FATIGUE PROPERTIES OF UNDERFRAME OF RAILWAY WAGONS UNDER IMPACT

"A comparative investigation into the impact fatigue life of welded component joints of railway wagon underframes"

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SUMMARY

The aim of the present investigation is to compare the impact fatigue life of different component welded joints generally utilized in railway wagon underframe. The information yielded from this comparative investigation is intended to help the designer in choosing the best joint for certain functioning.

Joints of underframe of railway wagon are subjected to complex conditions of impact loading during service. Due to this fact, the present investigation covered two types of tests which approximately simulate the loading conditions of railway wagon underframe.

(a) Vibratory impact load tests super-imposed on steady one carried out on usually adopted joints of cross and longitudinal beam underframe as well as suggested joints with different shape, size and fillet-weld constraints. These tests were carried out on hydro-[illegible] testing machine.

(b) Metallic impact load tests carried out on crank press on various joints with different shapes and size as well as different fillet weld constraints.

The stresses selected for this comparative study are ranged from 19 to 22 Kp/sq mm. which are relatively high to represent the severe working condition of joints during service.

The present investigation led to the following conclusions :

(1) Stressing under the two different impact loading conditions yielded similar comparative results.

(2) Gradual change in shape of joint by introducing triangular or crescent-shaped gusset plates between flanges of longitudinal and cross beams was found to improve significantly the impact fatigue life of welded joints.

(3) Elimination of fillet welds from tension was found to improve the impact fatigue life of welded joints. Designers may be forced to introduce fillet-welds in tension zone; in this case, the impact fatigue life of joints can be improved by introducing triangular or crescent-shaped gusset plates between webs of longitudinal and cross beam. This improvement in impact fatigue life of joints is due to better distribution of stresses in the joint cross-section.

(4) Relief of accumulation of welds from tension zone by welding a cross-beam of less height than longitudinal beam at a position remote from tension zone was found to improve significantly the impact fatigue life of welded joints.

Railway wagons are known to be subjected to an extremely complex state of dynamic loading during service. This is, besides other factors which affect its fatigue properties such as low temperatures and corrosive environment effects in some countries. In addition to slight displacement of the rail track when béing under action, the vehicle is acted upon by three sinusoidal motions,(1) as follows :

1. Vertical oscillation of the centre of gravity of the whole superstructure.

2. Pitching of body itself due to rail gaps.

3. Motion related to bogies and transmitted to the body.

The last one is known to be of smaller amplitude than the first two but of higher frequency. The transmission of vibrations to the body of railway vehicles with all types of working frequencies causes fatigue fractures in superstructure of most rolling stock in railway. Such a complex state of uncontrolled loading of wagon underframe on track is approximated by two defined loading systems as follows :

1. A vibratory impact load superimposed on steady one applied with hydro-mechanical fatigue testing machine. This approximately simulates the first kind of loading.

2. A repeated metallic impact load applied through a crank press to imitate the action of rail separations. Both loading conditions had the same maximum stress level which ranged from 19-22 Kp/ sq mm, which represents extreme cases of practical loading but have the accelerated test nature in order to get useful comparative results in a reasonable time.

The need to increase progressively the carrying capacity of vehicle, the speed of running besides obtaining the most economical working condition of wagon increases rapidly the probability of fracture due to fatigue. The study of fatigue behaviour of welded frame is of great importance in order to determine the safety and optimum life-time of the running structures.

The safety of underframe under static loading conditions can be assessed on a basis of static strength values for the material easily obtained from static tests. Under impact loading conditions there are no similar relationship yet known between carrying capacity of joints and strength values obtained for the material from fatigue tests. The safety of welded frame under impact loading condition can only be judged on the results of fatigue tests carried out on a prototype of underframe or on highly stressed component parts.

As regards the component parts under investigation, the present work deals with several types of joint which are fabricated following an average commercial practice and tested under impact loading. Meanwhile, the welded joints were both shaped and sized with important economical consideration.

Due to the fact that intermittent welds create undesirable effects compared with continuous welds, the present investigations covered the study of the variations of the position of such intermittent welds when specially shaped gusset plates join the longitudinal beam to the cross beam, thus resulting in the variations of the stiffness of joints.

The information yielded from the present comparative tests are intended to help the designer in choosing the appropriate joint for certain functioning and working conditions.

Object and Scope of Present Work

Object :

The object of this investigation is to determine the impact fatigue life under specific testing loading conditions of different component welded joints from built up I-beam sections generally utilized in railway wagon underframe.

Scope :

The scope of the present work covered the following :

A) Vibratory impact load superimposed on steady one tests carried out on usually adopted joints of cross and longitudinal underframe beams as well as suggested joints with different shape, size and fillet weld constraints.

B) Repeated metallic impact load tests carried out on various joints with different shapes and sizes as well as different fillet weld constraints besides similar tests were carried out on usually adopted cross joints with triangular gusset plates.

CHAPTER I

REVIEW OF PREVIOUS WORK

1.1. Introductory :

This chapter deals with the studies about the fatigue performance of Weldment, which are stated by different authors, and some of their experiments.

The effects of weld defects, residual welding stresses, heat affected zone, type of electrode, size and shape ... on fatigue behaviour of welded structures are summarized here.

1.2. Weld Defects :

Weld cracks have been known to appear in more than one group. Matskvich[2] divided them into three main groups : hot, warm and cold. Hot cracks occurred when the weld metal was still in two-phase condition (Liquid-solid). Warm cracks occurred when the heat introduced during welding process was dissipated. Cold cracks formed after the complete cooling of the object. He stated that cold cracks did not appear when proper welding technique was followed especially with high quality materials.

On the other hand, Severn[3] stated that there were two main types of weld cracks, cracks which were situated in the weld metal and generally associated with the quality of the filler material or electrode. These types of cracks were dependent upon the welding condition; various defects such as inclusion or blowholes. The other types of cracks were those situated in parent metal, originated in heat affected zone or junction zone and associated with the weldability of the material or with various embrittling factors. In addition, Gurney[4] recorded that there were two common types of weld cracks whose size was large enough to be detected by non-destructive examination. Solidification cracks occurred in metal while it was hot and in plastic condition; cold or hard zone cracks which occurred in heat affected zone after the joint has been cooled. Weck[5] studied the transverse contraction and reaction stresses in butt-welded mild steel-plate due to variation of speed of manual welding processes. A considerable scatter occurred in result of identical specimens. The investigator concluded that procedures using small electrodes and low current caused greater [illegible] than the deep penetration procedures. Stresses were found to be much greater near the weld and at the top surface. Fine cracks were found in first run of weld of some specimens where low current procedure was used.

Under cyclic loading condition many investigations were carried out by different investigators to study the influence of weld defects on fatigue performance of weldments. Weck[6] concluded that under state of repeated loading the very high stress concentration produced by weld defects might result in