EAN '92
30th Conference of Experimental Stress Analysis
30. konference o experimentální analýze napětí
2. - 5. 6. 1992 ČVUT Praha Czechoslovakia

ANALYSIS OF ELASTIC PLASTIC DEFORMATIONS AND LOAD DISTRIBUTIONS IN SCREW THREADS BY SPECKLE PHOTOGRAPHY

Stockmann M., Engelmann G., Naumann J., Heymann J.

Summary:
The evaluation of deformation in an original screw connection up to the plastic state is determined by speckle photography. This method is used to measure pointwise and in load steps the displacement vector in the bolt notches through small drillings in the nut. Load distributions for a normal nut and a special overload nut are evaluated and compared.

Keywords:
Speckle Photography, Screw Threds, Load Distribution

The speckle photography /1/ is a coherent optical method and can be used to determine the in-plane displacement vectors on optically accessible surfaces. The determination of load distributions in thread connections is only possible if the following two problems are solved:

- *measuring of the displacement vectors in all threads in the bolt-nut connections and*
- *derivation of a relation between the displacement function as the measuring result and the load distribution*

Figure 1 shows the experimental setup in two projections. The laser beam L is onedimensionally expanded through a cylinder lens CL and illuminates the completely threaded connection TC through a half-mirror HM. I(O) illustrates the illumination and obser-vation direction. On the right side the nut-bolt connection with the drillings in the nut is shown. These small drillings end in the measuring points on the bolt. These points are exactly situated in the notches. They are prepared with a special diffuse reflecting coat.

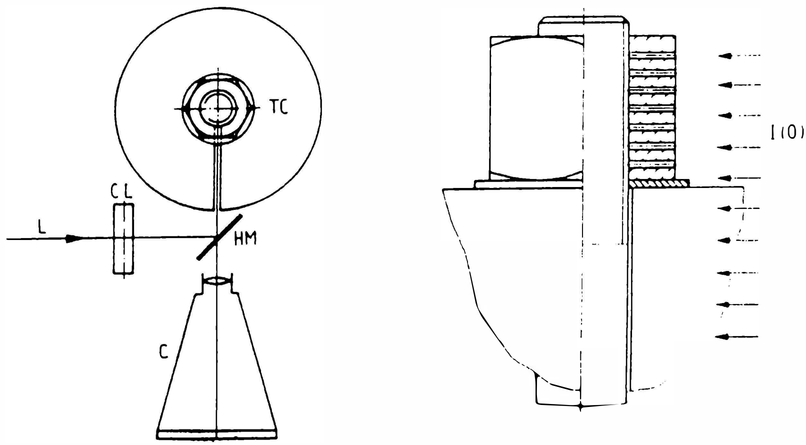

Fig. 1: Mode of experimental procedure for the deformation analysis of screw connections

Figure 2 shows this arrangement in the variant as a special nut. On the right side of this figure there is shown the construction of this nut.

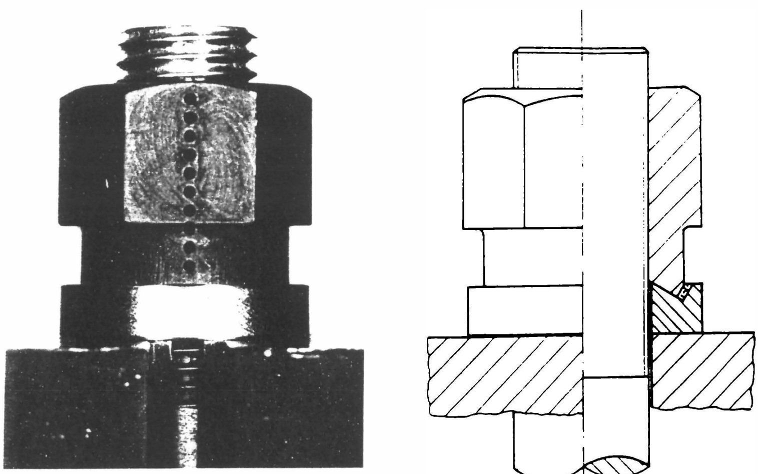

Fig. 2: Special nut-bolt connection with drillings and measuring points

Using the double exposure technique the specklegrams are recorded by the camera C. A pointwise filtering of this specklegrams in a well known manner produce the Young's fringe patterns and allows to determine the displacement vectors in all measuring points. The measured displacement components in axial direction for the example of the normal ISO-nut with 10 threads is presented in figure 3. The line shows the compensation function (cubic spline) and represents the function $u_x = u_x(x)$ with x as axial coordinate.

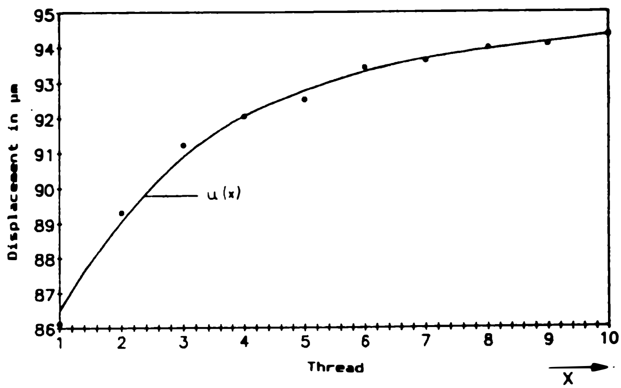

Fig. 3: Displacements of the measuring points and compensation function

In the further evaluation procedure it is necessary to consider the nut bolt connection as a continuous connection. The average axial stress in a bolt section is defined by

$$\sigma_x(x) = E \cdot \epsilon_x(x) = E \cdot \frac{du_x(x)}{dx} \quad .$$

Taking into consideration

$$F_x(x) = \sigma_x(x) \cdot A$$

the differentiation results in

$$\frac{dF_x(x)}{dx} = \frac{d^2u_x(x)}{dx^2} \cdot A \cdot E \quad .$$

On the left side it is possible to transform the differential quotient in a difference quotient because the screw pitch is constant. Thus a direct proportion results between the load increment and the second derivation of the displacement function.

$$\Delta F \approx K \cdot \frac{d^2 u_x(x)}{dx^2}$$

Figure 4 shows load distribution, determined with this method.

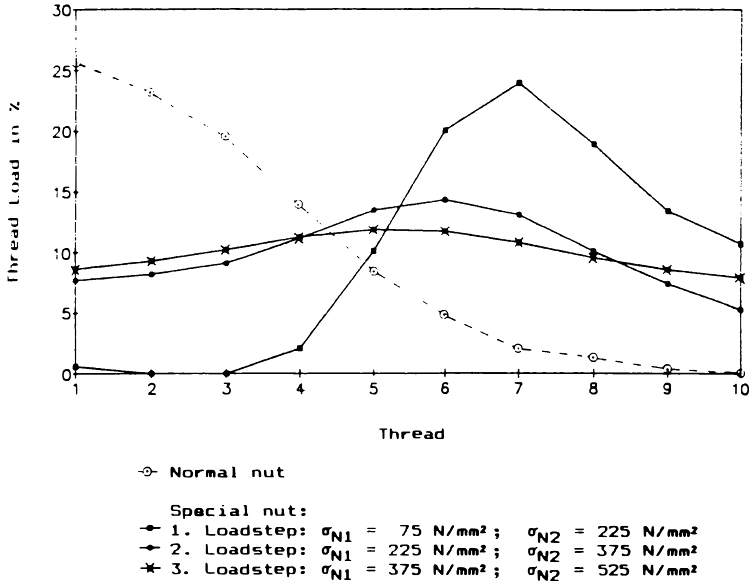

Fig. 4: Thread load of the normal and the special nut

The interrupt line represents the results of a thread connection with a normal ISO-nut. The other values are results of a special overload nut (see Fig.2). Before the real experiment this nut is loaded with σ_{N0} = 375 N/mm² and unloaded. This preload produces an elastic-plastic expansion on the buttom of the nut. In the loadsteps 3 and 4 there is determined a very balanced load distribution.

Dr.-Ing. M. Stockmann
Dr.-Ing. G. Engelmann
Dr.-Ing. habil. J. Naumann
Prof. Dr.-Ing. habil. J. Heymann

Technical University Chemnitz
Div. of Mechanical Engineering I
Dep. of Experimental Mechanics
P.O. Box 964, D-O-9010 Chemnitz
Phon: 668 328, Fax: 668 359