



EUROPEAN COMMISSION

5th EURATOM FRAMEWORK PROGRAMME 1998-2002

KEY ACTION : NUCLEAR FISSION

HTR-E

High-Temperature Reactor Components and Systems

CONTRACT N°

FIKI-CT-2001-00177

WORKPLAN OF WORKPACKAGE 3

“The Large Capacity Magnetic Bearings”

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GERMANY

Dissemination level : RE

Document N°: HTR-E-02/03-D-3-0-1

Status : Final

Delivery No.: D20



Ref.: HZG-IPM 610334/3/2.01/F

WORKPLAN OF WP3

"The Large Capacity Magnetic Bearings"

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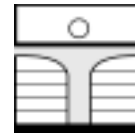
Zittau, 03/31/2002

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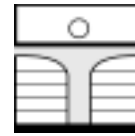


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Diese Organisation weist auf kontinuierliche Verbesserung der Umweltleistung
ein. Umweltmanagementplan nach der EG-Verordnung Nr. 761/2001 im ver-
einbarten, regelmäßig zur Überwachung, 02.01.02, Umweltmanagement-
system mit der Umweltleistung von einem zugelassenen, unabhängigen
Umweltprüfer geprüft. Es ist im EMAS-Register eingetragen und dadurch
öffentlich von EMAS-Zertifizierung anerkannt.



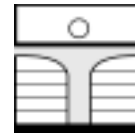
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1. Objectives of the Work Package

Magnetic bearings are used to support the rotating shafts of turbo-compressors or turbo-machines inserted in the direct cycle of a modern HTR. This kind of support has been selected for a modern HTR to avoid the risk of leakage and fluid ingress in the primary circuit induced by the concept of mechanical and lubricated bearings (bad experience feedback in US and German former HTRs). So, the magnetic bearings for rotors support are considered as key components with regards to the safety and competitiveness of a modern HTR. The general objective is to develop a concept proposal for the Active Magnetic Bearing support of the rotating components of future HTR. The proposal includes the Active Magnetic Bearings (with controls, sensors, and power electronics), Catcher Bearings and Diagnosis System.

2. Description of the task

The contractual objective of the work package is to produce eight documents which are identified D21, D22, D23, D24, D25, D26, D27 and D28.

2.1 Deliverable D21

The title of the document is "Functional requirements".

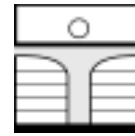
The basis for the investigations is the definition of the functional requirements for two turbomachine configurations (GT-MHR resp. PBMR) under normal and emergency operating conditions for Active Magnetic Bearings and Catcher Bearings. The following parameters will be defined: loads, speed levels, masses, geometry, size, temperatures, pressures, type of reactor, materials, life span, bearing No. and places). If necessary, input data from GT-MHR and PBMR can requested on the basis of HTR-TN agreements.

2.2 Deliverable D22

The title of the document is "Load analysis".

The first objective of the task is to analyse the loads at machines which are comparable with HTR rotating components (GT-MHR and PBMR) with Modal and Harmonic response analyses and Transient dynamic analyses with Finite Element Codes. The numerical results provide the boundary and loading conditions for the design and the simulation tool (MLDyn).

The second objective is to perform real time investigations of the complete system with the modular simulation tool MLDyn (unbalances, loads, speed levels). A first design will be examined with the DDS-Method (Design on Dynamic Stiffness).



2.3 Deliverable D23

The title of the document is “PMB Feasibility Study”.

The design and construction of a 1-kN-single PMB and related sleeve-type catcher bearing will be investigated by FZJ as a hardware study. The fail safe characteristics of this system could be particularly interesting to reduce the loads to the catcher bearings in accidental conditions (loss of power). FZJ will analyse the capability of a PMB concept to support large turbomachines and to meet the requirements defined in D21.

2.4 Deliverable D24

The title of the document is “Catcher Bearings Feasibility Study”.

A specific feasibility study on mechanical catcher bearings will be performed. Starting from a pre-definition of a standard solution for GT-MHR with axial and radial catcher bearings a limit analysis of the concept will be done.

2.5 Deliverable D25

The title of the document is “Concept proposal for AMB and diagnostic”.

Depending on the special requirements and the results of the load analyses a concept will be designed for Active Magnetic Bearings (with controls, sensors, and power electronics). An important aspect is the fact that sensor signals can be used for diagnosis algorithms. This allows innovations for controlling and monitoring.

Three steps are necessary:

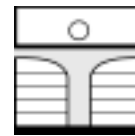
- Concept of bearings including the control tasks.
- Development and optimisation of controller algorithms by computer simulation depending on the analysed forces.
- Development of diagnosis algorithms for magnetic bearings, catcher bearings, rotor and test by computer simulation.

The dynamic behaviour (during shut-down, start up, unbalances, mechanical loads) of the Active Magnetic Bearing system will be determined with a simulation tool under online conditions.

2.6 Deliverable D26

The title of the document is “Mechanical analysis”.

With a numerical validation it is to determine whether the proposed magnetic bearing design satisfies the design requirements. The magnetic, thermal and structural behaviour of the magnet supported system for the various load cases will be determined by means of transient Finite Element analyses (ANSYS code).



2.7 Deliverable D27

The title of the document is “Experimental validation”.

With respect to the complexity of the AMBs supported system an experimental validation of algorithms and also the investigation of single effects are necessary. These experiments (FLP 500 and other test facilities of Zittau university) will complete the analytical investigations :

- Analysis of static and dynamic loads regarding to the rotational speed and the disturbances during operation
- Analysis of disturbances induced by thermal, mechanical and electromagnetic effects
- System optimisation
- Failure and function diagnosis for components (Active Magnetic Bearings, catcher bearings, rotor dynamics, behaviour of the driven machine)

2.8 Deliverable D28

The title of the document is “Recommendations and statement”.

From the results of the analytical and experimental investigations, recommendations and statements related to the studied components will be given. The guidelines of a future work in the FP6 program will be suggested.

3. Definition of the task of each partner

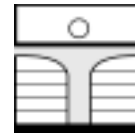
The partners involved in the work package are:

- Framatome ANP SAS – FRA (1)
- University of Applied Sciences Zittau/Goerlitz - Uni Zittau (3)
- Nuclear Research and Consultancy Group - NRG (4)
- Forschungszentrum Juelich GmbH - FZJ (5)
- Société de mécanique magnétique - S2M (9)

The proposal of the repartition of the budget by document and partner is the following:

	D20	D21	D22	D23	D24	D25	D26	D27	D28	Total
FRA (1)		2.0							1.9	3.9
Uni Zittau (3)	1.0		3.0			17.7		25.0	2.0	48.7
NRG (4)			1.0				5.8			6.8
FZJ (5)				5.9+2.9	2.9-0.9					8.8+2.0
S2M (9)					+1.0	6.0				6.0+1.0
Subcontract					+20 k€					+20 k€

TABLE 1: Budget repartition

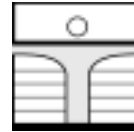


Remarks:

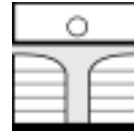
- The numbers in the columns are person month.
- For task 1.4, an additional budget is proposed to issue from the Balcke-Dürr contract for:
 - S2M: 1 Person month
 - FZJ: 2 Person month
 - External work (subcontractor): 20 k€

4. Future meetings

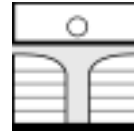
The next meeting will be held at the beginning of the 4th quarter of 2002. The location will be in Zittau. The precise date of the meeting will be proposed by the work package leader in accordance with the WP 4 meeting.

**TABLE 2: Detailed workplan regarding D20 to D28**

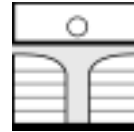
ID	Task of WP3	Start	End	Responsible	Input Results	Target date	needed from	Output Results	Target date	deliver to	Deliv. No.
1.0	WORKPLAN REPORT	01/02	03/02	Uni Zittau	Deliveries of all partners	02/02	all partners	Workplan	03/02	Coordinator	D20
1.1	FUNCTIONAL REQUIREMENTS	01/02	07/02	FRA				Requirements (loads, speed levels, masses, geometry, size, temperatures, pressures, type of reactor, material, life span, bearing no. and places)	07/02	Uni Zittau, all partners	D21
1.1.1	Definition of the functional requirements under normal and emergency operating conditions for Active Magnetic Bearings and Catcher Bearings for GT-MHR and PBMR	01/02	07/02	FRA	Input data from GT-MHR and PBMR projects brought HTR-TN agreements			1st draft of requirements	05/02	all partners	
1.1.2	Definition of requirements for blower support for magnetic bearings and catcher bearings	01/02	06/02	FZJ				1st draft of requirements	05/02	all partners	



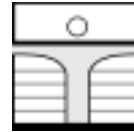
1.2	LOAD ANALYSIS	05/02	10/02	Uni Zittau				Report	10/02	Uni Zittau	D22
1.2.1	Modal and Harmonic Analyses, FEM (ANSYS) Investigation in 2 configurations (GT-MHR and PBMR)	05/02	10/02	NRG	1st draft of requirements 1st draft of requirements Requirements Tentative Parameter of AMB	05/02 05/02 07/02 06/02	FRA FZJ FRA S2M	First results of Modal&Harmonic Analyses Results of Modal&Harmonic Analyses	08/02 09/02	Uni Zittau Uni Zittau	
1.2.2	Real Time Investigations (MLDyn) Dynamic Simulation Investigation in 2 configurations (GT-MHR and PBMR) Definition of stiffness (Design on Dynamic Stiffness-DDS) Parametrization of MLDyn Simulation (unbalances, loads, speed levels)	05/02	10/02	Uni Zittau	First Results of Modal&Harmonic Analyses Tentative Parameter of AMB Results of Analyses	08/02 06/02 09/02	NRG S2M NRG	 Results of Dynamic Simulation	 09/02	 Uni Zittau	
1.2.3	Definition of configuration to be further investigated		04/03	all partners	Results of Modal&Harmonic Analyses Results of Dynamic Simulation	09/02 09/02	NRG Uni Zittau	Definition	04/03	Uni Zittau	



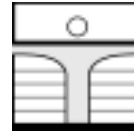
1.3	PMB FEASIBILITY STUDY	09/02	06/03	FZJ				PMB and CB hardware study	06/03	Uni Zittau	D23
	Design, construction and analysis of 1-kN single PMB (Hardware Study) Design, construction and analysis of sleeve-type catcher bearing for backup of 1-kN single PMB (Hardware Study)										
1.4	CATCHER BEARINGS FEASIBILITY STUDY	09/02	06/03	FZJ				CB feasibility study	06/03	Uni Zittau	D24
	Pre-definition of a standard solution for GT-MHR (axial and radial catcher bearing)	09/02	06/03	S2M							
	Limit analysis of the concept for GT-MHR	09/02	06/03	FZJ							
2.1	CONCEPT PROPOSAL FOR AMB AND DIAGNOSTIC	07/02	12/03	Uni Zittau				Concept proposal	12/03	Uni Zittau	D25
2.1.1	Concept of AMB	07/02	12/02	S2M	1st draft of requirements Requirements Results of Dynamic Simulation Results of Modal&Harmonic Analyses	05/02 07/02 09/02 09/02	FRA, FZJ FRA Uni Zittau NRG	Concept of AMB System Parameter of AMB	12/02 09/02	Uni Zittau Uni Zittau	



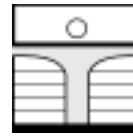
2.1.2	Concept for optimised controller algorithms by computer simulation depending on the analysed forces	07/02	12/03	Uni Zittau	Concept of AMB System Parameter of AMB	12/02 09/02	S2M S2M	Concept for opt. controller algorithms	11/03	Uni Zittau	
2.1.3	Concept of diagnosis algorithms for magnetic bearings, catcher bearings, rotor and test by computer simulation	07/02	12/03	Uni Zittau	Concept of AMB System	12/02	S2M	Concept of diagnosis algorithms	11/03	Uni Zittau	
2.1.4	Parametrization of Simulation Program MLDyn	07/02	12/03	Uni Zittau	Parameter of AMB	09/02	S2M	Parameters of AMB System	07/03	NRG	
2.1.5	Test of dynamic behaviour(during shut-down, start up, unbalances, mechanical loads) with the simulation tool under online conditions	07/02	12/03	Uni Zittau	Results of modal & harmonic analysis	09/02	NRG	Results of Simulation	07/03	NRG	
2.1.6	Concept proposal		04/03	Uni Zittau, S2M				1st draft	04/03	all partners	
2.1.7	Identification of supplementary work		10/03	all Partners				Draft of every partner	10/03	Uni Zittau	



2.2	MECHANICAL ANALYSES	07/03	06/04	NRG				Results of Analyses	06/04	Uni Zittau	D26
	Numerical validation of the proposed magnetic bearing design Determination of the magnetic, thermal and structural behaviour of the magnet supported system for the various load cases by means of transient Finite Element analyses(ANSYS code)				Concept of AMB System Parameters of AMB System Results of Simulation	12/02 07/03 07/03	S2M Uni Zittau Uni Zittau				
3.1	EXPERIMENTAL VALIDATION	06/03	09/05	Uni Zittau				Results of Experimental Validation	09/05	Uni Zittau	D27
	Description of the actual test facility FLP500 1st proposal of experimental test program Review of test program Final test program definition (report) Experimental validation of algorithms and investigation of single effects with FLP 500 and other test facilities		06/03 06/03 09/03 12/03 09/05	Uni Zittau Uni Zittau all partners Uni Zittau Uni Zittau	1st proposal Review Results of Analyses Results of Simulation	06/03 09/03 06/04 07/03	Uni Zittau all partners NRG Uni Zittau	Description of FLP500 1st proposal Review Draft of preliminary results	06/03 06/03 09/03 12/04	all partners all partners Uni Zittau all partners	



3.2	RECOMMENDATION AND STATEMENT	07/05	12/05	FRA				Report	12/05	Uni Zittau	D28
	Recommendations and statements including the analysis of analytical and experimental results	07/05	12/05	FRA, Uni Zittau	Results of All Tasks (Deliveries)	07/05	all partners				
	Identification of future work	07/05	12/05	FRA, Uni Zittau							

**TABLE 3: Manpower per year**

	2002	2003	2004	2005	Total
FRA (1)	1.95	-	-	1.95	3.9
Uni Zittau (3)	9.0	13.0	13.0	13.7	48.7
NRG (4)	1.2	0.9	4.7	-	6.8
FZJ (5)	2.0	6.8+2.0	-	-	8.8+2.0
S2M (9)	4.0	2.0+1.0	-	-	6.0+1.0
Subcontract					+20 k€

This work share may be revised taking into account the actual progress of the studies with the others partners.



TABLE 4: Schedule

		2002												2003												2004												2005											
ID	Name	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
	WP 3 : Magnetic Bearings																																																
1.0	Workplan Report																																																
1.1	Functional requirements																																																
1.2	Load analysis																																																
1.3	Permanent MB feasibility study																																																
1.4	Catcher bearings feasibility study																																																
2.1	Concept proposal for bearings and diagnostic																																																
2.2	Mechanical analyses																																																
3.1	Experimental validation																																																
3.2	Recommendation and statement																																																



Milestones:
M1: Concept Proposals
M2: Experimental Validation