



OPTIMAT BLADES

Variable amplitude loading

Task Group 1

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Knowledge
Centre

WMC



KAPE
CRES





Original aim of the work

- **Investigation of blade material behaviour under variable amplitude loading**

WP3: Variable Amplitude Fatigue loading

WP4: Establishment of NEW WISPER spectrum

WP5: Interactions with variable amplitude spectrum

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WP3: Variable Amplitude Loading

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- To address the effect of variable amplitude fatigue loading by comparing test results of dedicated tests with constant amplitude and variable amplitude loading



Task 3.1

Establishment of present status variable amplitude influence

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- **Assessment**

Benchmarking of Lifetime Prediction methods

- Identify the influence of each element of the whole lifetime prediction methodology on the overall results
- Ensure a unified basis for the comparison of obtained results

- **Status**

Task successfully finished



Task 3.2

Selection of reference material and fatigue test program

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- **Assessment**

DPA

- A comprehensive detailed plan of action was generated to meet with the requirements of constant and variable amplitude testing and lifetime prediction methodology as well.

- **Status**

Task successfully finished



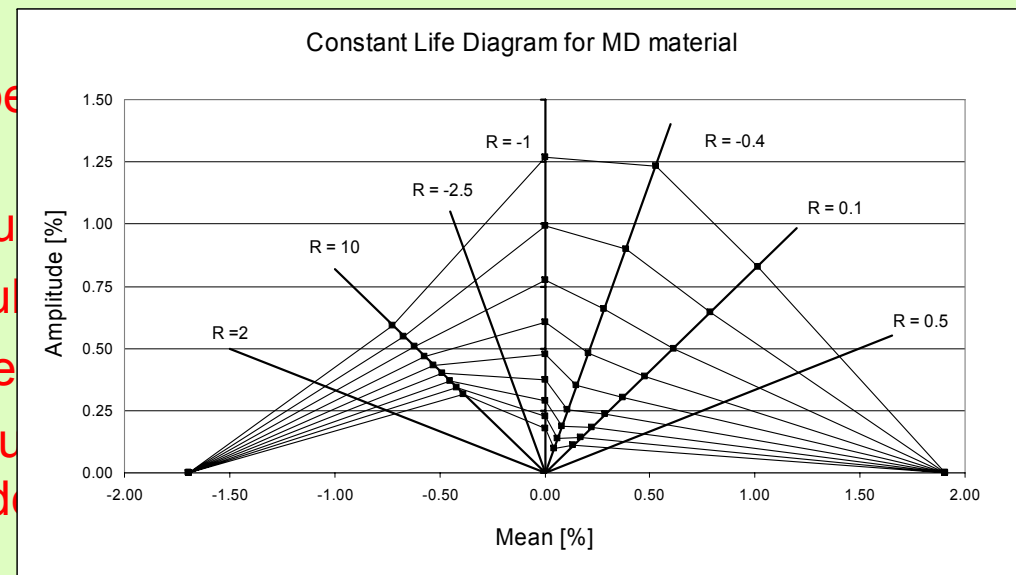
Task 3.3 Constant Amplitude behaviour

● Assessment

Fatigue test program

- Establishment of 2 S-N curves ($R=-1, 0.1$) for UD material
- Establishment of 4 S-N curves ($R=-1, 0.1, 10, -0.4$) for MD material
- Establishment of 3 S-N curves (UD: $R=10$, MD: $R=0.5, -2.5$) ongoing

- For definition of specimen geometry necessary
- Lower testing frequency
- Scatter of test results
- Buckling of UD specimens
- Significant delay due to the number of specimens needed





Task 3.3

Constant Amplitude behaviour

- **Status**
 - 80% completed

- **Planning**

Fatigue test program

- Complementary and finalising tests at MD-specimens with R-ratios of -2.5 and 0.5
- Finalisation of R=10 tests for the UD material under avoidance of buckling problems
- **Expected results**
 - For the UD material the basic material characterization can be achieved
 - For the MD material an extensive constant life diagram is intended to achieve a more accurate lifetime prediction.



Task 3.4

Variable Amplitude behaviour

- **Assessment**

Fatigue test program

- Extensive block test program added
 - ▶ For information about load sequence effects
 - ▶ Input for degradation models of WP13 (TG5)
- Analysis of block tests still in progress
- Block tests: occurrence of premature failures in 1st block
- Load spectra tests not yet started due to delay in CA testing

- **Status**

- 40% of block tests accomplished
- 0% of load spectra tests accomplished

- **Planning**

- Continue and finalising block testing
- Load spectra tests with WISPER on MD and UD material



Task 3.4

Variable Amplitude behaviour

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- **Expected results**

Fatigue test program

- From the block tests valuable results can be expected for the evaluation of the load spectra tests and also for the residual strength tests and degradation models of WP13.
- The foreseen load spectra tests with WISPER serving as an input for the validation of the NEW WIPSER load spectra will be accomplished
- Since the establishment of a short version of the NEW WISPER load spectra in WP4 was not necessary, the tests concerning the influence of omission with WISPERX are no longer of interest



Objective of WP4

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- To define a new standard load spectrum, based on the size and use of contemporary large wind turbines and compare the results of this to the present spectrum



Task 4.1

Definition and collection of blade spectra

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- **Assessment**

- Set-up criteria for acceptance and normalisation of load measurements
- Good agreement in benchmark tests on rainflow-counting using same sample data set on flatwise bending loads
- NEW WISPER synthesis process developed according WISPER synthesis by ten Have

- **Status**

Task successfully finished



Task 4.2 Synthesis of spectra to NEW WISPER

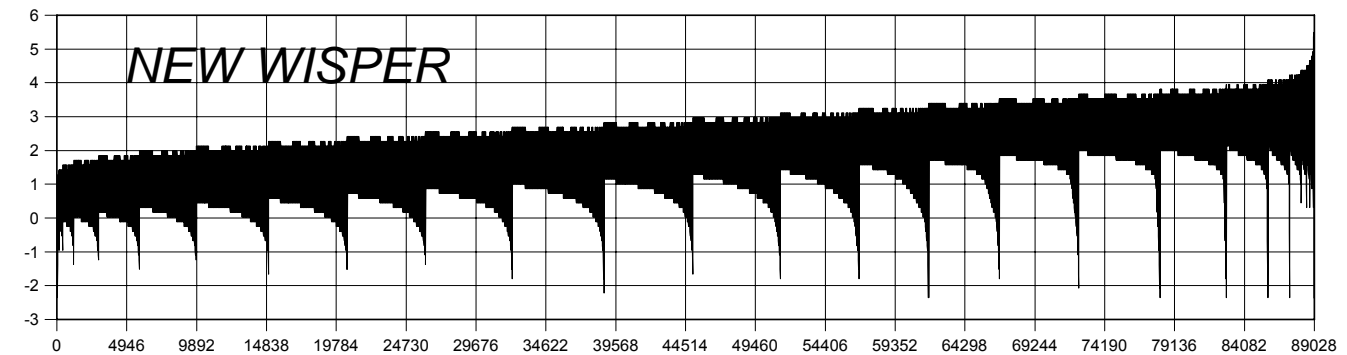
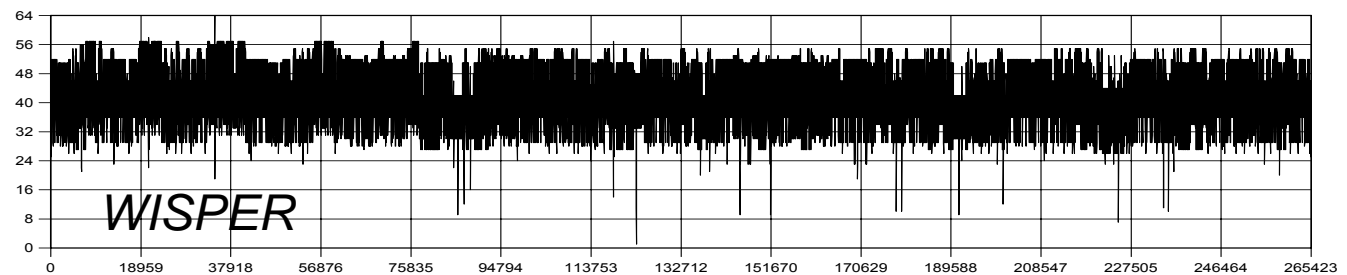
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- **Assessment**

- Rainflow matrix generated applying NEW WISPER synthesis process on data from 8 wind turbines
- NEW WISPER test sequence derived from the averaged Rainflow matrix

- **Status**

Task succ





Task 4.3

Experimental validation of NEW WISPER

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- **Assessment**
 - Load spectra tests not yet started due to delay in synthesis of NEW WISPER
- **Planning**
 - NEW WISPER load spectra tests with MD and UD reference material
 - Lifetime prediction analysis comparing the “OLD” and NEW WISPER
- **Expected results**
 - Despite of the delayed synthesis of the load spectra, the experimental validation should be successfully finished



Task 4.4

Evaluation of variable amplitude influence

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- **Assessment**
 - Influence not yet evaluated, since no results of load spectra tests are available and block tests are still in progress
- **Planning and expected results**
 - The lifetime prediction models will be used to evaluate the influence of NEW WISPER against WISPER on the basis of constant life diagrams and variable amplitude



Title and Objective of WP5

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Old Title:

Interactions with variable amplitude spectrum

New Title:

Fatigue interactions with alternative material

Objective:

- To characterise the severity of combinations of aspects like load variation, extreme conditions and bi-axial loading on fatigue life **of alternative material**



Tasks within WP5

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DPA – Interaction test plan

Interaction tests of bi-axial with variable amplitude loading

Interaction tests with alternative materials

Variable amplitude testing of alternative materials

Evaluation of interaction effects



Task 5.1

Interaction test plan

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- **Objective**
 - A detailed test plan will address interactions to the Work Packages 7,9 and 13



Task 5.2

Interaction tests with alternative material

- **Planning**

- Accomplishment of block tests by DLR and WMC
- Residual strength tests by WMC
- Accomplishment of CA tests on cruciform specimens by VUB

- **Expected results**

- The block tests give valuable input for comparison of results within WP3
- The residual strength tests will serve as a link to WP13 “RESIDUAL STRENGTH” (TG 5)
- The tests on cruciform specimens are linked to WP7 “COMPLEX LOADING” (TG 2)



Task 5.3

Evaluation of interaction effects

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- **Objective**
 - The results will be compared to the results of the reference material and used for the refinement of the prediction and, thus, for the design recommendations



Deliverables and Milestones

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● Deliverables

No	WP	Deliverable title	Form	Due Date		Report(s)	% Done (Remarks)
				Original	Expected		
1	3	Test report describing the material, laminates and fatigue tests	Report	5		OB_TG1_R005	100%
15	4	Description of NEW WISPER standard load spectrum (report)	Report	26	40	To be done	95%
16	4	Validation report of NEW WISPER	Report	26	50	To be done	0%
32	5	Report on interaction tests and NEW WISPER testing on alternative materials. NB will change to: Report on basic static and fatigue tests of alternative materials.	Report	43	50	To be done	0%
NEW	3	Test Specification for Variable Amplitude Testing	Report	39	39	To be done	30%
NEW	3	Report on Benchmarking of Lifetime Prediction Methods	Report	34		OB_TG1_R012	100%

● Milestones

No	WP	Milestone description	Due Date		Reached	Remarks
			Original	Expected		
2	3	DPA on variable amplitude	5		Yes	
3	4	DPA on NEW WISPER	5		Yes	
11	4	Evaluated influence variable amplitude effect	26	50		
16	5	DPA on interaction effects	27	40		
25	5	Finalisation of activities on interaction effects	43	50		