EXPERIMENTAL TECHNIQUE FOR BIAXIAL TESTINGS OF FAILURE ON SEMI-BRITTLE STEELS

H. Nega*, K. Sandler*

INTRODUCTION

Important defects of well-known strength hypothesises for the description of the failure behaviour of so-called "semi-brittle" materials under multiaxial stress states are shown. On this basis, a test method for the failure by plastic deformation is discussed. This method will provide more accurate specific results for materials under stress. These investigations are an essential part of a similarity model to explain the complex failure properties of supporting rings for anvils and punches of high pressure chambers. Essential aspects of strength behaviour of selected high-strength steels such as the alloy tool steels 56NiCrMoV7.4, X80WMo6.5 and 210Cr46 will contribute to an explanation on the base of experimental limit-deformation values.

Methodical investigations have been carried out with respect to stress distribution in the test specimens, to the frictional behaviour at the points of action of a load, to optimization of sample geometry, to determination of the stability and to the residual stresses in the specimens. The multiaxial stress investigations have to consider a very general homogeneous stress distribution, insignificant bending stress and friction all over the load period. In this way an independent failure behaviour of the sample geometry and external effects will be reached. Generally, only thin-walled cylinders comply with these demands. Therefore, the devices for the load condition have to guarantee a deformation without strain obstructions in every load phase. The decrease of the friction at the ends of the hollow cylinders can be reached by application of load conditions nearly free from friction such as caused by paraffin. A comparison of the stress-strain ratios measured at the ends of the cylinder and at the point of the maximal strain rates shows the efficiency of the applied load conditions (Figure 1). Significant radial strain differences do not occur at the application of a load condition with decreased friction caused by paraffin when stress proportions are

*Academy of Sciences of the GDR
Central Institute for Physics of the Earth, Potsdam

higher than $\sigma_t:\sigma_z \geq 0{,}5:1$. Furthermore, this system for the action of a has the function to prevent peaks of compressions in the load area and stress distribution without gradients till the failure.
Another example of the design of a additional arrangement for a load condition with decreased friction in thin-walled cylinders is described and test results are presented. The problems of collapsing buckling stress on thin-walled cylinders are especially considered in the experiments. The tests were made with cylinders in axial compression and axial compression with hoop tension. The test results confirm the demand for the least radial stress obstruction at the ends of the specimens during the load increase reaches the critical buckling stress. The results show that the critical buckling stress is in the first place determined by the kind of load condition and only in the second place by the specimen design especially of the wall thickness - diameter relation ($s/2r_i$). The value of the critical buckling stress increases with specimens under axial compression and additional internal pressure. Only on the understanding that load conditions with decreased friction and specimens with a wall thickness - diameter relation of about $s/2r_i \approx 0{,}044$ have been applied the percentage plastic deformations of $\varepsilon_{zpl} \approx 1{,}2$ % could be reached by pure axial compression and $\varepsilon_{zpl} \approx 1{,}5$ % by axial compression with additional internal pressure.

First comparisons of the multiaxial test data with values calculated by means of the hypothesis of energy of distortion for the yield condition show differences of about 10 %.

SYMBOLS USED

F_z = axial load

p_i = internal pressure

ε_{r1} = radial strain at the ends of the cylinder

$\varepsilon_{r2/3}$ = maximum radial strain

σ_t = hoop stress

σ_z = axial compression

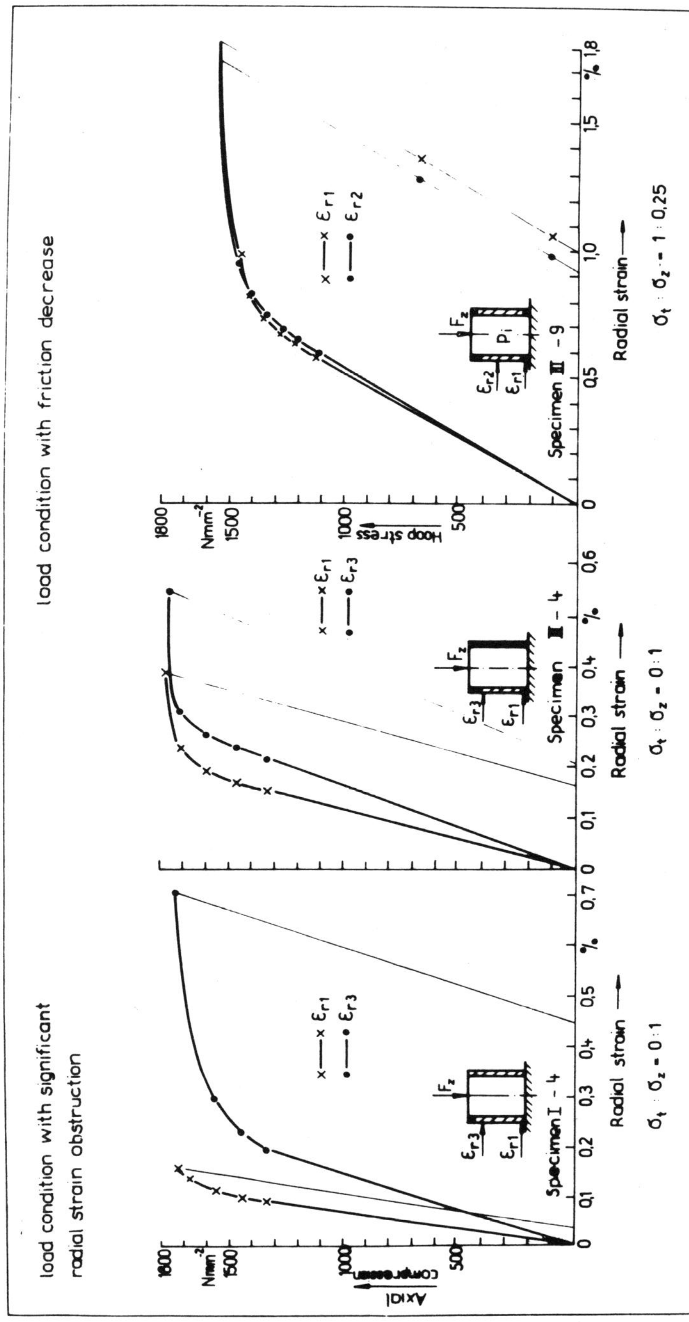

Figure 1 Comparison of the radial strain values depending on the load conditions and on the stress proportions