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The fatigue-life testing method of the axle shaft and drive shaft on the test stand, wheeled agricultural tractor

农业轮式拖拉机半轴和驱动轴台架疲劳寿命试验方法

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Foreword

Annex A and Annex B of this standard are informative annexes.

This standard was proposed by the China Machinery Industry Federation.

This standard is under the jurisdiction of the National Technical Committee on Tractors Standardization.

Drafting organization of this standard: National Tractor Quality Supervision and Inspection Centre.

Main drafters of this standard: Jin Xiping, Wang Fengyu and Chen Zhen.

1 Scope

The Chinese national bench test for the fatigue life of a tractor's axle shafts and drive shafts. These are the shafts that carry the whole traction effort of the machine to its wheels, and in field work they are loaded in pulses rather than steadily: every time a plough bites, a wheel slips or the clutch takes up, the shaft sees a torque peak. Failure, when it comes, is a fatigue crack rather than a single overload break, so a static torsion test says very little about how long a shaft will last. This standard puts the shaft on a torsional fatigue rig under pulsating cyclic loading, derives the test torque from the load on the drive axle, the rolling radius, the coefficient of adhesion of the ground and the design bending moment, and runs a sample of at least five shafts to failure while the cycles are counted. It defines when a specimen is considered to have reached the end of its life, fixes the loading, the frequency and the accuracy of the rig, and evaluates the results with a two-parameter Weibull

distribution, from which a median life and a life at ninety per cent survival are read. It also states the five occasions on which such a verification is required, such as a new design, a change of material or process, or early damage found in service. It is used by tractor manufacturers and by the test centres that qualify their transmissions.

This standard specifies the bench fatigue-life testing method for the axle shafts and the drive shafts of wheeled agricultural tractors.

This standard is applicable to the axle shafts and the drive shafts of wheeled agricultural tractors.

2.1 Terms and definitions - the torsional fatigue-life

The life reached when a crack appears on the surface of the specimen, when the rate of change of the dynamic angular displacement of the specimen is greater than or equal to the stated fraction of the dynamic angular displacement, or when the load carrying capacity of the specimen falls so markedly that the testing machine can no longer work properly.

2.2 Symbols

i, the transmission ratio from the axle shaft to the drive wheel (for the drive shaft, i = 1); r, the rolling radius of the drive wheel, in m; Mj, the nominal torque of the axle shaft or of the drive shaft, in N-m; Mw, the design bending moment borne by the axle shaft and the drive shaft, in N-m; Wr, the load carried by the drive axle, in N; the coefficient of adhesion of the ground and the conversion factor from bending moment to torque, both of which are given fixed values in the standard.

3 Purpose of the test

Verification of the fatigue life of the axle shaft and of the drive shaft shall be carried out in the following cases: a) a new design or an improved design; b) a change of material or of process; c) an increase of load capacity or an extension of service life; d) early damage found in service; e) resumption of production after transfer to another works or after a long stoppage.

4 Number of specimens

Specimens shall be drawn at random from the qualified products of the manufacturer, and the number of test samples shall be not less than five.

5 Test method

5.1 Test load. Pulsating cyclic loading is used and the relation between load and time is shown in Figure 1. The test load is determined by Formulae (1) to (3), which relate the load amplitude to the nominal torque, the mean load to the load amplitude and the minimum

load to the difference between the mean load and the amplitude; the nominal torque of the axle shaft or of the drive shaft is itself calculated by Formula (4) from the load on the drive axle, the coefficient of adhesion of the ground, the rolling radius of the drive wheel, the transmission ratio and the design bending moment.

5.2 Test frequency. A test frequency above the stated value is preferred, and the test frequency shall not be changed during the test on one and the same specimen.

5.3 Test rig. An exciter type or an electro-hydraulic servo torsional fatigue testing machine may be used; the error of the test load shall not exceed the stated limit and the load shall remain stable throughout the test.

5.4 Mounting of the specimen. The clamping position of the specimen on the testing machine shall be such that its stress state and its critical section are the same as in service.

5.5 Application of the load. The load shall be increased slowly from zero to the specified value, within the prescribed loading time.

5.6 Test records. 5.6.1 The counting of the cycles shall begin at the moment the load reaches the specified value. 5.6.2 The running condition of the specimen shall be observed and recorded at the prescribed interval of cycles. 5.6.3 The number of cycles at which the life of each specimen ends is the life of that specimen. 5.6.4 The final failure mode and failure location of each specimen shall be recorded. 5.6.5 When a specimen reaches the specified number of cycles without damage it shall be recorded as undamaged, and the test shall be continued with a new specimen. 5.6.6 The test record form is given in Annex A.

6 Evaluation of the test

6.1 Evaluation of the fatigue life. The data of the torsional fatigue-life test of the axle shaft are processed by the Weibull graphical method; the median life and the life at ninety per cent survival shall reach the values required by the standard. A two-parameter Weibull distribution fitted by the method of least squares is used, calculated by Formula (5), in which the failure rate, the slope parameter and the characteristic life parameter appear.

6.2 Test report. The format of the test report is given in Annex B.

A Annex A (informative) Fatigue test record form

Table A.1 is the fatigue test record form; it carries the name of the specimen, the load parameters (mean load, load amplitude and frequency), and, for each entry, the date, the specimen number, the number of cycles, the running condition, the failure mode and location and the name of the operator.

B Annex B (informative) Torsional fatigue test report

Table B.1 is the torsional fatigue test report form; it records the tractor model, the load on the drive axle, the rolling radius of the drive wheel and the transmission ratio from the axle shaft to the drive wheel; the name, material, heat treatment and nominal torque of the specimen; the purpose of the test and the test rig; the load parameters; the results, namely the number of specimens tested and the life at ninety per cent survival; a brief report; and the names of the reporter and of the reviewer, together with the commissioning body and the dates.