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Fatigue improvement modification in a cold-worked rail bolt hole

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ABSTRACT : Rail joint is the critical section where induced fatigue stresses are maximum due to the presence of bolt holes where the cross-sectional area is minimum. These holes may cause a major source of fatigue cracking when high shear loads are transferred through the joint. This makes the joint weak and ultimately the critical site for failure. Therefore, it is imperative to pay attention towards improvement of fatigue life of rail joint. Residual stress is having a significant effect on fatigue life of the structural engineering components. Mandrellizing expands the hole diameter by means of the radial interference pressure to allow radial plastic flow of material and some elastic recovery after the removal of mandrel. Thus it produces a large residual compressive zone around the hole. This zone acts as a barrier to crack growth thereby enhancing the service life of the structural components. This paper focuses on the mandrellizing *i.e.* the cold expansion process of the rail bolt-hole joint which induces compressive residual stress around the holes, thereby enhancing the service life of rail joint.

KEY WORDS : Fatigue, Pre-stressing, Residual stresses, Split-sleeve process

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With the need for higher strength to weight ratio of engineering components, fatigue has become a very important phenomenon especially in automobiles, aircrafts, gas turbines which are subject to repeated loading and vibration. Considerable interest in the influence of residual stresses on fatigue behaviour of components exists in the industry

Cold expansion of Rail bolt-holes is one of the methods to increase the fatigue life of assemblies (Rail joint), Rail bolt-holes may cause a major source of fatigue cracking when high shear loads are transferred through these joints. Cold expansion introduces compressive residual stresses around the hole, which delay or suppress the crack initiation or reduce the crack propagation rate. An attempt is made in this work to simulate a continuous sleeve split mandrel and pilot cold expansion (CsSmPCx) process to introduce a uniform compressive residual stresses around the Rail bolt-hole [1]. This newly proposed method is more reliable and gives increased service life enhancement compared with the presently used mandrellizing methods, without any weight and risk penalty.

The split sleeve cold expansion technique was developed by the Boeing Company and marketed by Fatigue Technology Inc. It has been widely accepted as a standard practice in the United States Fig A. [2].

The process is accomplished by using an oversized solid tapered mandrel and a lubricated split sleeve. The nose cap assembly restrains the sleeve in the hole while the mandrel is pulled through the hole. The purpose of the sleeve is to prevent the hole from damage while the tapered mandrel expands radially and cause the material surrounding the hole to yield. The sleeve is discarded after the expansion process. The insertion of the mandrel and removal of the sleeve in the cold expansion process does not require access to the backside of a component, thus easing the repair of existing structures. The process can also be applied to stack-up of multiple materials [3].

Fig. B shows a typical photo-elastic pattern for a cold expanded hole and its corresponding residual stress field. The residual stress field is formed as a result of the plastic yielding of the surrounding material and subsequent elastic spring back of the material lying beyond the plastically deformed hole.

Fig. C shows the typical distribution of residual radial and circumferential stress surrounding a cold-worked hole. The annular zone of compressive stresses typically extends radially from the edge of the hole and has a peak magnitude approximately equivalent to the material compressive yield