Fundamental aspects of the effect of shot peening on the fatigue strength of metallic parts and structures

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1 - Introduction

Many factors can contribute to fatigue failure; however, the fatigue strength of a part is generally determined by the microstructure and mechanical properties of its surface layers.

It is for this reason that an improving method such as shot peening, which leads to the formation of surface compressive residual stresses, is widely used in mechanical industry and is beginning to be used for the construction of welded assemblies.

The purpose of this bibliographical overview is firstly to describe the role of this method and the effect of shot peening parameters, and secondly to discuss the effectiveness of this method according to loading conditions and environment.

2 - Rôle of residual stresses in fatigue crack initiation

2.1 - Macrostresses and microstrain

Residual stresses are generally considered to refer to the stresses existing in a part when the latter is not subjected to an external force. Several types of residual stresses can in fact be considered on the basis of the size of the volume of material in which they are present.

A distinction is made between first order stresses that produce strain in the part on a macroscopic scale, and between second or third order stresses that result in microstrain at intergranular level or in the crystalline structure respectively. These three types of stresses are interactive.

It is above all first order stresses (macrostresses) that affect fatigue strength; second and third order stresses (microstrain) affect the stability of residual stresses under fatigue loading conditions.

2.2 - Effet of mean stress

The macroscopic definition of residual stresses allows elasticity equations to be applied, particularly expressions of stress situations in which two stress components are superimposed.

When a part is simultaneaously subjected to residual stresses, characterized by σ_R, and stresses produced in service, characterized by σ_S, the real stress to which the part is subjected is defined by $\sigma_R + \sigma_S$ (figure 1).