST) block was used. The dimensions of these vessels are bigger than all designs at DESY have been in the past. Since it was very difficult to find any supplier for material in 316 LN, a compromise was found to use 316 L. In the material certification the value for the hardness was a little bit under the minimum boundary of DESY’s specifications with 158 HB.

General information

Stainless steel material (SST):

- Development around 1910
- Non magnetic property
- Durability of surface condition
- Good welding properties
- Corrosion and oxidation resistance
- Standard material on market
- High temperature mechanical strength

Producing of SST:

- Vacuum Melting process (VMP)
- Electro-Slag-Melting process (ESR)
- Annealed
- Forged multidirectional
- 3.1 certified to described requirements
- High metal SST alloys 316 L 0.316 LN

Vacuum sealing technology:

- Gasket sealing technology defined by the American Vacuum Society
- Vacuum connections effectively by compressing a gasket
- Metal gasket or non metal gaskets
- For one time use or multiple use
- Flat, wire or polygonal
- Used under pressure or shear
- Vacuum level from low to UHV and XHV vacuum requirements

Results and Conclusion

The results are presented in this chapter. After several months ramp-up time of testing, investigations and analysis the new production went smoothly. The newly selected material had a significantly higher hardness than the DESY specifications have been described. The FEM simulation results gave a lot of new aspects in several iteration steps all critical forces and forces were pointed out. The FEM simulation gave excellent results for deeper understanding both common knife edge versions used at DESY.

Lessons Learned

One lesson learned was to say good bye to constructions of massive blocks like these two designs with integrated Conflat flanges. Running into serious problems in case of having to rework these chambers is one aspect for using vacuum chambers made of standard Conflat flanges with normal standard SST pipes.

Cooking recipe:

- First clarify, concentrate and be precise about all requirements to the design (incl. all environment conditions, to be bake out, movements, cleanliness requirements...)
- Clarity and require the raw material specifications
- Use standard norms, references or guidelines
- Earliest decision “Make” or “Buy”, as the price of stainless steel changes in a very fast way
- Make a requirement matrix and evaluate the technical functions, write out the results
- Before ordering raw material, check very carefully and control the material properties which will be documented in the 3.1 material raw certification. This 3.1 certification should be related to your delivered batch!
- Hardness for secure and reliable UHV or higher vacuum applications should be over 170 HB, better up to 185 HB (results of many tests and tests)
- Nb better than 0.14 %, Cr not over 17.5 % and Ni more than 12 %
- ESR = Electro-Slag-Roasting, forged multidirectional and annealed is mandatory, full austenitic structure
- Early integration of material producers or vendors, manufacturers and purchase office
- If you make your own design, build more than one prototype for serial productions
- Independent material tests of the raw material should be done after delivering the material
- Make Quality Audits with suitable vendors or manufactures
- Make a risk analysis and if you can use project management competences

GOOD LUCK!!