INVITED PAPER

PRESENT STATUS ON INTERNAL WIND TUNNEL BALANCE TECHNOLOGY

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Summary

T*he ever rising accuracy requirements in wind tunnel testing for airplane development enforce continuous improvement of force testing technology. The introduction of the cryogenic tunnel is an additional challenge for the force balance, since now the balance accuracy is requested over an operational temperature range of 200 Kelvin.*

More than 28 years ago several teams in the world therefore started with investigations in the area of internal balances for cryogenic wind tunnels. This was the beginning of the last important development period for internal strain gauge balances.

In Germany in 1983 the "Cryogenic Balance Program" was started by the German Ministry for Research and Technology with the target to develop internal balances and calibration technique for the cryogenic wind tunnels Cologne Cryogenic wind tunnel (KKK) and European Transonic Wind tunnel (ETW).

In this program all aspects of force testing technology have been dealt with and developed to new standards by the Technical University of Darmstadt (TUD). After the finish of the program TUD continued as a balance manufacturer and a group of balance experts was established to continue the research work and to conserve knowledge and skills on strain gauge based wind tunnel balances.

Within this period 12 balances for cryogenic wind tunnels and many other conventional balances were built.

The areas of interest are:

Basic research on the aspects of metallic spring materials resulted in new understandings about material selection and material treatment for optimum results.

Principle balance design optimizations are done with finite element analysis. For the routine balance design an interactive computer program was created.

The very successful technique of the Electron Beam Welded Balance was developed. The balance structure is fabricated from parts, which are welded together by electron beam welding. This technique makes it possible to build balances with a complex inner structure to minimize the interferences.

For cryogenic balances the main problems are zero shift and sensitivity shift over the large temperature range and false signals especially in the axial force element due to temperature gradients. The problems were overcome by a very careful strain gauge matching process, by use of special gages, by application of numerical corrections and by a special design of the axial force system with tandem measuring elements in the flexure groups.

For the calibration of the balance a new third order numerical algorithm was developed. The algorithm works with arbitrary load combinations. This was a requirement for the development of a fully automatic balance calibration machines. The machines perform a six component calibration including all single loads and all combinations of two loads in one working shift. The first machine was built in co-operation between former Carl Schenck AG, Darmstadt; Airbus Bremen and the TUD.

After the completion of the ETW machine further research was done by TUD to improve the design and the concept for a fully automatic calibration machine. The result of this research is a new design and construction of a small second generation calibration machine for TUD.

So all components of the wind tunnel force testing technology have been developed to new standards with the result of considerable accuracy improvements of the wind tunnel results.

The wind tunnel balance business is a rather small one but it has a key function in the aircraft design, because almost all wind tunnel tests for the development of a new aircraft use a wind tunnel balance in some way.

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