EUROPEAN COMMISSION

Community Research

# RAPHAEL

**Contract Number: 516508 (FI6O)**

**DELIVERABLE (D-CT2.5)**

# Detailed Design of PMB

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Reporting period: e.g. DIP 1– DIP 3

Date of issue of this report : 10/10/2007

Start date of project : **15/04/2005** Duration : **48 Months**

| **Project co-funded by the European Commission under the Euratom Research and Training Programme on Nuclear Energy within the Sixth Framework Programme (2002-2006)** | | |
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| **Sub-project:** SP-CT 2.5<br>**Work package:** 2 | **RAPHAEL document no:**<br>RAPHAEL-07/10-D-CT2.5 | **Document type:**<br>D |
| **Issued by:** Forschungszentrum Juelich, FZJ, Germany<br>**Internal no.:** | | **Document status:**<br>Final |

**Document title**

# Detailed Design of Permanent Magnetic Bearing

**Abstract**



**Revisions**

| Rev. | Date | Short description | Author | WP Leader | SP Leader | Coordinator |
|---|---|---|---|---|---|---|
| 00 | dd/mm/yyyy | First issue | Name, Organisation | Name, Organisation *Signature* | Name, Organisation *Signature* | Name, Organisation *Signature* |
| 01 | 10/10/2007 | Final Document | B. Lindenau, FZJ | | | |
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# 1 Detailed Design of Permanent Magnetic Bearing

The Permanent Magnetic Bearing (PMB) which has been proposed as a support and back-up device for the catcher bearings commonly used in electro-magnetically suspended gas blowers has been realized.

A schematic of the PMB as it is designed for test in combination with the FLP500 at the IPM in Zittau is shown in Fig1.

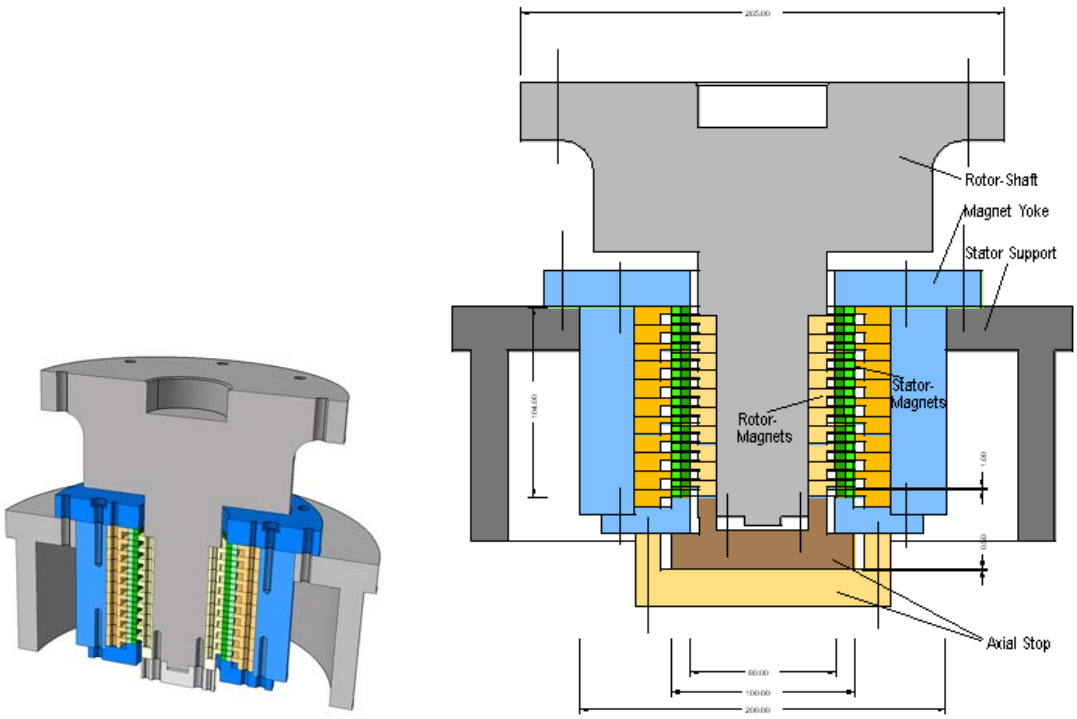


Fig.1 Sketch of PMB appendix

The functional part of the bearing is a stag of 11 double ring stator magnets which are cogged with a corresponding stag of 10 double ring rotor magnets. (Fig.2)

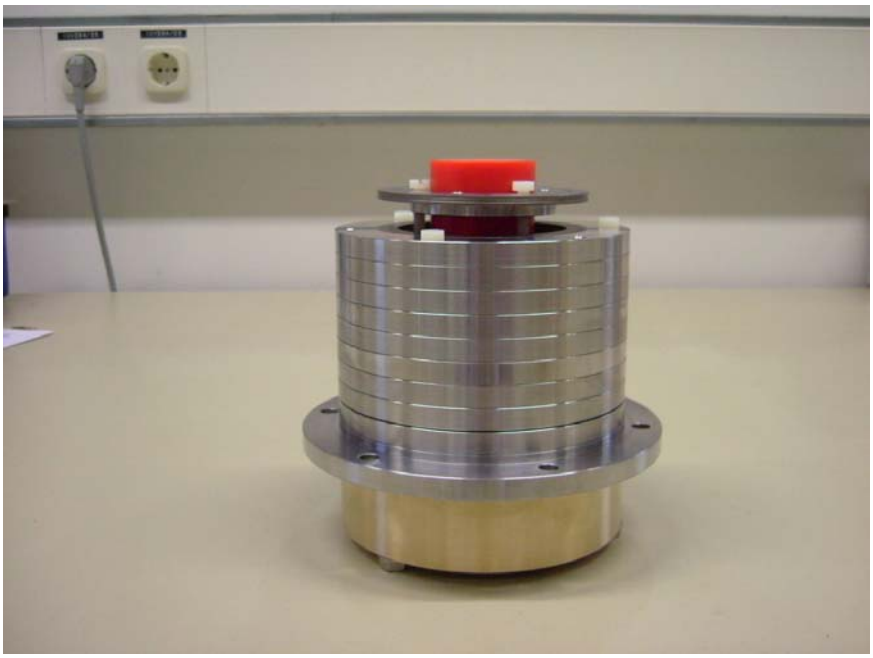

Fig.2 PM shear-force bearing

The magnet rings are mounted in stainless steel collars which produce a nominal gap between rotor and stator magnets of +/-1mm.

This magnet arrangement makes a shear force bearing which features radial restoring forces and provides an inherent stable central rotor position. In case of a vertical rotor shaft additional advantage can be taken from the negative axial stiffness of this set-up. If the design rotor position for free suspension is adjusted for a smaller gap, i.e. <1mm, between the upper surface of the rotor magnets and the stator magnets than at the lower side, the magnetic attraction will contribute to the rotor levitation.

The combined magnet stags are enclosed by a steel housing which serves as magnet yoke and closes the permanent magnet circuit. Fixed to this magnet housing is an axial stop for the rotor shaft. The axial stop restricts the maximum axial rotor movement to +/-0.5mm in order to avoid any contact between rotor and stator magnets and possible damage.

The stiffness of the PMB configuration has been independently calculated by 3D simulation (Finite-Boundary-Element method; software FARADY) and 2 D simulation with FEMM.
The results of both simulations are in fair agreement and yield a stiffness in radial directions of 3255 N/mm respectively 3573 N/mm and a negative stiffness of 6738 N/mm respectively -7704 N/mm in axial direction.
These figures were confirmed by experiment. Force versus displacement measurements were performed with load cells in a test set-up for a single pair of rotor-stator of magnets.
From the measured radial stiffness of 173.4 N/mm and -377.4 N/mm axial stiffness the values for the complete magnet stag was extrapolated. The result is 3468 N/mm radial stiffness respectively -7548 N/mm axial stiffness in good agreement with the expected values.
Direct evaluation of the stiffness data of the complete bearing unit turned out to be less reproducible because of the limited stiffness of the available support structures.

Fig.3 Components of the PMB, FLP500 shaft extension and bearing support

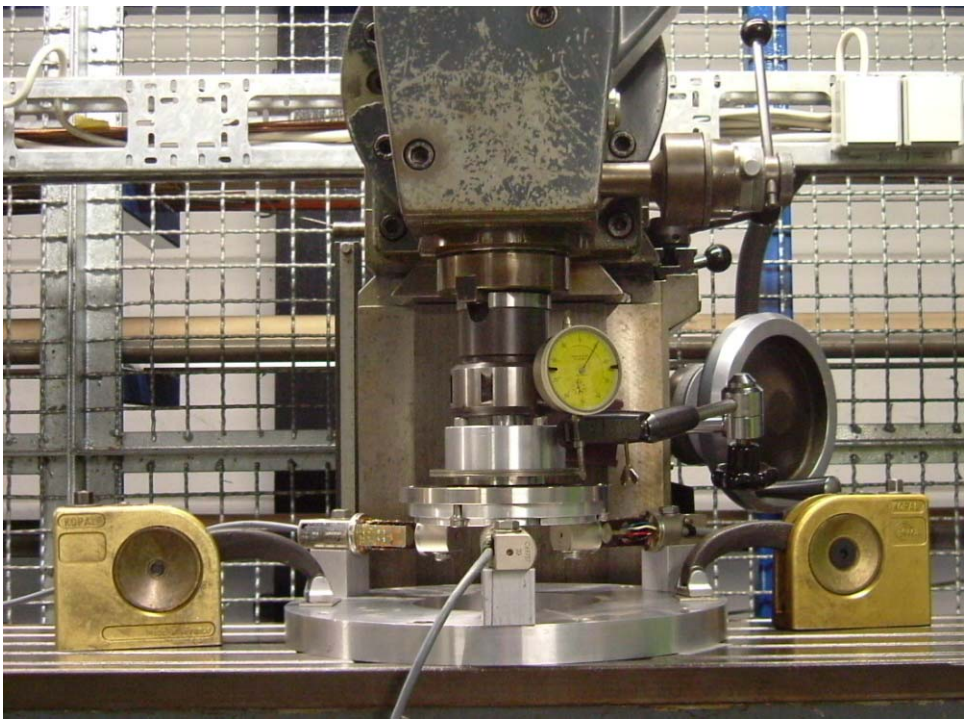

Fig.4 Stiffness tests

Rotor shaft extension and stator support had been designed to fit the existing FLP500 test rig. The assembly has been transferred to IPM in Zittau in April 2007. Fig.5 shows the mounting of the PMB unit to the lower end of the FLP500 rotor shaft.

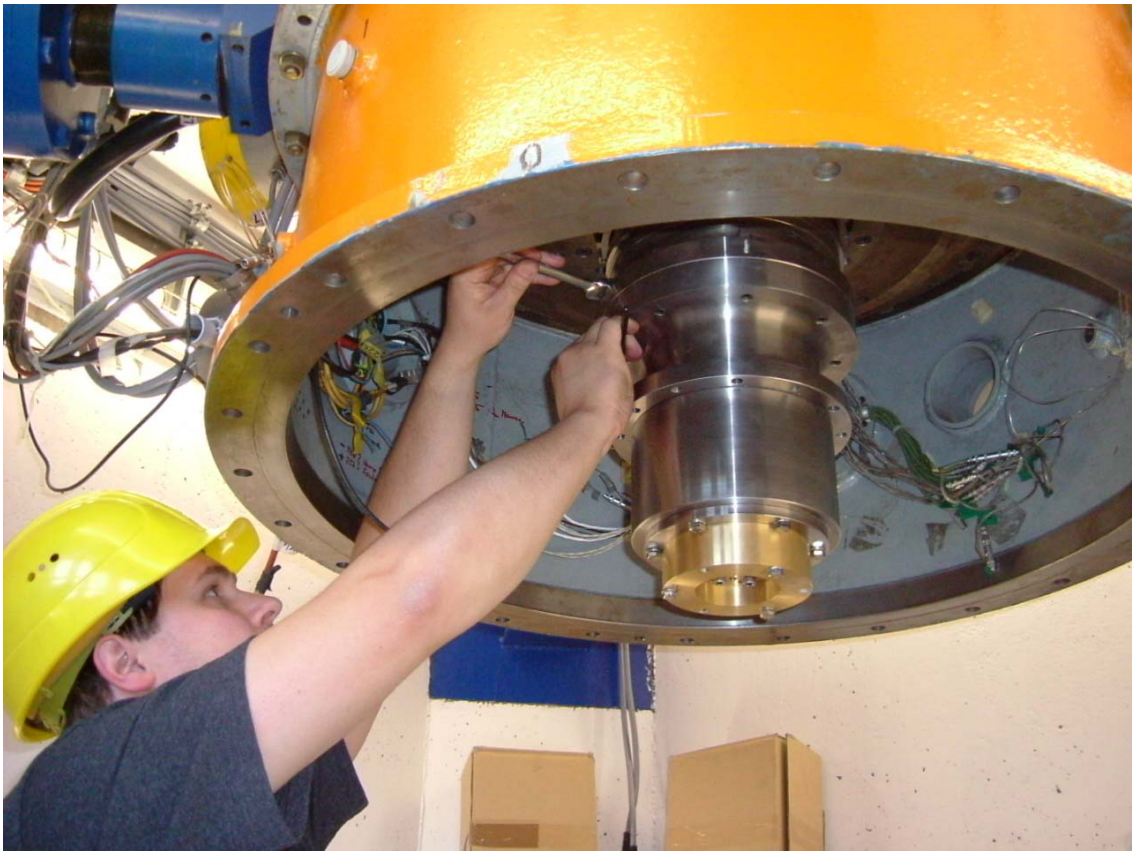

Fig.5 Mounting of PMB

The preliminary adjustment of the PMB stator position with respect to the nominal positions of the FLP500 shaft has been carried out in cooperative effort of IPM and FZJ.