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Analysis of the *S–N* curves of welded joints enhanced by ultrasonic peening treatment

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ABSTRACT

Contrast fatigue tests were carried out on *T-shape* tubular joints of 20 steel in three conditions: as welded, treated by ultrasonic peening treatment (UPT) before loading and UPT under loading. Results are: (1) Dispersity of test results measured by nominal stress is much larger than that measured by hot spot stress. After UPT before loading, fatigue strength of 20 steel tubular joints measured by hot spot stress increases by 67% and fatigue life is prolonged by 22–45 times. (2) Under low stress ratio *R*, UPT before loading can improve the fatigue performance of welded tubular joints significantly. (3) Under high stress ratio *R*, UPT under loading (static load) is recommended to improve the fatigue performance of welded tubular joints. UPT under loading not only enhances the fatigue properties at low stress level, but also at high stress level. (4) The general rule of *S–N* curves of welded joints treated by UPT is commonly effected by external load (static load) and self release of residual stress.

1. Introduction

Welded tubular joints are widely used in ocean projects such as oil production platform. Under wave, wind and the load of ice, steel structures in ocean projects bear mostly variable amplitude loads. Therefore, fatigue failure is one of the most important failure cases. Because of the high notch stress concentration and the residual stress of the tubular nodes, which are induced by welding, their capacity of bearing fatigue load is poor [1–5]. Consequently, it is very meaningful to take technologic treatment to improve the fatigue performance of the welded tubular joints.

The existing methods of ameliorating fatigue strength consist of common hammering, TIG dressing and shot peening. Ordinary hammering method has some disadvantages, such as low efficiency, large noise, great labour intensity, poor controllability and instable effect [1,6], which is not suit for standard-processing. For TIG dressing, the processing technic is rather complex and improper operation will cause side effects [7,8]. In addition, though shot peening has much more practical use than the above two methods, it also produces large noise and its equipment is space-consuming, which impedes the realization of energy saving and easily mobile operation. Due to pills rebounding, pills need to recycle, further worsening the working efficiency [9].

On the contrary, the ultrasonic peening treatment (UPT) has many advantages, e.g. handy operation, little noise, high efficiency, low cost, energy saving and so on. So it is an ideal post-weld method that can be applied to intensify the welded joints fatigue performance [10–12].

Both of the famous Ukraine Barton Welding Institute [10] and the Tianjin University have performed fatigue tests on tubular joints treated by ultrasonic peening before loading, which verifies that the ultrasonic impacting technique can boost the fatigue strength of welded tubular joints to a high level. Meanwhile, this kind of technique is able to overcome the reduction of tubular joints fatigue strength caused by structural stress concentration on tubular joints, notch stress concentration on welded toes and high numerical welding residual stress.

It is worth mentioning that current research focuses on preservice welded joints processed by UPT before loading. However, these structural components are already under loading before UPT processing in practice, such as maintenance or life-extension treatment on bearing structure in active service. Therefore, study on the UPT under loading has more practical significance. Nevertheless, the reason for improvement of fatigue strength by UPT under loading has not been studied until now [13]. In this paper, fatigue property differences between as-welded joints and UPT joints are discussed based on numbers of test results, together with the statement of some expedient suggestions.

2. Testing materials and method

2.1. Joint type and preparation of specimens

Specimens are of welded tubular joints, whose geometrical characteristics are shown in Fig. 1. Twenty steel is adopted here

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