Innovative Fatigue Test Procedures and Equipment for Shot Peened Specimens and Components

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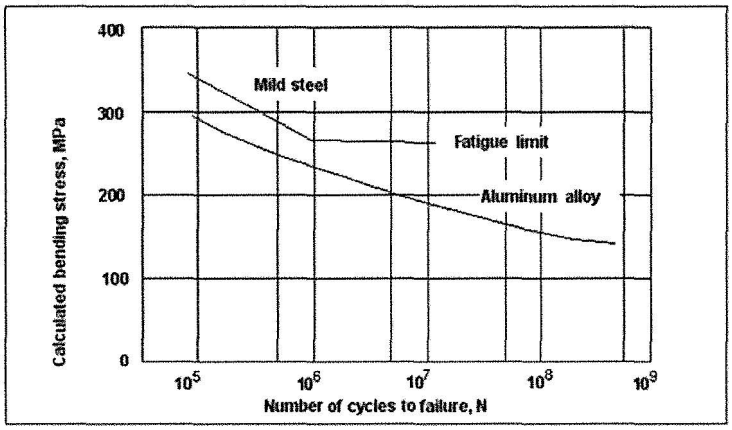
Introduction

Shot peening is one of the most successful, efficient and universal applicable technologies to increase the fatigue strength of material specimens and components. To investigate the effect of different parameters of the process of shot peening, destructive fatigue tests are most favorable. The tests must be fast, accurate and energy efficient to get best and durable test results. This paper presents a big range of test equipment and also the test procedures how to do these tests with high frequency, high precision and energy efficient test machines in the high cycle fatigue HCF area. The latest development of very high frequency material and component test machines up to 300, 500 and 1100 Hz will be presented. Various test procedures and gripping devices for different loading like tension-compression, rotating bending, pure bending, torsion and multiaxial loading will be introduced. The currently most applicable and used procedure of stair case method will be explained and shown with an example. Various component test machines for typical components for the shot peening process will be visualized.

S/N Curves

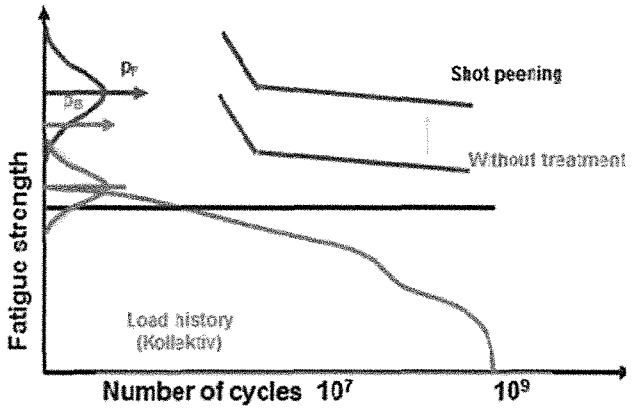
The S/N-curve or Wöhler-curve represents the characteristic diagram of fatigue performance of materials or components. Component S/N-curves are much more realistic because all manufacturing processes and their influence to the fatigue life are automatically integrated. A typical S/N-curve for steel and for aluminum alloys are shown in the next figure.



Steels show often a distinctive edge in the S/N curve at about 1-2 million cycles. Aluminum materials don´t show such a distinctive S/N curve, the transition area of LCF to HCF-area is fluently.

Effect of Shot Peening to the life time of Materials and Components

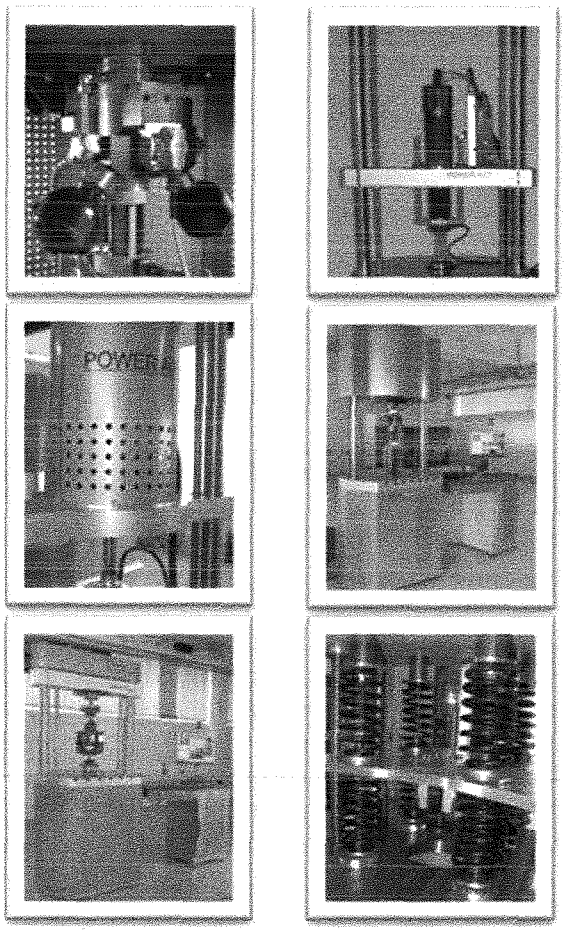
The surface strengthening effect of shot peening helps to increase the fatigue limit of components in the range of 20 – 60%. There are a lot of parameters such as material, geometry, size, surface condition, hardness, other treatments of the material, size, duration and speed of the of shot peening, etc. which have an influence to the fatigue performance. One of the most important parameters is the failure strain or ductility of the material. A high work-hardening capability usually leads to good fatigue response to shot peening.



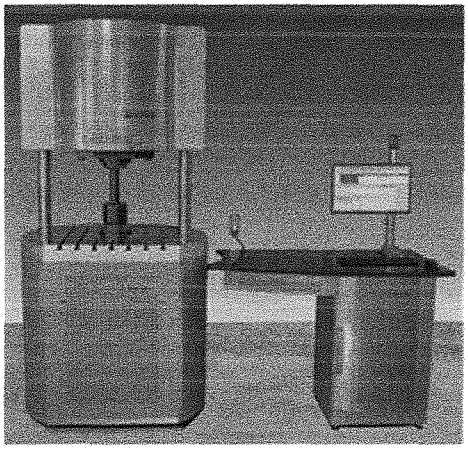
Overview of Test Technologies

A Current look to the test technology which is used in the dynamic fatigue laboratories show technologies as follows: Servohydraulic test systems are common and multiple applicable. The biggest disadvantages are the costly infrastructure and the high running costs. Mostly, the test frequency is very low. Electroactuatoric is more and more coming up because of the high accuracy. Servopneumatic is still an easy to use technology, but also high in running costs.

The fastest and most efficient technology to do cyclic fatigue tests is still the resonance test system. There are two principles of exitation, the magnetic one and the motoric one with unbalanced masses. .Magnetic test systems are material test systems for pure tension- compression tests and high frequencies. Motoric resonance test systems are component test systems also usable for bending and torsion applications, higher displacement tests and tests with clearance and damping. In the following section, pictures of various test machines for various components are illustrated.



a) Material Test Machine POWER SWING MAG



b) Magnetic Resonance Test Machine for testing cylindrical or flat specimens

Fig. 1: Component Test Machine POWER SWING MOT

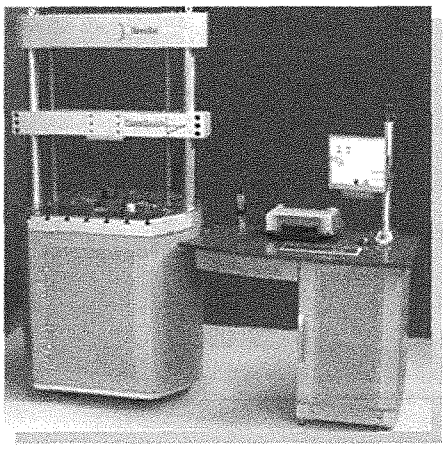


Fig. 2: Motoric Resonance Test Machine for Components under Tension-Compression, Bending or Torsion, universal applications

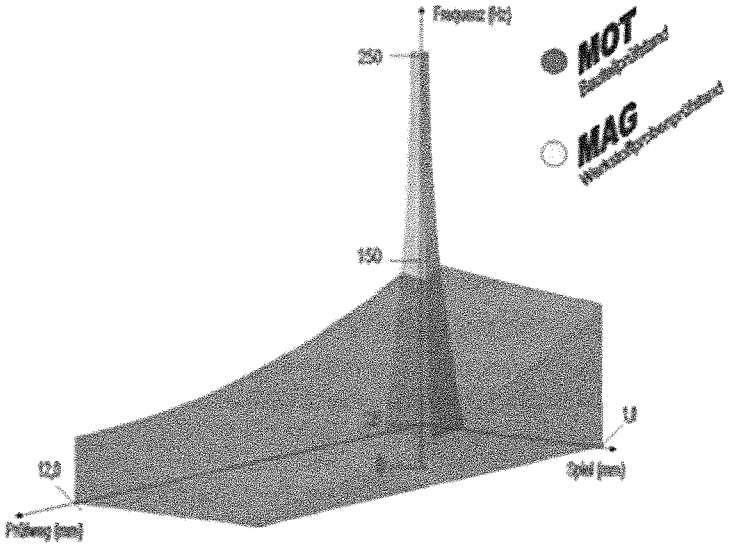


Fig. 3: Connecting Rod Test Machine

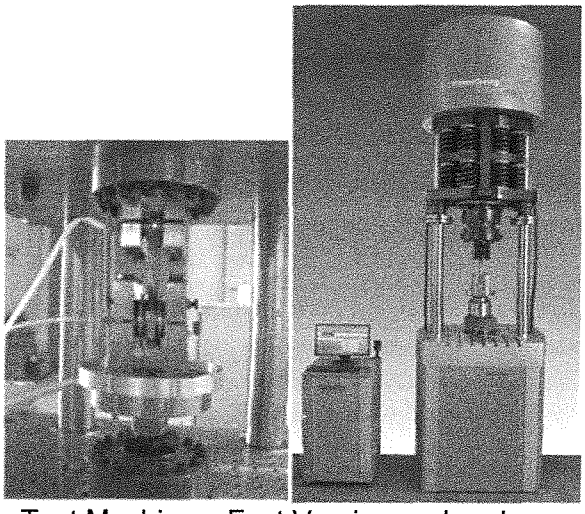


Fig. 4: Axle Spring Test Machines, Fast Version and under corrosion and dirty water

Fig. 5: Spring Test machine for Industrial Springs

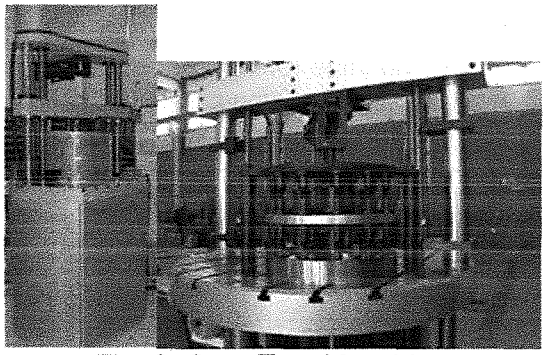


Fig. 6: Gear Test Maschine

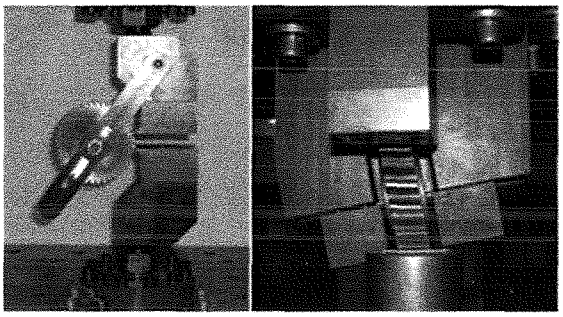
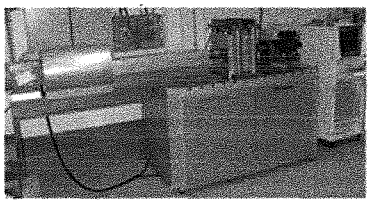
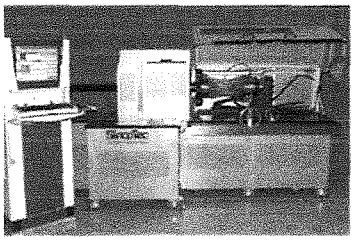


Fig. 7: Torsional Test Machine



a) Test equipment for high frequency torsional load under rotation



b) Test machine for drive shafts and drive line components

Fig. 8: Rotating Bending Test Machines

Fig. 9: Rotating Bending Test Systems from 100 Nm up to 1000 Nm are most applicable to do parameter tests. A whole surface can be investigated statistically.

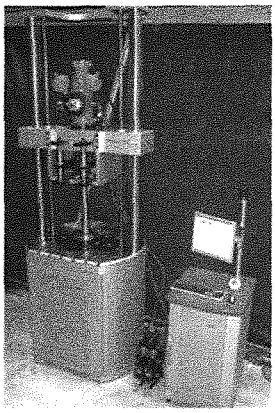


Fig. 10: Biaxial Test Machine Tension/Compression and Torsion

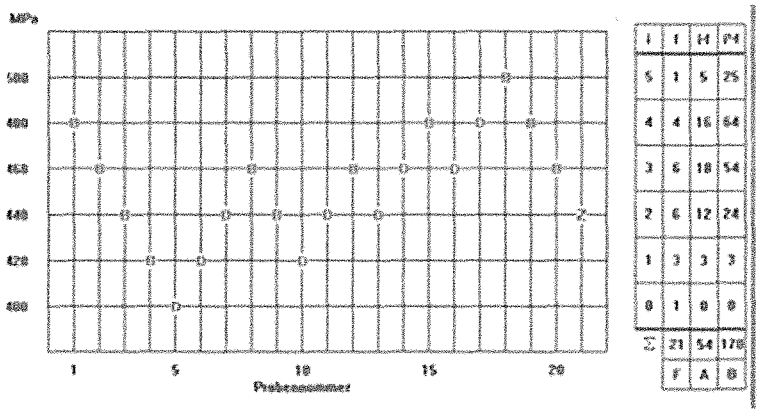


Fig. 11: Stair case method – the best way to calculate the fatigue limit

Conclusions

Test technology must be fast, reliable and accurate to do fatigue tests up to millions of cycles in a moderate time. Resonance machines are currently the best and cheapest way to do very efficient and fast constant amplitude fatigue tests. The crack detection because of the change of stiffness helps to detect microcracks in the really beginning. The stair case method is currently the best and method to calculate the fatigue limit with a reduced number of specimens.