ORAL/POSTER REFERENCE: ICF100544OR

The Dynamic Mechanical Respondence of Weldment with Mechanical Heterogeneity by SHPB Testing

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ABSTRACT

A large number of research reports about dynamic mechanical behaviors with the metal and nonmetallic materials have been published in domestic and international publications. The studied results made it known that the dynamic mechanical behaviors of the majority of metals and alloys have the close relationships with the strain rate. The weldment is widely used in some important structures with a dynamic loading especially an impacting in earthquake. The dynamic mechanical respondence of a pressure vessel steel and its weldment with mechanical heterogeneity were investigated by means of Split Hopkinson Pressure Bar (SHPB) testing with different loading rates. The results show that the loading strain rate will affect the dynamic strength of the weldment, that the dynamic respondence of the weldment with mechanical heterogeneity is sensitive to the direction of loading. A testing procedure with SHPB is proposed in order to get reasonable results to describe the dynamic property of weldment with mechanical heterogeneity.

KEY WORDS: SHPB testing, Weldment, Dynamic Mechanical respondence

INTRODUCTION

Much attention has been taken into the mechanical properties of weldment with mechanical heterogeneity, and a lot of numerical and experimental researches are relating with the behavior of mis-matched weldment[1-3]. In general, the strength of mis-matched weldment has much relation with the size of weld metal. The narrower the weld metal is, the higher the strength of weldment at static situation. A few works are down relating with the dynamic respondence of weldment with mechanical heterogeneity, although a large number of researches have been down about the dynamic mechanical behaviors with the metal and nonmetallic materials[4-5]. It is getting more and more important and necessary to study the dynamic respondence of weldment as the increase usage of welded structures in some important structures suffering the dynamic loading such as earthquake and so on. The studied results made it known that the dynamic mechanical behaviors of the majority of metals and alloys have the close relationships with the strain rate. The dynamic mechanical respondence of a pressure vessel steel and its weldment with mechanical heterogeneity were investigated by means of Split Hopkinson Pressure Bar (SHPB) testing with different impacting rates in this paper. The dynamic stress of base metal, weld metal and weldment is recorded and discussed. Some important conceptions are built thought the basic experiment.

MATERIALS AND TESTING

The material used in the SHPB experiment is a pressure vessel steel, 16MnR with 16mm thickness. Its chemical compositions and mechanical properties are shown in table 1. The specimens for welding with

16x50x500 mm are welded manually with J507 electrode (Chinese standard). The welding conditions are the following: welding current 120A, welding voltage 25V and welding speed 120 mm/min. The J507 electrodes were preheated at 350°C with 2 hours before welding. Three kinds of impacting specimens of base metal, weld metal and weldment were extracted from the welded specimens according to the specimen scheme shown in Fig.1. The specimens extracted were machined to the size of ϕ30x15. The weldment specimen contains three region, weld metal base metal and HAZ(heat Affected Zone).

The test devise is a kind of Split Hopkinson Pressure Bar testing equipment called as SHPB testing and the measuring system is illustrated in Fig.2. The pressure bars, input pulse bar and output pulse bar, are made of 40Cr alloy steel and the size of input pulse bar is ϕ40x800mm. The experiments are done in room temperature and the impacting rates are near 18 m/s, 23m/s and 39m/s respectively.

RESULTS AND DISCUSSION

Fig.3 shows the dynamic stress of the base metal with different loading rates. It is shown in Fig.3 that the maximum value of the dynamic stress becomes larger as the increase of loading rate and that stress curve at loading rate 39.4 m/s is delayed largely. The dynamic stress of the weld metal is indicated in Fig.4 for different loading rates. It is also shown in Fig.4 that the larger dynamic stress is correspondent with the larger loading rate. Comparing with Fig.3 for near same loading rate, there are two conclusions that the maximum stress of base metal is larger than that of weld mental at loading rate 39.6m/s and the contrary at near 23m/s. Although the yielding stress and tensile stress of the base metal(16MnR) and weld metal(J507) are almost the same in static situation, the dynamic stresses are not the same. It means that the matching property of weldment is changing with dynamic loading situation. The large loading rate will change the matching property of the weldment from the other words. Fig.5 expresses the dynamic stress of weldment with different loading direction at the same loading rate. The type C specimen is taken in the experiments. The specimen consists of the weld metal and the base metal. There exists so called HAZ(Heat Affect Zone) between the base metal and weld metal. Two type of loading directions are used in the testing. One type is from the base metal to the weld metal and the other is from the weld metal to the base metal. It can be seen from the Fig.5 that there is different dynamic stress for two directions. The dynamic stress from base metal to weld meta is larger than that from weld metal to base metal. Comparing with Fig.3 and Fig.4, it can be understood that the dynamic mechanical respondence of weldment with mechanical heterogeneity is different with homogeneous materials. And the mechanical heterogeneity of weldment will affect the dynamic respondence of weldment. Therefore, the mechanical heterogeneity of weldment should be taken into account in designing the welded structure with dynamic loading.

CONCLUSION

The dynamic mechanical respondence of a pressure vessel steel and its weldment were investigated by means of Split Hopkinson Pressure Bar (SHPB) testing with different loading rates. The results show that the dynamic respondence with mechanical heterogeneity is sensitive to the loading direction, the maximum dynamic stress becomes larger with the loading rate, and the matching property of weldment at dynamic situation would be affected by the dynamic loading rate and direction.

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Table 1 The chemical composition and mechanical properties of 16MnR ateel

C	Mn	Si	S	P	σ_b(Mpa)	σ_s(Mpa)	δ(%)
0.19	1.4	0.45	0.023	0.015	540	340	21

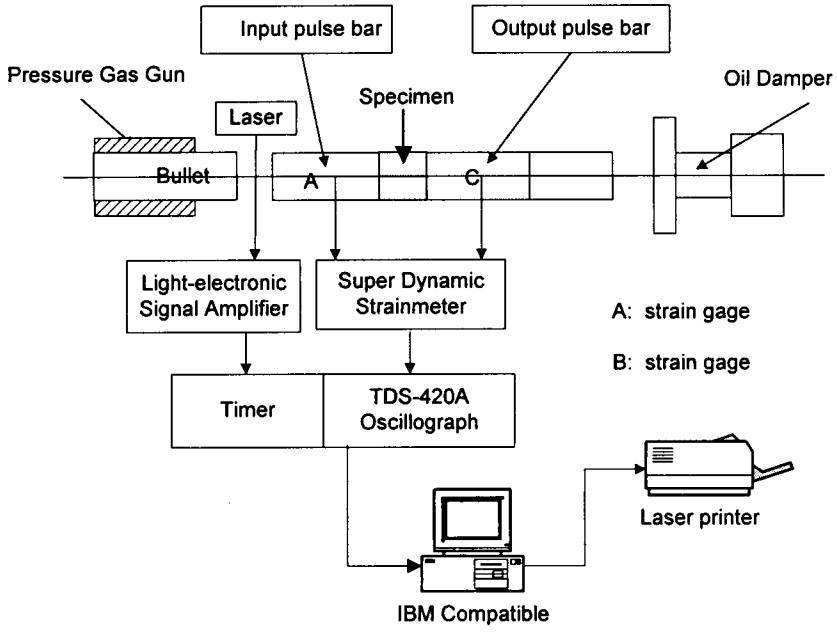

Fig.1 Illustrition of the equipments and measurement system in SHPB

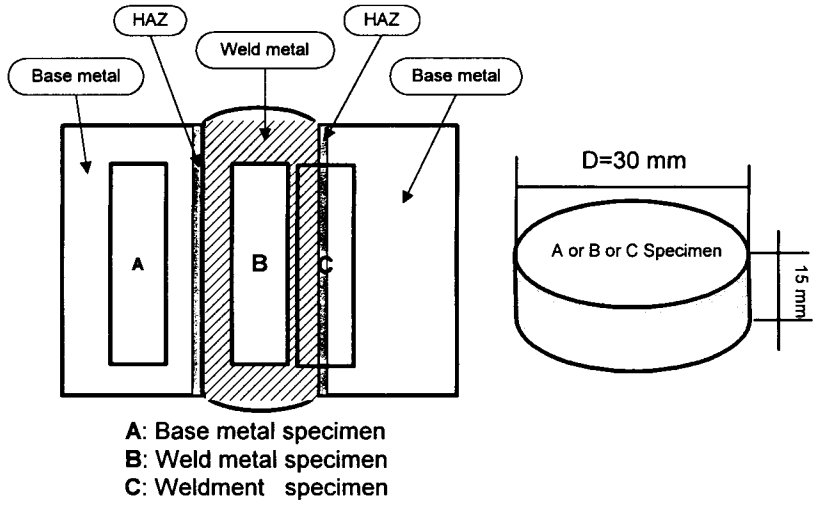

Fig.2 Illustrition of speciments used in SHPB experiments

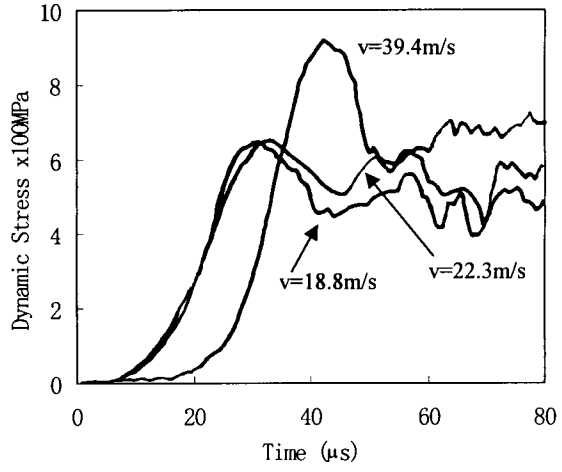

Fig.3 Dynamic stress of base metal with different loading rates

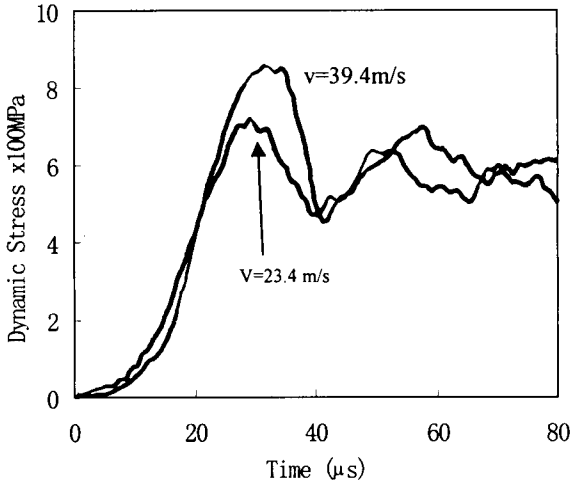

Fig.4 Dynamic stress of weld metal with different loading rates

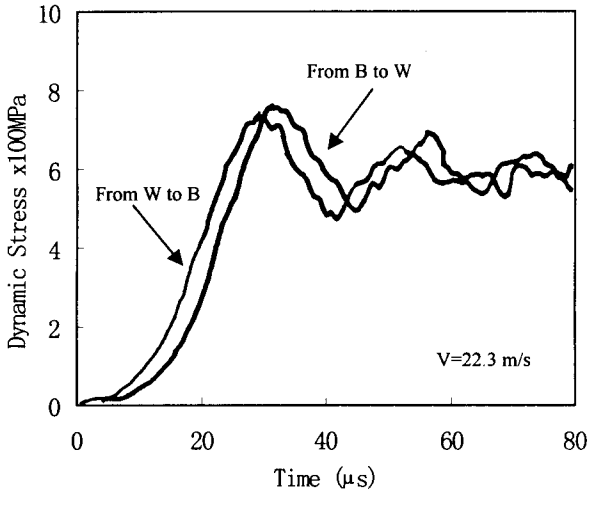

Fig.5 Dynamic stress of weldment with two loading directions