NEW WISPER: A New Edition of The Classic Fatigue Load Sequence WISPER for Variable Amplitude Testing on Materials Used in Wind Energy Industries

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In 1988 A. A. Ten Have from NLR in Netherlands [1] described the rational for developing a loading standard for use in fatigue analysis of wind turbine rotor blades. To improve the qualification of materials used in wind turbine blade manufacturing the WInd SPectrum Reference was set up to allow for variable amplitude testing of the materials. This WISPEReference consists of a "dead" load sequence of 265423 subsequent load reversals for blade flap loading. At that time variable amplitude testing has been considered more realistic compared to the commonly applied constant amplitude tests as it better represents the interaction of the individual load cycles that occur during the wind turbine blade's service life. In fact the load sequence repeatedly applied during variable amplitude testing ensures maximum compliance with the actual loading situation in use. Hence, the data found in material coupon tests are considered to deliver best accurate fatigue life or crack growth characteristics of the tested materials.

Today, some 16 years later a subtask of the European Union co-funded project OPTIMAT BLADES [2] is about to finalise its work on modernising the widely and internationally accepted WISPER standard load sequence (WISPER had been developed in the framework of IEA standardisation work). The general motivation of the group consisting of DLR, ECN, CRES, TU Delft and DEWI was to ensure that the modern wind turbine techniques are truly reflected in a NEW WISPER load sequence that is used to support the development of new optimal design materials and procedures for wind turbine blade manufacturing. The original WISPER is based on measurements on 9 wind turbines with rotor blades made of steel, GRP and wood and diameters ranging from 11.7 m to 100 m. Today's wind turbines differ from those wind turbines of the mid eighties in terms of considerably larger average capacities with typically three bladed rotors operating with full span pitch control, having much lighter blades. Load measurements for certification purposes are more or less standard at present and as a consequence it was decided that a new standard had to be based on measured data from series produced wind turbines of the megawatt size. The group members active in the field of wind turbine load measurements s. a. CRES, ECN and DEWI were asked to supply qualified data after acquiring the permission from the wind turbine manufacturers. Finally, ECN could bring in one data base, CRES 2 data bases and DEWI 4 data bases adding up to a total of 7 wind turbines with diameters of 37 m to 80 m. The sole materials found in these selected wind turbine rotor blades are GFRP and CFRP.

The base line for the set up of a new procedure for a NEW WISPER test load sequence is threefold: Only standard techniques as laid out in the existing standards (IEC 61400-13) shall be applied. Sufficient simplicity and transparency of the synthesis process shall be achieved to enable a potential user to judge for himself on suitability of NEW WISPER for his purposes. And at last confidentiality of the measurement data by working with processed and normalised data sets shall be ensured. The idea for such underlying principles was to make it easy for the wind turbine manufacturers to give permission to use their data in the project and at the same time ensure a high technological standard that will make the NEW WISPER test load sequence a trustful and hopefully equally wide accepted standard as WISPER.

Following this line of thinking all partners involved in the process of NEW WISPER synthesis have participated in a rainflow and load spectrum benchmarking to ensure that the techniques are reasonably well aligned. This allows each partner to use their own rainflow counting and load spectrum synthesis procedures.

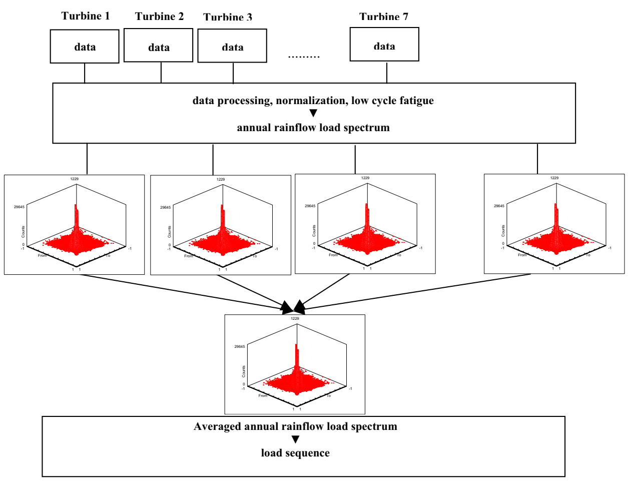

Fig.1: Data Processing Scheme for NEW WISPER Synthesis

The rough outline of the NEW WISPER synthesis is as follows [3]:
First a normalisation of flatwise bending loads measured on various machines with different designs has been set up and was applied on the individual data bases. The largest values found for all turbine data bases were used to set the limits for the rainflow counting into a 64 x 64-bin-matrix.
Next an annual cumulated rainflow load spectra was derived by each data supplying partner for each of the used data sets using the IEC class II wind regime.

As the turbines have different rotor speeds and a portion of the loads are having frequencies of occurrence related to the rotor speed a normalisation aiming at these cyclic rainflow counts was carried out.

In order to account for transitions from one mode of operation to another (i.e. low cycle loads and transient loads occurring when the wind speed changes from one 10-minute average to another) a proposal from RISOE [4] was adopted. For this procedure DEWI supplied a year round 10-minute-average-wind speed time history that fulfilled IEC class II requirements.

From the individual annual rainflow load statistics a composed flatwise load statistic of all turbines is yet to be generated. This step will be done by DEWI. Finally, from the combined rainflow load statistic averaged over all turbines a load sequence is to be drawn using standard industrial techniques. This final sequence will then be validated and compared against the old WISPER standard. The results of this validation process will be published in an oral presentation at the DEWEK 2004 conference at Wilhelmshaven (20/21.10.2004).

References

[1] ten Have, A. A.: WISPER a Standardized Fatigue Load Sequence For HAWT-Blades. Paper at the ECWEC 1988 at Herning, Denmark.

[2] http://www.wmc.tudelft.nl/optimat_blades/index.htm

[3] Bernard Bulder - ECN, Denja Lekou, Pantelis Vionis - CRES Rogier P.L. Nijssen - TUDelft, Theo Kramkowski, Holger Söker - DEWI: SYNTHESIS PROCESS OF A NEW WISPER LOAD SPECTRUM. Project internal document, DEWI, 27.10.2003, Wilhelmshaven

[4] Larsen, G.; Thomsen, K.: A simple approximative procedure for taking into account low cycle fatigue loads. Paper presented at IEA-Symposium on Wind Turbine Fatigue, Stuttgart, February 1-2