A DEVICE FOR SEALING SURFACE RECONDITIONING OF CYCLOTRON CAVITIES

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The PSI ring cyclotron cavities have been operational for approx. 30 years. The vacuum seals between the cavities and the vacuum chamber show increasing leak rates, making it more difficult to maintain the desired vacuum quality in the cyclotron. Leaks develop at the O-rings on the aluminium cavity wall side of the sealing bellows. The aluminium surfaces have been hand polished numerous times, with decreasing success – the danger of a longer lasting shutdown due to a complete failure of one of the 8 seals is increasing with time and every additional removal of one of the cavities. A device has been designed and built which will allow a relatively speedy reconditioning of the cavity sealing surfaces, should this suddenly be required.

INTRODUCTION

In order to improve the vacuum seals of a cavity, a complete mechanical grinding and polishing process of the sealing surface has to be performed. An even (flat) and polished surface (Ra=0.50 µm) is required as an end result.

Methods and equipment to obtain such results have been investigated, then, the necessary devices and fixtures were designed, and a prototype was built during 2001. The prototype was test-mounted on a cavity during the shutdown 2002, and later in the year, polishing tests on a dummy surface were performed. Based on these test results, the design then was optimised, and the results will be presented here.

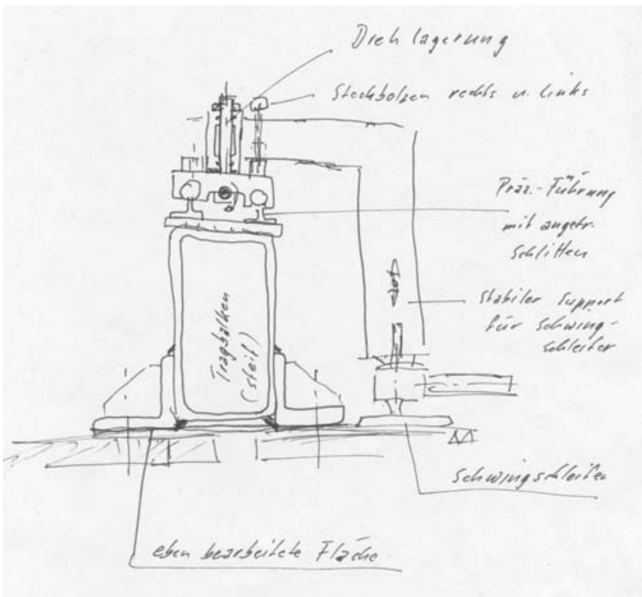

Fig. 1: The first conceptual sketch.

CONCEPT OF A SURFACE CONDITIONING UNIT

The complete device consists of a motor driven belt grinder/polisher module, mounted on a support plate, which in turn is temporarily attached (wedged into) the beam slit of the cavity. The module moves along a gear rack in the shape of a racetrack around the beam slit; its speed along the rack is controllable, as is the belt speed of the grinder. Attached to the rear of the grinder module is a dust pick-up hose, leading to a vacuum cleaner. A more detailed description follows.

MAIN COMPONENTS

(1) Support Plate: the support plate covers the beam slit of the cavity; it is held in place by 13 block fixtures, and has to be flexible enough to follow the deformed cavity contour. The fixtures are temporarily wedged in the beam slit opening. Mounted on the support plate is a closed oval gear rack (Fig. 2), which acts as the forward motion traction system for the grinder module. Additionally, two precision rails, parallel to both sides of the gear rack, assure free-from-play motion of the grinder module as it moves around the beam slit. The gear rack, plus both rails, and one rail clamp, can be seen on the test installation, in Fig. 2.

Fig. 2: Grinder/polisher module on support plate, installed on dummy cavity gap.

(2) Belt grinder/polisher module: The belt and drive system is visible at the bottom of the module in Fig. 2, and the drive motor, controlling the movement along the track, sits on top.

Several conditions have to be met by this device:

- The speed along the track has to be variable; no side-to-side oscillation is permitted. The forward motion of the module is therefore motor controlled, and it has to be interlocked with the drive motor of the belt polisher. The necessary interlock system is integrated into the electronic control units for both motors.

This is to prevent operation of the belt grinder when the module is not moving: the consequences would be indentations across the sealing surface. Correction would then require taking off additional material around the entire sealing surface, a process that was found to take approx. 8 hours!

- The grinding depth and the angle of the polisher with reference to the track also have to be adjustable.

- It is desirable to utilise a dry polishing process. The polishing belt should not cause scratching of the aluminium surface due to build-up of aluminium residue on the belt surface (clogging).

Fig. 3: Bottom view of polishing module as it swings around the end of the beam slit. Shown is the belt and its fixture, and the dust pick-up hose leading to the vacuum cleaner.

Suitable belts (called 'Trizact') have been newly developed at 3M-Scotch Company; they consist of polyester fabric belt material, coated with structured (pyramid-shaped) silicon carbide particles. During polishing, these particles are continuously carried off such that new polishing material is exposed, until the entire polishing layer on the belt is exhausted. Belt speed is recommended to be in the 25-35 m/s range. The drive motor is therefore specified as a synchronous servomotor. Frequency control permits a variable speed, up to 7500 rpm, thus allowing optimisation of the grinding and polishing process.

- Grinding/polishing dust has to be removed and collected behind the polishing belt - to prevent longitudinal scratching and because the material can be slightly radioactive. A special vacuum cleaner with a dust pick-up and a flexible hose is used for that purpose.

TEST RESULTS

After extensive testing, the following settings for the process were established:

One full cycle on a cavity-sealing surface lasts about 45 min., at a maximum speed of 3 mm/s along the track. Not more than 0.05 mm of material thickness should be taken off per grinding cycle. For grinding, 3M- Scotch 'Trizact'- belts with denomination A90 and A60 can be used – A20 belts have to be used for the final polishing process. Two to three full cycles of polishing have to be carried out to reach the desired surface condition of Ra = 0.50 µm. The sense of rotation of the belt has to be in the same direction as the motion of the grinding/polishing module, to prevent scratches in the longitudinal direction. If the forward speed is too high, or the depth adjustment of the module is too big (<0.05 mm), strong vibrations set in, and ugly grooves perpendicular to the polished track develop.

Fig. 4: Final result of a successful grinding and polishing process; shown is one end of the 'racetrack'–shaped sealing surface around the end section of the beam slit.