ÉCOLE POLYTECHNIQUE
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**FACULTE SCIENCES ET
TECHNIQUES DE L'INGENIEUR**

Information for 3D Computations of the STCF 4 Test Cases

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Report LTT - 02 - 04

	ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE	
EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE	*FACULTE SCIENCES ET TECHNIQUES DE L'INGENIEUR*	LTT
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Abstract:

The present report gives some additional information that is needed for 3D calculations on the Standard Configuration 4 test cases.

The 2D geometry information and original measurements can be found in Bölcs and Fransson, 1986. Some more recent measurement results for this configuration can be found on the web site:

http://www.egi.kth.se/ekv/research/stcf/

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1. Introduction

In the collection of Standard Configurations for the validation of numerical codes designed for aeroelastic problems (Bölcs and Fransson, 1986) the emphasis was put on 2D measurements and calculations. The numerical resources at that time did not allow 3D computations. Thus the information given in the above mentioned report was complete only with the objective to do these 2D computations.

Now computers have a larger capacity and unsteady 3D computations become possible. Thus additional information is needed to model the real movement of the blade, as well as eventual leakage flows.

The following document is supposed to give some information on the 3D geometry of the cascade of Standard Configuration 4, the 3D movement of the blades and the gaps generating secondary flows. Since the measurements for this configuration were made 20 years ago, the following information had to be assembled from different documents from the archives and some movement measurements on the partly reassembled cascade.
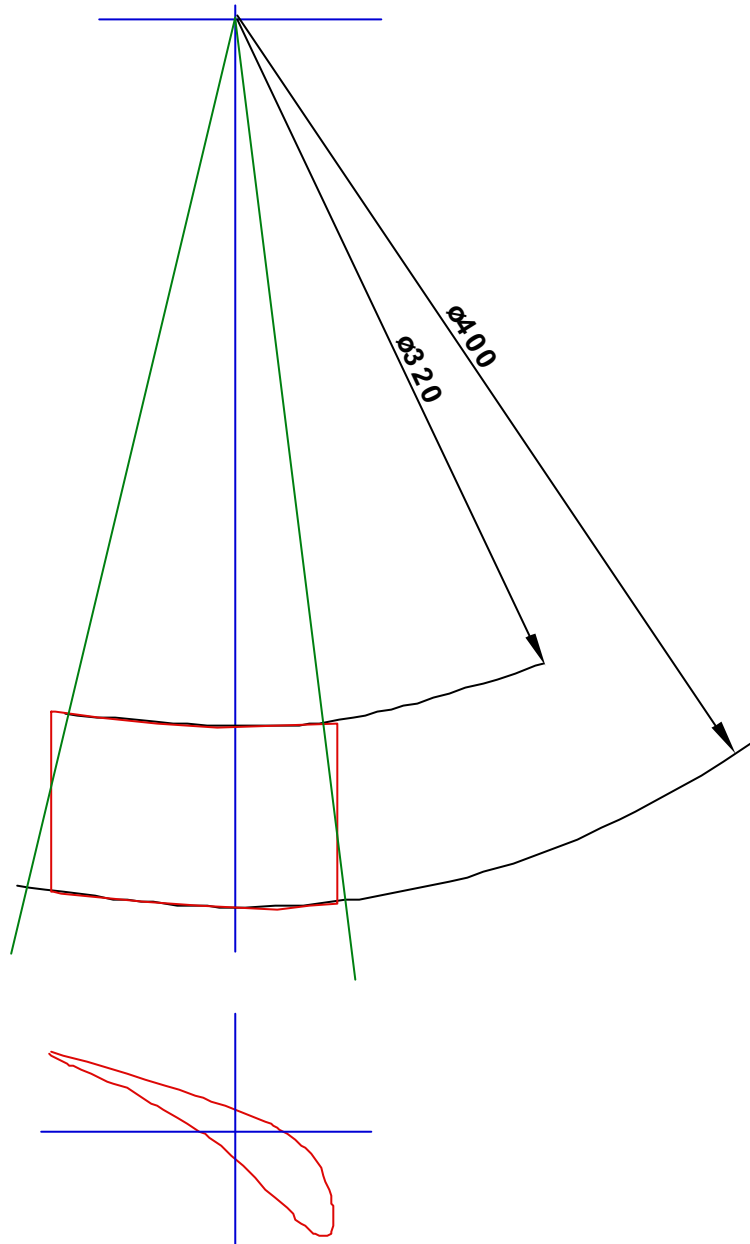
2. Stacking

Figures 1 and 2 are scans from drawings and allow the determination of the stacking presented in Figure 4. The blades are built by a cylindrical projection using the 2D profile given in Bölcs and Fransson, 1996. The 3D blade geometry can be obtained by stacking the 2D profile on a radial line along the center of gravity of the 2D blade section.
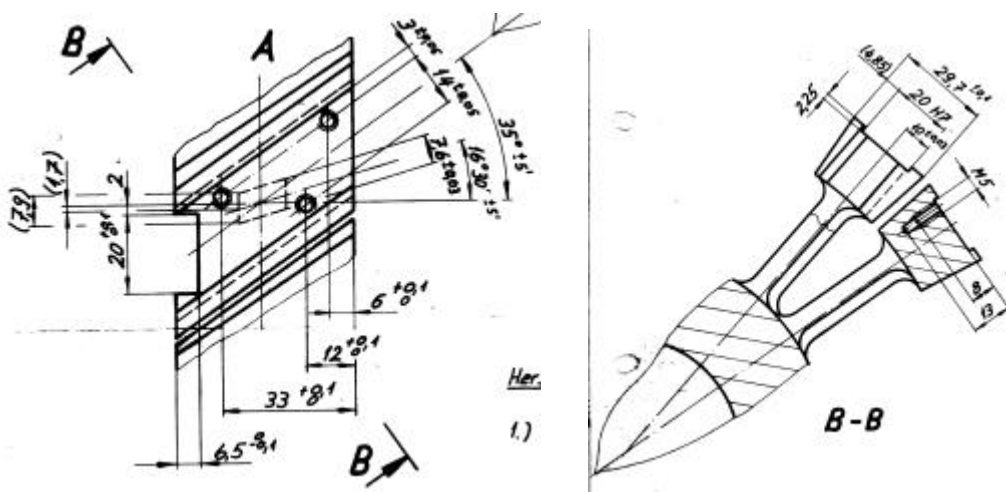
Fig. 1: *Details of drawing "TX-S 11505" (BBC, 23.06.1978)*
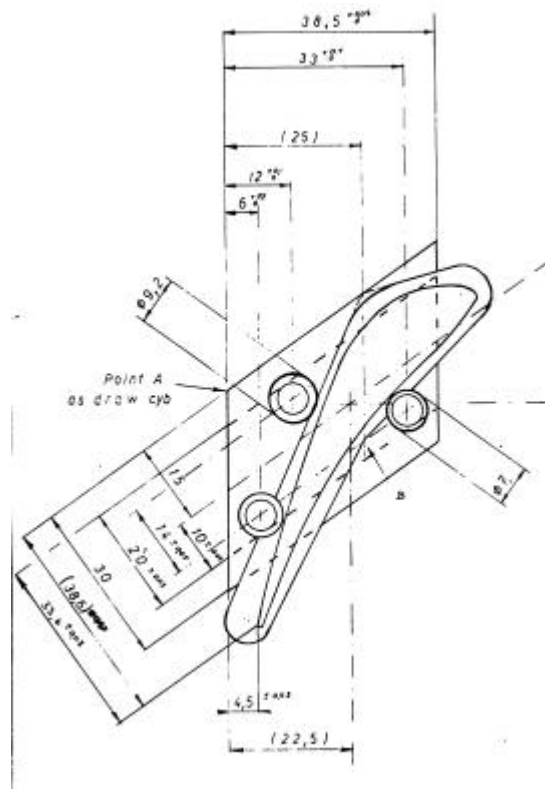
**Fig. 2:** *Detail of drawing "RGP 400.08.002.SUB" (EPFL, 20.08.1982)*

Fig. 3: *Sketch for the stacking of Standard Configuration 4*

3. Tip leakage

The theoretical tip gap was determined from the original drawings to 0.7 mm. This was verified by measuring the diameter of the cascade at several positions. This measured diameter is 399.48 mm. With the inner diameter of the test section of 400.0 mm (slightly oval by 0.1 mm) this gives a real tip gap size of only 0.25-0.3 mm.

4. Hub leakage

The blades are fixed on the spring body (built in one piece!, Figures 4-6). A ring wall in two parts builds the inner wall. This hub wall leaves place for the blade to pass. On the blades are welded thin steel sheets that are supposed to block leakage flows through these spaces (see Figures 7-9). Nevertheless these thin steel sheets also disturb the flow at the hub wall.
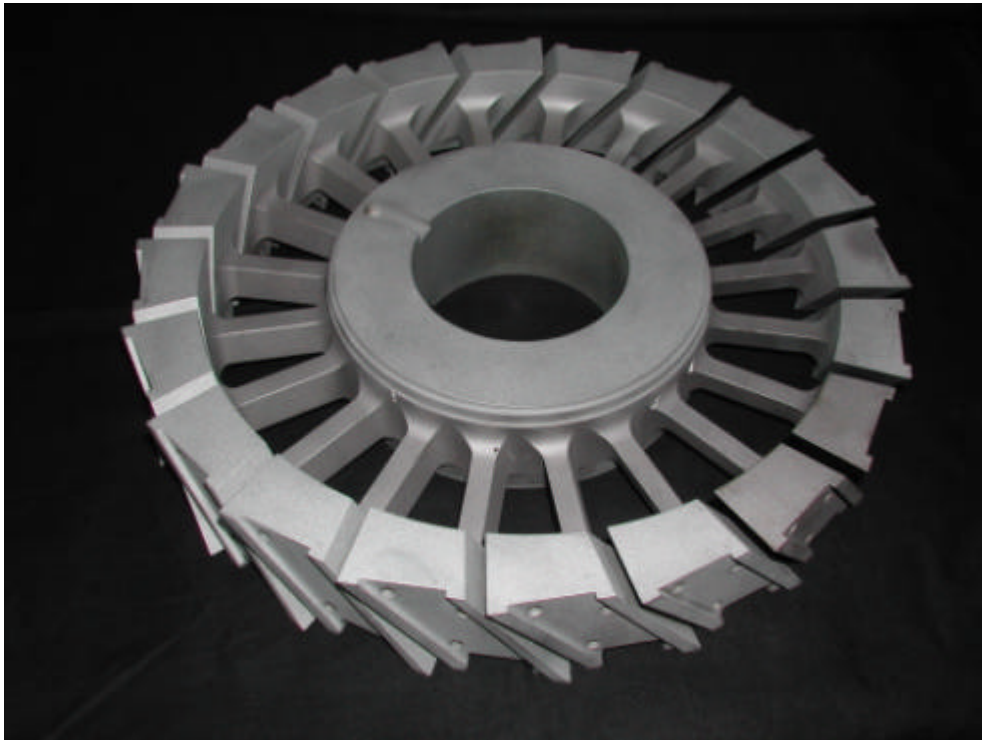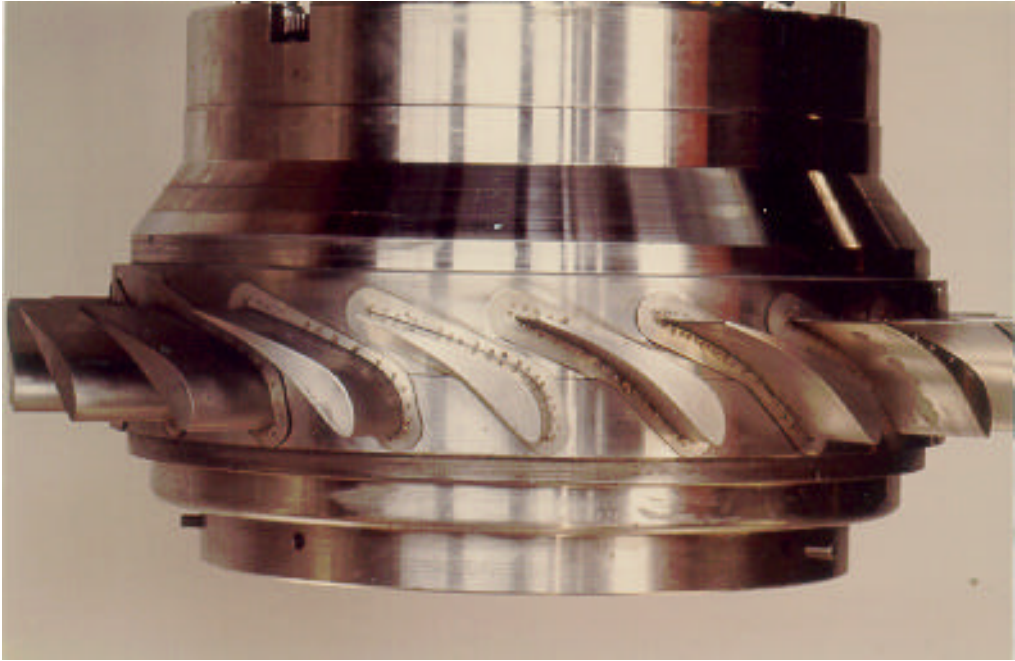

Fig. 4: *Photo of the spring body*
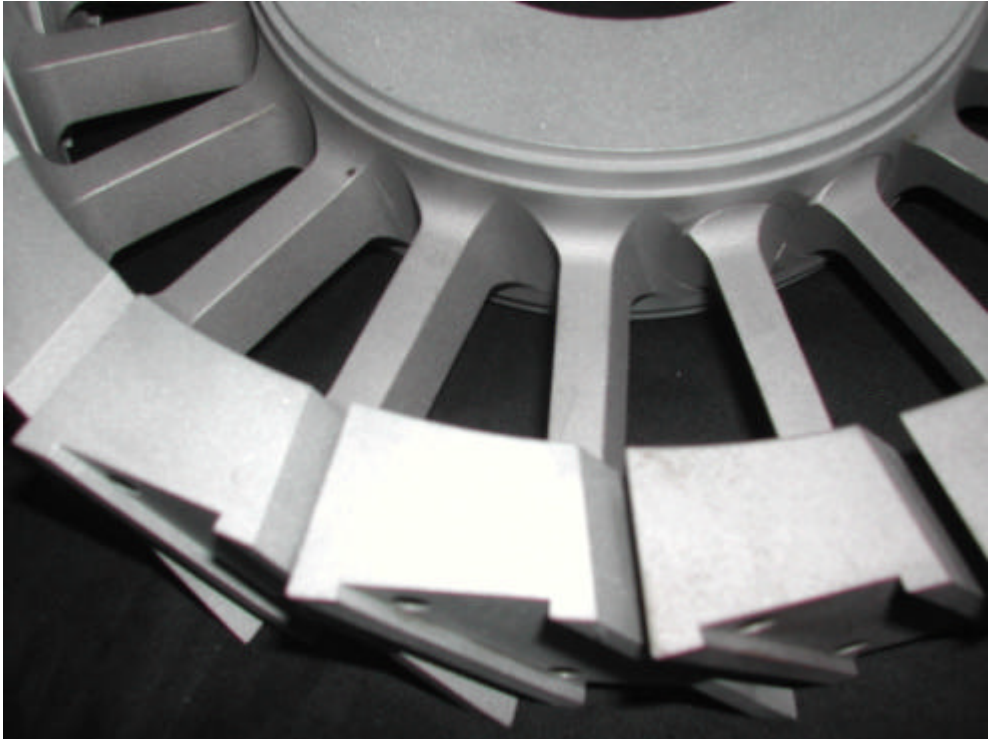
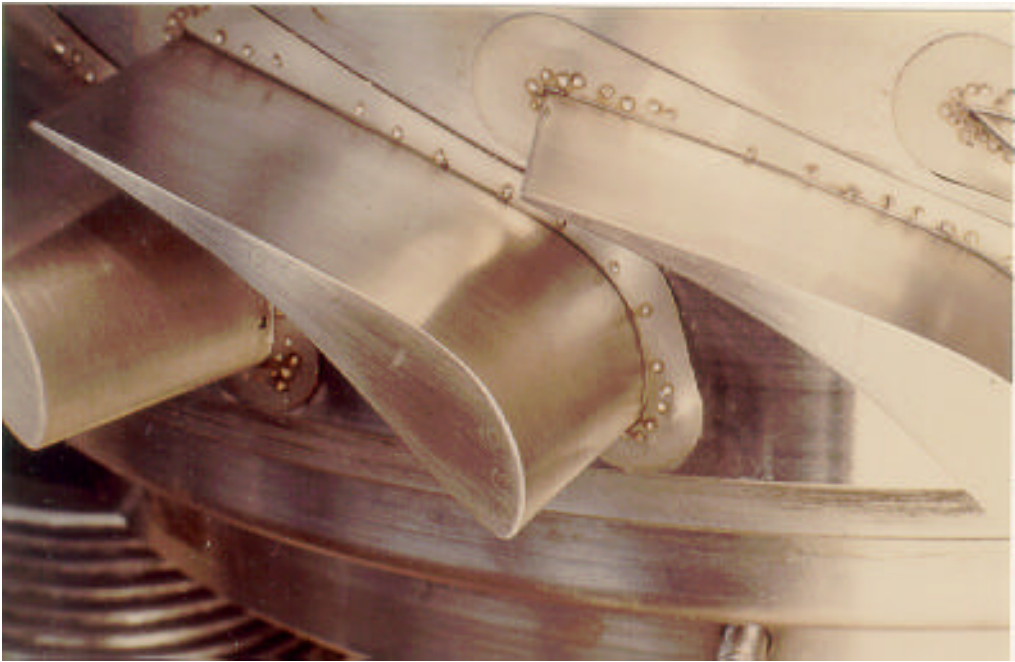**Fig. 5:** *Photo of the spring body (detail)*
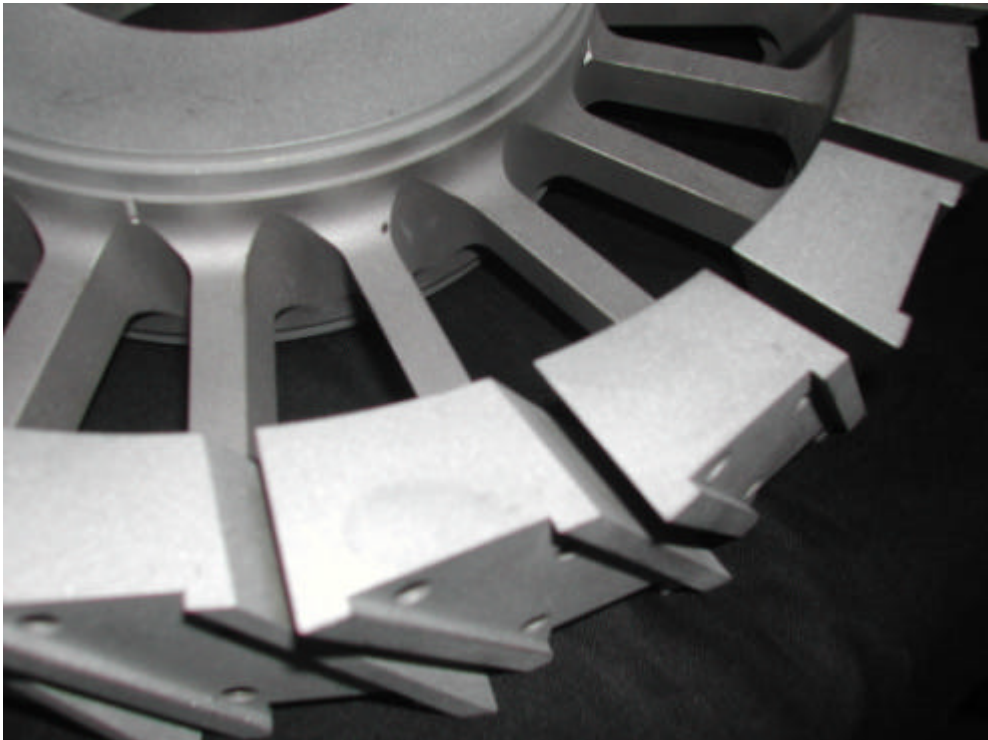
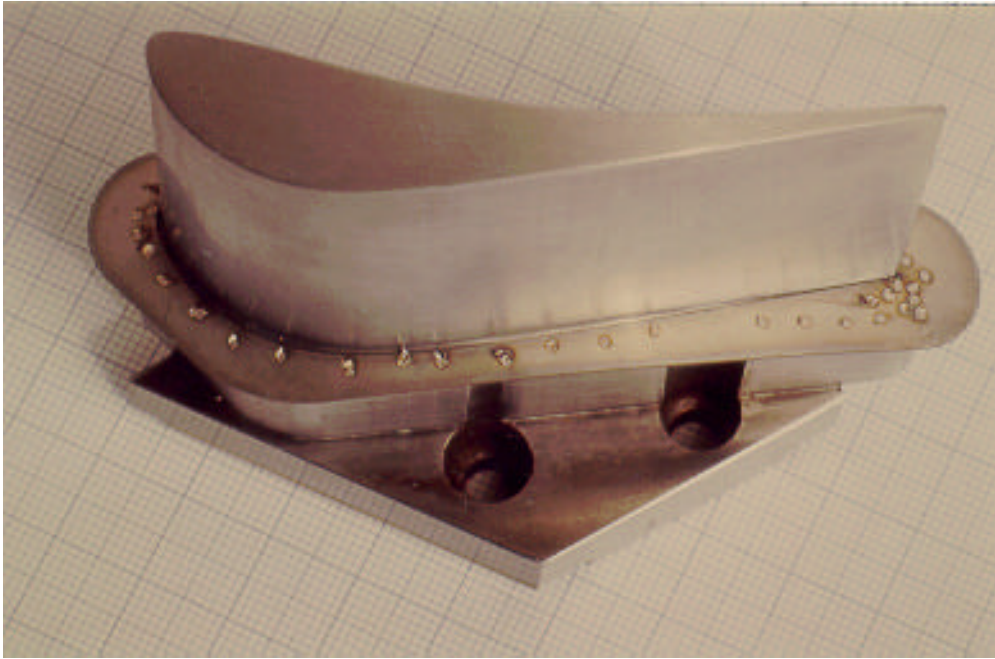**Fig. 6:** *Photo of the spring body (detail)*

Fig. 7: *Photo of the test cascade*

Fig. 8: *Close-up of the test cascade*

Fig. 9: *Photo of a test blade*

5. 3D movement of the blades

The bending amplitudes mentioned in the test protocols are the measured amplitudes in mid height of the blades. The blades move as rigid bodies around a fictive rotation point somewhere on the spring. The amplitude at the hub is thus smaller than at the tip. The increase of the amplitude is linear.

For the determination of the rotating point on the a similar setting as for Standard Configuration 11 can be used as first approximation (Jöcker, 2001).

Figure 10 shows a schematic presentation of the bending of the cascade. Most of the parts will behave like rigid bodies. Bending will take place only in the spring section. As a simplification for the movement it can be assumed that the blade moves as a rigid body in a rotational motion around a point x_{rot}. A good guess for this location would be the middle of the spring section:

$$x_{rot} = 88.5 \text{ mm (with } x = 0 \text{ in the center of the test facility)}$$

In order to verify this location of the rotation point x_{rot}, measurements were made on the original blades and spring body, partly reassembled. At two locations on the blade were put accelerometers and then the blades were put in vibration. Both locations of the amplitudes (x_1 and x_2) were known. Together with the measured amplitudes a_1 and a_2

the position of the point with no amplitude x_{rot} could be determined with a moderate accuracy. These measurements confirm the first estimation locating the rotation point at the middle of the spring section.

Just to remind: the unsteady pressures and the vibration amplitude were measured in the middle of the flow channel which corresponds to $x = 180$ mm in this coordinate system.
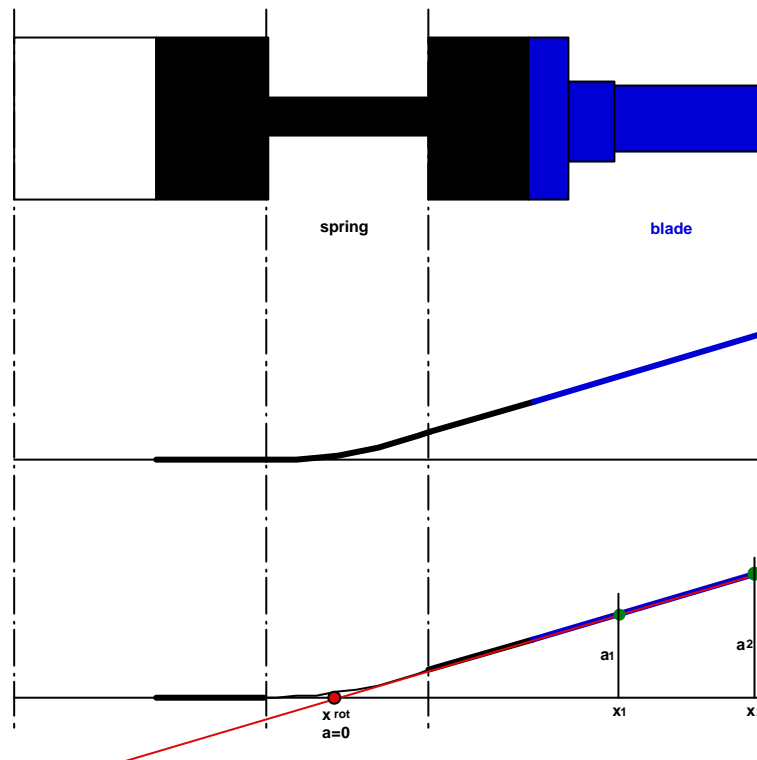
Fig. 10: *Schematic view of bending*

6. Literature

Bölcs, A.; Fransson, T.H.; 1986
Aeroelasticity in Turbomachines; Comparison of Theoretical and Experimental Cascade Results
Communication du Laboratoire de Thermique Appliqué et de Turbomachines Nr. 13 Lausanne, EPFL, 1986

See also the web pages: http://www.egi.kth.se/ekv/research/stcf/

Jöcker, M.; 2001
Information for 3D Computations of the STCF 11 Test Cases
Technical Report HPT-11/01
KTH, Department of Energy Technology, Stockholm, 2001