Effect of in-plane and out-of-plane waviness on the compressive strength of UD NCF-reinforced composites



L.E. Asp, D. Wilhelmsson, R. Gutkin and F. Edgren

Div. of Material and Computational Mechanics

The NFFP-project KOMPRESS

Compressive failure of complex NCF composite structures

PhD-student: Dennis Wilhelmsson

Main supervisor: Prof. Leif E. Asp Dr. Renaud Gutkin

Co-supervisor:

Project manager: Dr. Fredrik Edgren





Div. of Material and Computational Mechanics

Emission and fuel costs challenge

World Passenger Air Travel by Volume, 1950-2012



ICAO: International Civil Aviation Organization IATA: International Air Transport Association

Aero-engine efficiency



Image from Wikipedia, Author: K. Aainsqatsi

Weight

Increased diameter => Increased bypass => Increased weight (1 kg => 2.25 kg)



Image from GKN Aerospace

Dept. of Applied Mechanics

GKN Aerospace - **OGV**



Section A-A



OGV - Complex geometry

Conventional laminate





Carbon fibre architectures

Prepreg

NCF=Non Crimp Fabric

Weave



ZOLTEK™

Image from www.Zoltek.com







Image from www.medfish.com



Compressive strength

 X_C / X_T

Prepreg: 70 %

NCF: 40 %

CHALMERS

Compressive failure of unidirectional NCF composites



Objectives: Study the compressive stiffness and strength experimentally. Develop a method to characterize fibre orientations.

Motivation: Gain understanding of compressive failure in NCF composites for future model development

Div. of Material and Computational Mechanics

CHALMERS



Background and outline

- 1. The compressive strength and stiffness is controlled by fibre waviness!
- 2. The effect of material characteristics on the waviness?
- 3. The effect of waviness on the compressive stiffness and strength?
- 4. A method the characterize the waviness?



Waviness out-of-plane



Fibre misalignment angle from waviness

Compressive failure

Initial fibre misalignment of critical importance!



CHALMERS



Dept. of Applied Mechanics

Compressive failure



t = 2 mm

Kink-Band through the thickness

Measurement of fibre misalignment angles



A comprehensive test series

Effect of material characteristics



CHALMERS

Stiffness - Overview



Stiffness - E (V_f)



Stiffness - Knock-down



Stiffness - Knock-down



Strength - Overview



Strength - Maximum angle



Strength - Mean angle



Probability distribution



Probability distribution



Compressive strength



Compressive strength



Conclusions





Dept. of Applied Mechanics

Acknowledgements





Work in progress - Spatial distribution of θ

