Yearly report of TG3 (2002)

OB_TG3_R003 rev. 000

Draft version
Confidential

OPTIMAT BLADES

TG3

M. Megnis
P. Brøndsted

RISØ VTT TU Delft Delft University of Technology VUB LM LM Glasfiber A/S Vestas

Change record

Issue/revision	date	Pages	Summary of changes
draft	11-02-03	Na	na

DETAILED REPORT FOR TASK 3

In the following, detailed information can be found regarding the activities for Task 3: 'Extreme conditions' (WP8 and WP9).

Main objectives for this period

The main objectives for this 12 month period were as follows:

- generate the Detailed Plan of Action (DPA), which includes an overview of geometries, laminates, selected extreme conditions, and degradation parameters, an experimental plan and time schedule
- Identification of extreme conditions
- identification of degradation parameters
- phenomenological modeling and experimental determination

Overview of technical achievements

DPA of WP8 and WP9
After a considerable amount of discussion, the DPA has been drafted in accordance with the choices made regarding the specimen geometries for the whole project. The DPA has been approved by the Scientific Committee in their Stuttgart meeting of December 16.

Extreme conditions
Extreme conditions that are relevant to service conditions of wind turbines are determined. The determined conditions are: temperature variations at ambient relative humidity –40C, +60C and RT, as well as salt water environmental conditions. The salt water extreme conditions means that the specimens are submersed in the salt water. One half of them is kept for 6 month and tested after, another half is kept longer, 12 month, and tested after exposure.

Degradation parameters
Stiffness degradation as function of applied strain and number of loading cycles is identified as damage parameter. It allows to determine a rather small amount of damage long time before final failure of the specimen. Furthermore, damage mechanics and fracture mechanics based modeling can link stiffness degradation to different failure mechanisms acting on laminate and microscopic levels. With this method is possible to study damage evolution rate for different fracture mechanisms.

Phenomenological modeling and experimental determination
Number of fatigue characterization methods for composite materials are found in literature, such as statistical description of fatigue life diagrams, statistical description of stiffness degradations, and damage mechanics based stiffness degradation.
The statistical methods, such as linear regression, maximum likelihood using pooled or censored data, statistics for conditioned random variables, Weibull statistics, or combination of mentioned are available to describe fatigue life diagrams and its tolerance bounds. All the methods will be analyzed theoretically and compared in order to formulate methods that satisfy the considered tests and its objectives.
Fatigue lifetime can be predicted using statistical stiffness degradation measurements. This method has been already used by several authors that we can find in literature. The methods are acknowledged, and will be utilized and further developed to account for particular applied

conditions. Further, the damage mechanics based modeling can be utilized to connect statistical stiffness degradation measurements to particular damage mechanisms acting on macro and micro scale. This approach is on its development stage. The isothermal formulation for laminates of particular lay-up only is available for the moment. It has to be generalized for arbitrary laminate, isothermal conditions to start with.
Corresponding test program is compiled that renders all the necessary data for characterization of considered mechanical properties at selected extreme conditions.

Preliminary test series are carried out in order to test performance of particular specimen geometries to be considered as Optimat standard geometry.

Comparison of planned activities to accomplished work

Considerable time was needed for the initial phase of defining the standard Optimat specimens. Drafting of the DPA has taken much more time than anticipated, amongst others due to the time that was needed before formal approval was given by the SC. All the preparation work is accomplished, and testing of basic material can be started as soon specimens are manufactured and delivered to the partners.

Planned activities for the next period

According to updated time schedule testing at extreme conditions will start in the first half of 2003, on basic material. The phenomenological modeling and damage analysis will continue parallel with testing, as planned. The first phase is expected to be accomplished on Apr. 2002.

Pre-draft version of Design Recommendations

In the following a sketch is given of what the Design Recommendations could look like for the part addressed by TG3. No exact figures can be given at this moment.

The elastic properties, strength and fatigue lifetime will be analyzed at different extreme conditions, and expected differences will be quantified. Where the quantified values can be transformed into safety factors if necessary.
Analysis of damage mechanisms and evolution will be studied that results in knowledge of what damage mechanisms are the most sensitive and to be considered at design stage of the blade in order to ensure more predictable lifetime of the blade. Also gives basic understanding of what would happen if the lay-up of the laminate would be changed.