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IMPROVING FATIGUE STRENGTH OF WELDED JOINTS BY HAMMER PEENING AND TIG-DRESSING

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The effectiveness of fatigue strength improvement methods, namely TIG-dressing and hammer peening, were examined using out-of-plane gusset welded joints of high strength steel (SM570). In addition, the mechanism of each improvement method was discussed with respect to the decrease in stress concentration and residual stress at the weld toe. Finally, various methods for improving the effectiveness of these fatigue strength improvement methods are proposed.

***Key Words:** improvement of fatigue strength, TIG-dressing, hammer peening stress concentration, residual stress*

1. INTRODUCTION

Recently, fatigue damages on actual steel bridges has been often reported. The fatigue failure has a possibility to lead terrible accidents on steel bridges so that fatigue failure is one of the failure modes, which must be prevented. Most of those fatigue damages occurred at welded joints[1)2)] so that it is very important to improve fatigue strength of welded joints in order to extend the service life of the steel brides.

The applicability of high strength steel has been started to study because the application is effective in decreasing the weight and may also reduce the cost of bridge structures. However, fatigue strength of the welded joint does not depend on steel strength[3)]. In addition, it has been often reported that the fatigue strength of large-scale welded joint specimen decreases with increasing steel strength[4)]. Therefore, fatigue design of welded joints becomes even more critical when using high strength steel[5)]. Also in this point of view, the improvement of the fatigue strength of welded joints becomes important.

The fatigue performance of the welded joint is greatly affected by high stress concentration at the weld toe and high tensile welded residual stress. Decreasing stress concentration and tensile residual stresses are generally said to be efficient methods of improving the fatigue strength of the welded joint. Actually, aiming the above effects, various improvement methods have been proposed, including the welding electrode or welding condition[7)-9)] and post-welding treatments (TIG-dressing, grinding, peening, *etc.*)[10)-22)]. However, some of the above-mentioned improvement methods still have problems. For example, (1) any standard of treatment condition has not been established, (2) the effectiveness of fatigue strength improvement is scattered and depends greatly on the skill of worker and (3) the mechanism of improvement remains unclear. For these reasons, the above-mentioned improvement methods are seldom applied in actual steel bridge construction.

The International Institute of Welding IIW XIII committee conducted a research program on the following fatigue strength improvement methods: TIG-dressing, hammer peening and burr-grinding[23)]. Eight laboratories, including author's laboratory, are involved in this research program, and the results of this collaborative study have been published[24)]. However, only the transverse fillet welded T joint was examined as a specimen type in the IIW collaborative research and testing was performed only under bending. Therefore, the effectiveness of these methods in the case of axial force and on other joint types must be confirmed. The present study investigates the effectiveness of hammer peening and TIG-dressing using out-of-plane gusset welded joint specimens. In addition, the mechanism of improvement of fatigue strength, particularly the effects of stress concentration and residual stress, were examined.

Table 1 Mechanical properties and chemical compositions

	Y.P.	T.S.	El.
SM570	555 MPa	626 MPa	40%

Y.P: Yield Strength, T.S.: Tensile Strength, El.: Elongation

C	Si	Mn	P	S
0.14	0.35	1.32	0.009	0.002

[Weight%]

Table 2 Mechanical properties of weld metal and welding conditions

Electrode	Welding Conditions
Electrode : L-60G	Current : 320 A
Y.P. : 530Mpa	Voltage : 28 V
T.S. : 630MPa	Travel Speed : 24cm/min

Table 3 Specimens

Name	Treatment	Welding
As-Weld	None	Fillet
TIG-Dressing	TIG-dressing	Fillet
1-Pass H.P.	1-pass Hammer Peening	Fillet
3-Pass H.P.	3-pass Hammer Peening	Fillet

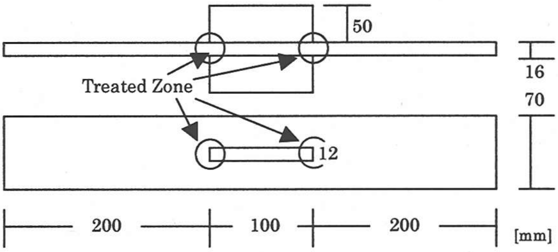
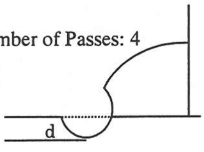


Fig.1 Out-of-plane gusset welded joint specimen

Table 4 Condition of toe treatment

<In the present study>
1) TIG-dressing
· Current: 150A · Voltage: 14V · Travel Speed: 80mm/min
2) Hammer Peening
· Type: Air-Driven · Pressure: 6kgf/cm^2 · Weight of Hammer: 1.7kg · Diameter of Tip: 12mm · Blow Speed: 43 / sec · Travel Speed: 1.2mm/sec · Number of Passes: 1 and 3
<Recommendation in IIW round robin test>
1) TIG-dressing
· Pre-heating: 50～200°C · Current: 160～250A · Voltage: 12～17V · Travel Speed: 80～160mm/min
2) Hammer Peening
· Type: Air-Driven · Pressure: 5～7bar · Diameter: 6～18mm · Blow Speed: 30～50/ sec · Travel Speed: 20mm/sec · Number of Passes: 4 · Depth of dent: d (<1.0mm) Mild Steel > 0.5 mm Medium Steel > 0.25 mm High-Strength Steel > 0.1 mm 

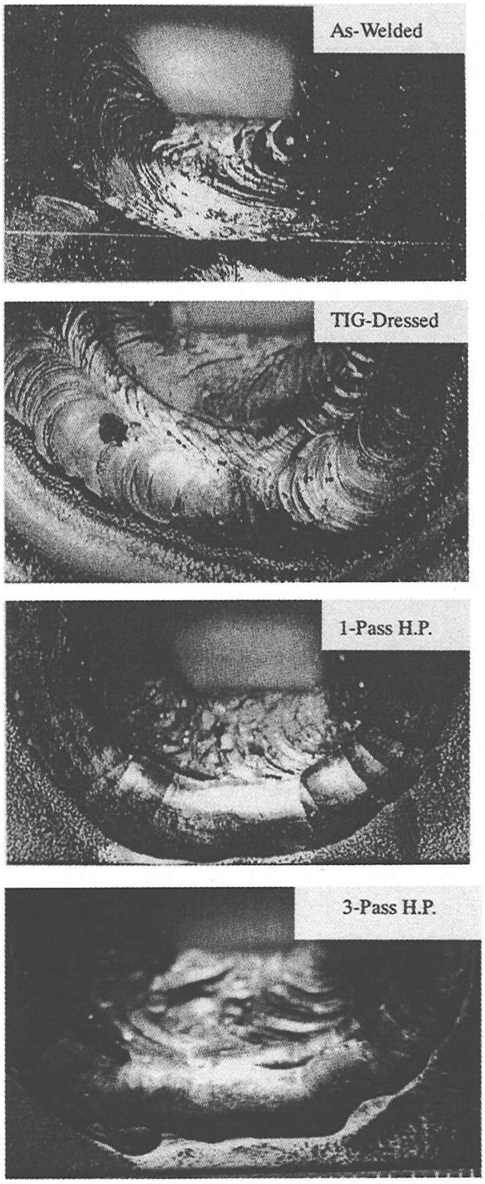


Fig.2 Observation of treated surface

2. SPECIMEN AND IMPROVEMENT METHODS

The mechanical properties and chemical composition of steel used in the present study are listed in **Table 1.** The welded joint type of the specimen is the out-of-plane gusset fillet welded joint, shown in **Fig.1. Table 2** shows the mechanical properties of the welding metal and the welding conditions.

Table 3 lists the types of specimens prepared for this study. The improvement methods examined in this study are TIG-dressing and hammer peening. The treating conditions are listed in **Table 4** and are almost identical to those used in the IIW collaborative research listed in **Table 4**. However, the travel speed of hammer tip was selected to be 1.2mm/sec, because it was determined in a preliminary study before fabrication of specimen that the recommended travel speed was too fast to obtain good quality of hammer peening. The numbers of hammer peening passes applied in the present study were 1 and 3.

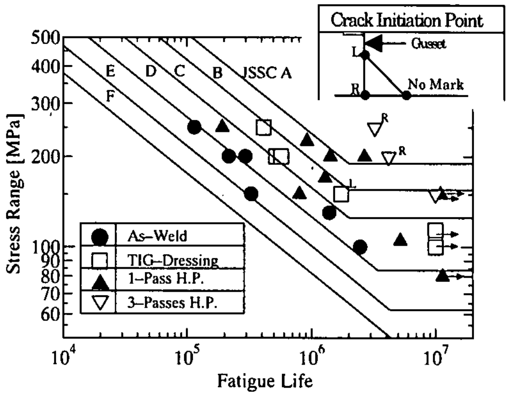
Fig.2 shows the weld toe and the treated surface of the specimens. Using these specimens, fatigue tests (minimum load = 1tonf) were carried out using testing machine having a dynamical loading capacity of ±30tonf.

3. FATIGUE TEST RESULTS

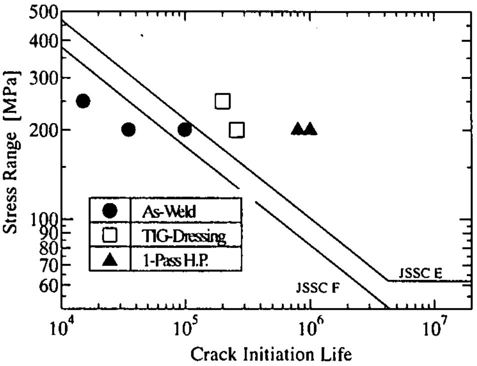
Fig.3 shows the results of the fatigue test. **Fig.3(a)** shows the relationship between the nominal stress range $\Delta\sigma_n$ and the fatigue life N_f of all specimens. Some specimens were tested under two-step loads in order to obtain beach marks on the failure surfaces. From the observation of the beach marks the initiation and propagation behavior of the fatigue cracks can be clarified. In the present study, crack initiation life was defined as the cycle when the fatigue crack depth reached 1 mm, as determined from the observation of beach marks on the failure surface. Using the data of the specimen whose crack initiation life N_c and crack propagation life N_p could be distinguished from the observation of beach mark, the relationships between nominal stress range $\Delta\sigma_n$ and N_c ,and between $\Delta\sigma_n$ and N_p are shown in **Fig.3(b)** and **Fig.3(c)**, respectively.

Fatigue strengths of all treated specimens are much higher than as-welded specimens. Among treatment methods, 3-pass hammer peening was the most effective. In all 3-pass hammer peened specimens fatigue cracks initiated from the weld root instead of the weld toe, and the fatigue test results are plotted over a JSSC A class curve. The fatigue strengths of TIG-dressed specimens are one or two JSSC criteria classes higher than those of the as-welded specimens. In addition, the improvement of fatigue strength by TIG-dressing and 3-pass hammer peening was not found to be dependent on the stress range, as indicated in **Fig.3(a)**.

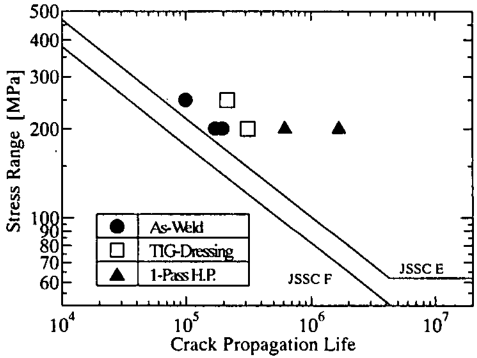
In the case of 1-pass hammer peened specimens, fatigue cracks were initiated at the hammer peened surface in the vicinity of the weld toe. Thus, the fatigue strength seems to depend on stress range. Although, great improvement could be achieved over the low-stress range, the improvement over the high stress range was found to be slight.



(a)Nominal Stress Range $\Delta\sigma_n$ —Fatigue Life N_f



(b)Nominal Stress Range $\Delta\sigma_n$—Crack Initiation Life N_c



(c) Nominal Stress Range $\Delta\sigma_n$ — Crack Propagation Life N_p

Fig.3 Fatigue test results

The effectiveness of the improvement methods are examined using relationships $\Delta\sigma_n$-N_c and $\Delta\sigma_n$-N_p. In the crack initiation life N_c, fatigue strength was improved by all methods. In addition, crack propagation life N_p was also improved by hammer peening. However, the improvement of N_p by TIG dressing is very small.

Fig.4 shows the failure surfaces. By observing the beach marks, the changes in crack shape with respect to the propagation can be observed. The crack aspect ratios (depth/surface length) during

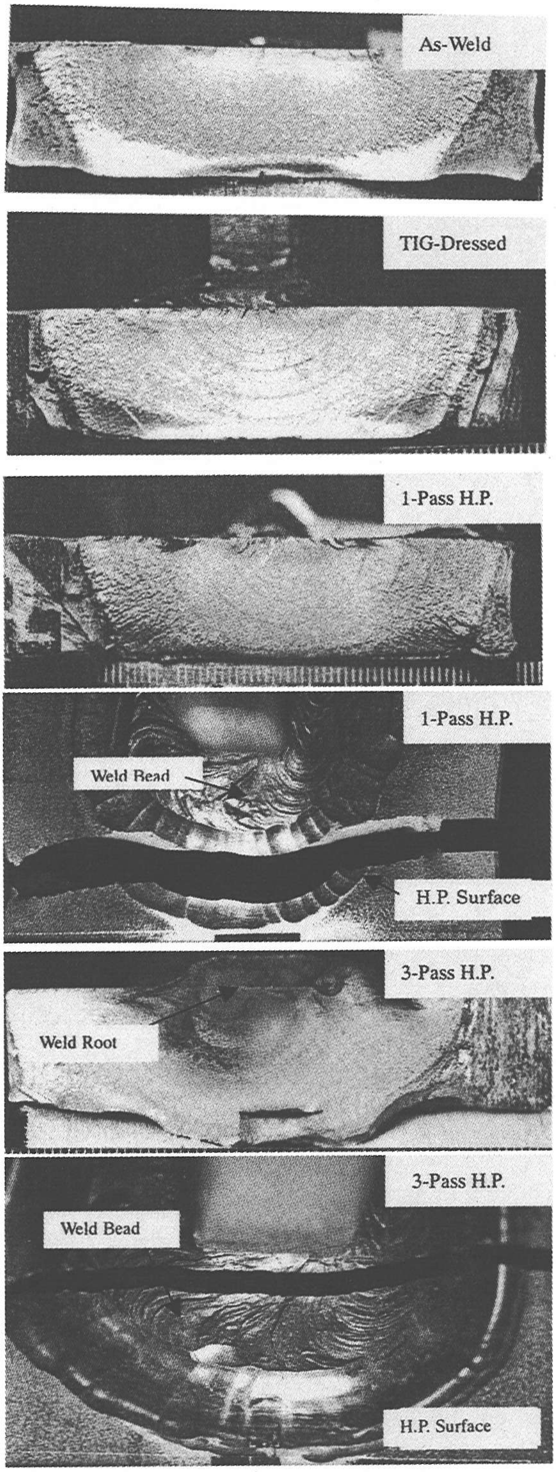


Fig.4 Fracture surface

crack propagation are shown in **Fig.5**. The aspect ratio of the 1-pass hammer peened specimen is larger than that of the as-welded specimen. This

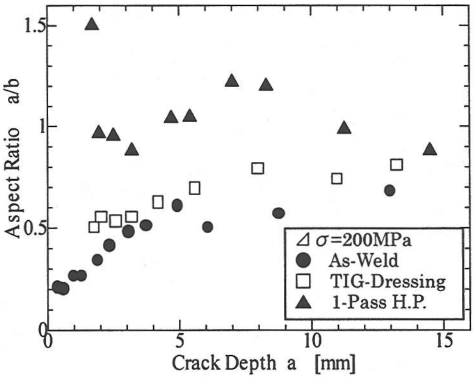


Fig.5 Relationship between aspect ratio and crack depth (Observation of beach-mark)

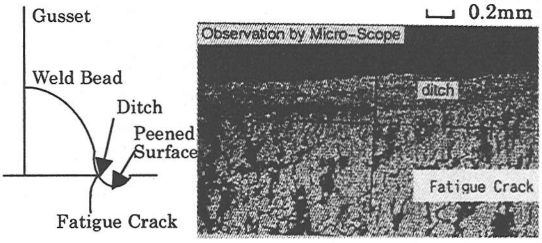


Fig.6 Fracture surface of 1-pass hammer peened surface near specimen surface by microscope

appears to be due to the introduction of high compressive residual stress and the decrease in stress concentration at the peened surface.

Fig.6 shows a micrograph of the failure surface of the 1-pass hammer peened specimen taken near the surface. A long and narrow ditch zone that was induced by hammer peening was observed. The ditches were visible to the unassisted eyes on peened surface[24)], and were found on all hammer peened specimens over the entire region where hammer peening was applied. Fatigue cracks initiated from these ditches in all of the 1-pass hammer peened specimens. These steep ditches may cause high stress concentrations which overcome the compressive residual stresses that are induced by hammer peening under the high stress range fatigue test condition. These ditches are also responsible for the insufficient improvement of fatigue strength by 1-pass hammer peening under such condition.

Fig.7 shows the relationship between crack depth and loading cycle, and that between crack propagation rate and crack depth from the observation of beach mark. Crack initiation of TIG-dressed and 1-pass hammer peened specimens were later compared to the as-welded specimen. However, compared to the as-welded specimen, the crack propagation of the TIG-dressed specimen was

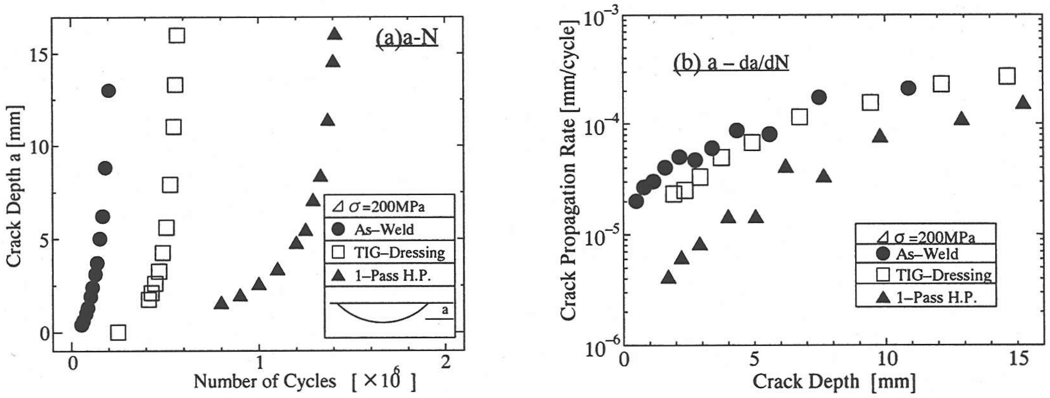


Fig.7 Crack propagation

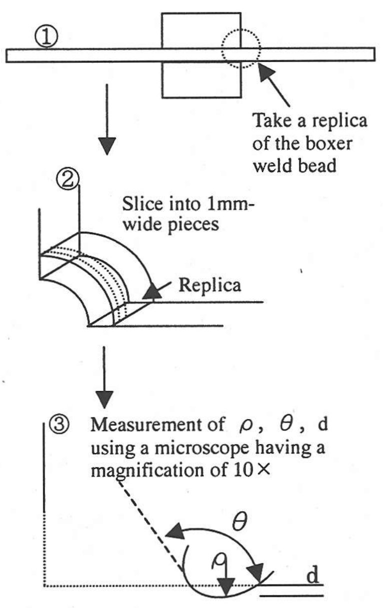
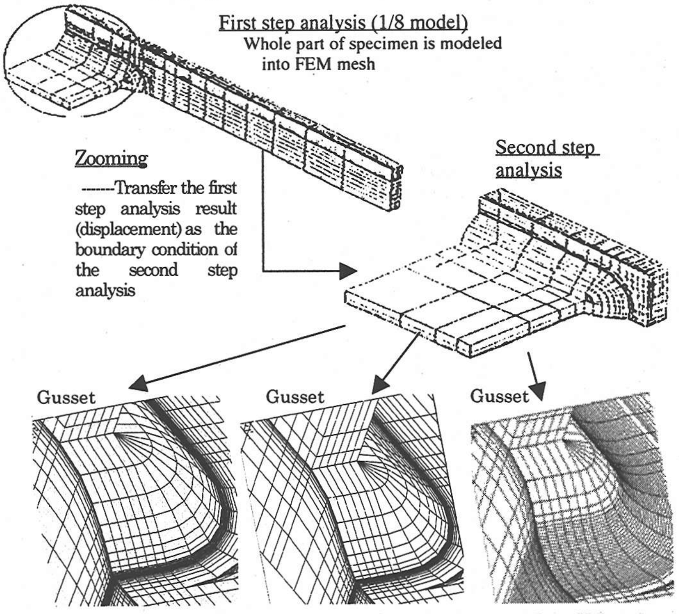


Fig.8 Procedure to measure the configuration of the toe



As-Weld TIG-Dressing 1-Pass H.P.

Fig.9 FEM model and analysis procedure

almost identical when the fatigue crack depth from the surface was more than 1mm. On the other hand, the crack propagation rate of the 1-pass hammer peened specimen was much lower than that of the as-welded specimen even when the crack depth was larger than 1 mm.

Table 5 Measurement results used for FEM model

	ρ	θ	d
As-Weld	0.8	138	–
TIG-Dressing	3.1	155	–
1-Pass H.P.	6.6	137	0.2mm
3-Passes H.P.	d=0.25～0.3mm		

4. MECHANISM OF FATIGUE STRENGTH IMPROVEMENT

(1) Stress Concentration

In order to evaluate the effect of stress concentration by toe treatment, stress analysis was performed using the COSMOS/M FEM code.

In order to properly model the toe configuration into FEM model, local radius ρ, angle θ and depth d of the dent of the weld toe or treated surface were measured using a replica, as shown in **Fig.8**. The number of samples of each type of specimen was 70～100. Samples were taken from part of the boxer welded bead. The parameters ρ, θ and d were measured using a microscope at 10 magnification, and the average values of the measurement results are shown in **Table 5**.

FEM models and the analysis procedure are shown in **Fig.9**. The analysis consisted of two steps. In the first step analysis, the entire region of the

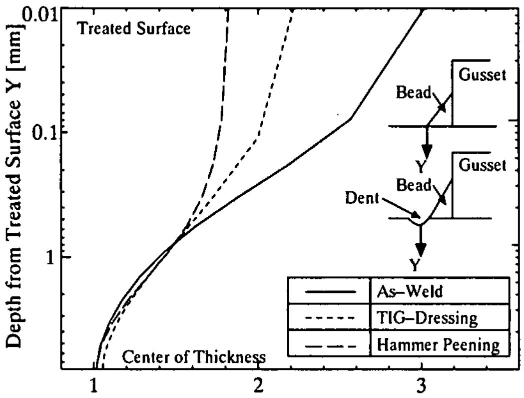


Fig.10 Analysis Results

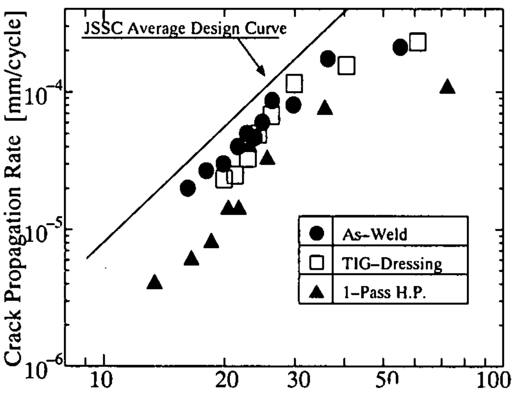
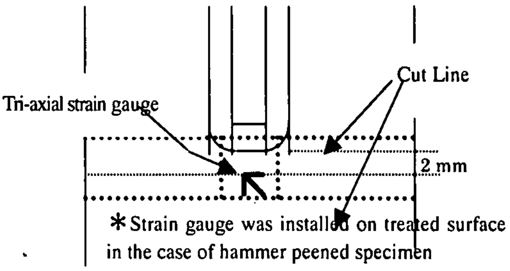


Fig.11 Crack Propagation Rate and Stress Intensity Factor



＊Strain gauge was installed on treated surface in the case of hammer peened specimen

Fig.12 Installation of strain gauge and cut-line

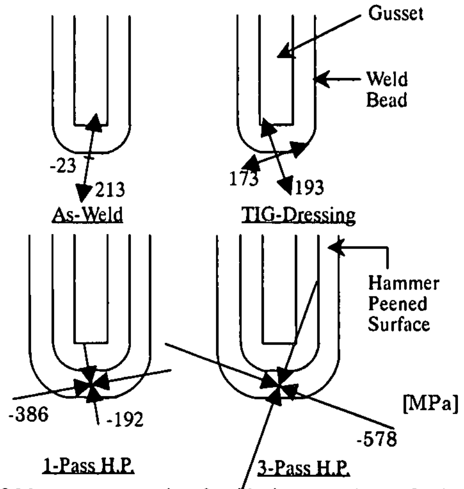


Fig.13 Measurement results of residual stresses (on surface)

specimen was modeled. In the second step, detail analyses of the weld toe and treated surface regions were performed. In this step, local configurations, ρ, θ and d were also examined and the displacement at boundary calculated in the first step analysis were used as boundary conditions.

Fig.10 shows the results of analysis, that is, the distribution of stress concentration in the thickness direction. In order to emphasize the stress decrease near weld toe, the log-scale on this figure is chosen for Y axis. In present study, stress concentration was defined as ((longitudinal stress of analysis result) / (nominal stress)). Stress concentration factor at the weld toe is decreased both by TIG-dressing and hammer peening. Especially, by hammer peening, the stress concentration can be greatly decreased. However, the decrease in stress concentration is found only from the treated surface to a depth of 1 mm. Agreement between this result and the effect of the TIG-dressing, which decreases the stress concentration at the weld toe, could be obtained only in the N_c region.

Fig.11 shows the rearrangement of **Fig.7** as the relationship between stress intensity factor range and crack propagation rate. Crack propagation rates in the TIG-dressed specimens are almost equal to those in the as-welded specimens. However, the crack propagation rate of the hammer peened specimen is still much lower, even after using the stress intensity factor, which can evaluate the differences in stress concentration and crack aspect ratio.

(2)Residual Stress

In order to examine the effect of residual stress due to toe treatments, residual stresses near the weld toe or on the treated surface are measured by saw-cutting methods. **Fig.12** shows the placements of the strain gauge and the saw-cut lines. For the as-welded specimens and TIG-dressed specimens, strain gauges were installed 2 mm away from weld toe. For the hammer peened specimen, strain gauges were installed on the peened surface.

Fig.13 shows the results of measurements. High tensile residual stress was measured on the TIG-dressed specimen and was found to be almost equal to that of the as-welded specimen. However, high compressive residual stress can be introduced on the surface of both 1-pass and 3-pass hammer peened

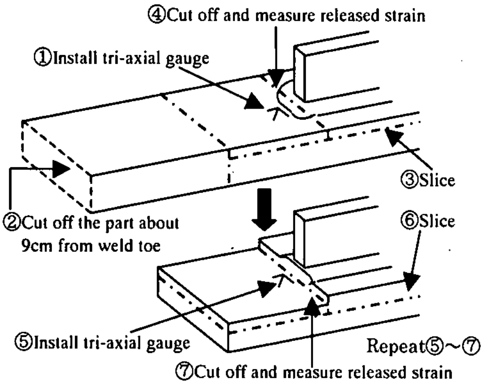


Fig.14 Procedure used to measure the residual stress distribution in the thickness direction

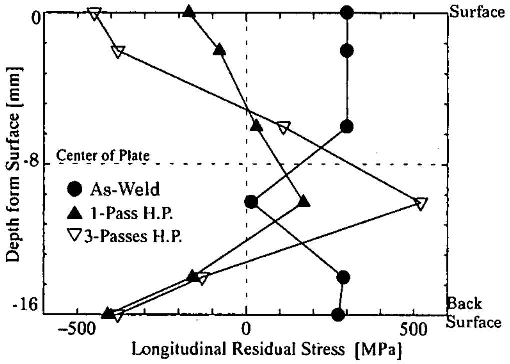
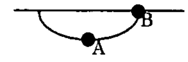


Fig.15 Residual stress distribution in the thickness direction

Table 6 Analysis parameters (modified Paris' law)

$da/dN = C(\Delta K^m - \Delta K_{th}^m)$ (modified Paris' law)
C: 1.5×10^{-11} m: 2.75 ΔK_{th}: 2.0 MPa$\sqrt{}$m
<Calculation of K value>
Based on JSSC fatigue design recommendation
$K = \sigma\sqrt{\pi a} \cdot F$
$F_A = Ft_A\, Fg_A\, Fe_A\, Fs_A$
$F_B = Fw_B\, Fg_B\, Fe_B$



Ft,Fw: Finite thickness or width
Fe : Crack shape
Fg : Stress gradient
Fs : Surface crack
<Initial Crack>
- Semi-circular surface crack: radius 0.05 mm
  ---- For all specimens
- Only hammer peened specimen
  Semi-elliptical surface crack
  : depth 0.3 mm (correspond to depth of ditch)
  surface length 2b=12 mm
  (correspond to thickness of gusset)

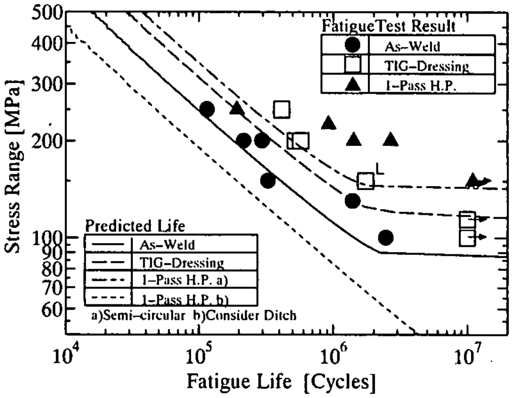


Fig.16 Analysis result (effect of residual stress is not considered)

specimens.

The distributions of residual stresses in the thickness direction were measured in hammer-peened specimens and in the as-welded specimen by the saw-cutting method, as shown in **Fig.14**[26]. The locations of installed strain gauges are also shown in **Fig.14**. The base plate was divided into five layers.

Fig.15 shows the results of measurements. Compressive residual stresses are measured from the peened surface to a depth of 3~5 mm on 1-pass and 3-pass hammer peened specimens. This result not only indicate the effect of hammer peening, but also including the welding residual stress existed before applying hammer peening. However, it can be said the compressive residual stress makes the fatigue crack propagate rate of hammer peened specimen lower than other specimen even when the fatigue crack length becomes longer than 1mm.

On the peened surface, compressive residual stress of the 3-pass hammer peened specimen is higher than that of the 1-pass hammer peened specimen because the increase in the number of passes of hammer peening can induce a larger plastic deformation at the peened surface. However, the difference in the distribution in the thickness direction between the hammer peened specimens is not clear from the measurements performed in the present study.

(3) Analysis of Fatigue Crack Propagation

Fracture mechanics analysis[6] of fatigue crack propagation was performed in order to evaluate the possibility of explaining the improvement of fatigue strength as shown in **Fig.3** by considering the decrease in stress concentration and the change in residual stress. **Table 6** shows the conditions of the analysis. By using the least squares method, these conditions were determined considering that the analysis results (N_c, N_p, N_f) of as-welded specimen coincided with the fatigue test results of as-welded specimen. Same conditions were applied also to all types of specimens. By applying these conditions to other type specimens, with which analysis results and fatigue test results have a good agreement each other in the case of as-welded specimen, it can be

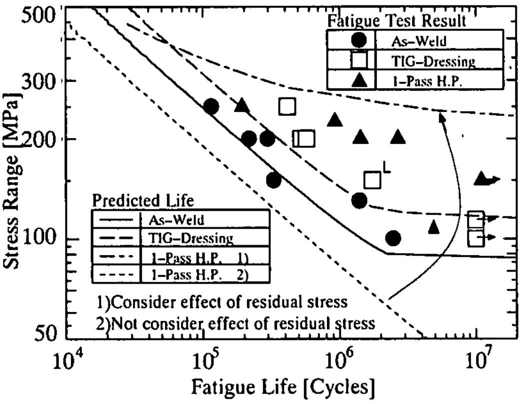


Fig.17 Analysis result (with the consideration of residual stress)

said the difference of fatigue strength between as-welded specimen and other type specimens can be evaluated. In order to simplify the analysis, only single initial fatigue crack was considered. However, in the analysis of the hammer peened specimen, two initial conditions about initial crack shape were used: a) conditions used for the as-welded specimen and b) a semi-elliptical (surface length 2b=12 mm and depth a=0.3 mm) crack which was assumed to correspond to the ditch induced by hammer peening.

Fig.16 shows the predicted S-N curves and fatigue test results, N_f. The estimated fatigue lives of as-welded and TIG-dressed specimens agree with the fatigue test results. Therefore, the fatigue strength improvement by TIG-dressing can be explained satisfactory by considering the decrease in stress concentration at the weld toe. However, when the ditch induced by hammer peening is not taken into account, the predicted fatigue life of the 1-pass hammer peened specimen is much higher than that of the as-welded specimen. Thus, a large improvement can be obtained even when only a decrease in stress concentration, as a result of the dent induced by the impact of the hammer, is expected. However, in actual 1-pass hammer peened specimens, fatigue cracks initiated from the ditches. When the ditch is considered in the analysis, the calculated fatigue life of the 1-pass hammer peened specimen is lower than that of the as-welded specimen. Actually, in the JSSC fatigue design recommendation, the allowable under-cut depth is specified as 0.5mm, so that it can be said the depth of the ditch, 0.3mm, satisfies that recommendation. However, the ditch is sometimes very steep and exists at whole part where hammer peening is applied, so that the influence of the ditch must be considered. Contrary said, the one of the possible ways to improve the efficiency of the hammer peening is to prevent the occurrence of the ditch.

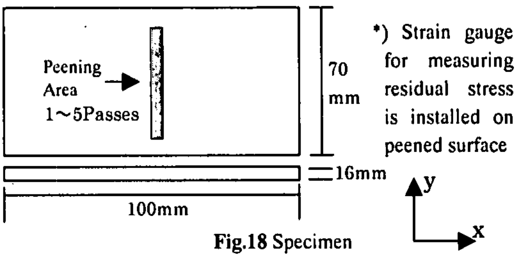


Fig.18 Specimen

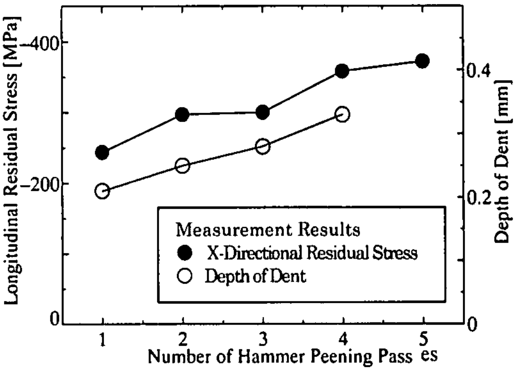


Fig.19 Measurement result (residual stress and depth of dent)

The predicted fatigue strength of the 1-pass hammer peened specimen is much lower than as-welded specimen because the compressive residual stress introduced by hammer peening is not taken into account. However, a procedure for evaluating the effect of residual stresses on three-dimensional fatigue crack initiation and propagation has not yet been established. Hence, according to Mukai[27)], it is assumed that only the tensile stress of the sum of the applied stress and the residual stress contribute to fatigue crack propagation. Measurement results of the 3-dimensional residual stress distribution and FEM analysis results were used in the present analysis. **Fig.17** shows the results of fracture mechanics analysis with taking into account the compressive residual stress distribution. By taking into account the residual stress, the predicted fatigue strength of the 1-pass hammer peened specimen becomes high. In addition, the dependence of the improvement of fatigue strength on the applied stress range can be approximated well by considering the compressive residual stress. However, even after taking the residual stress distribution into account, it can not be said that the predicted fatigue strength of the 1-pass hammer peened specimen agrees well with the fatigue test results. It is because of the procedure to take the residual stress into account and the modeling of the ditch into initial crack of the fracture mechanics analysis.

5. IDEAS FOR FURTHER IMPROVEMENT OF FATIGUE PERFORMANCE

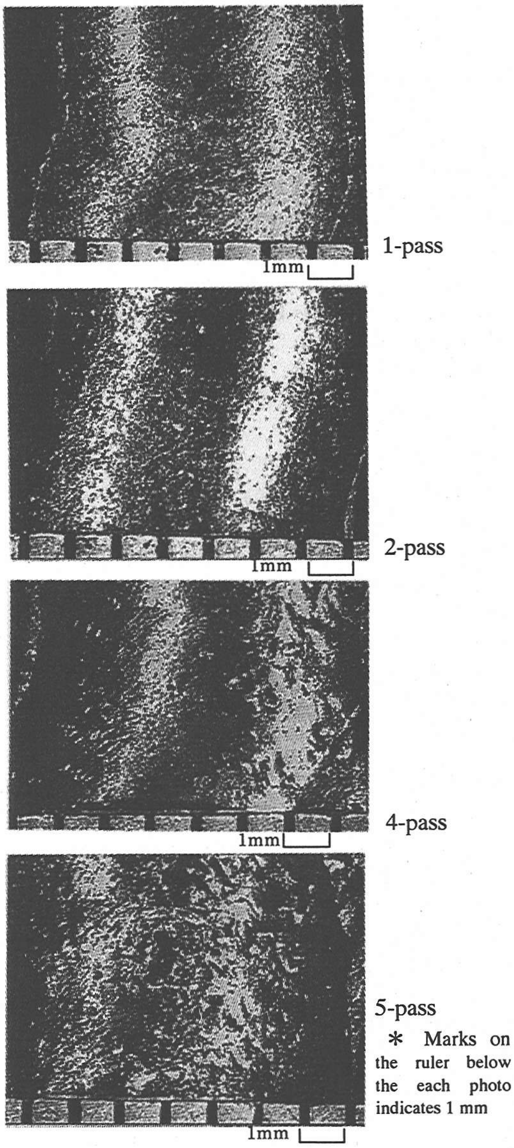
(1) Hammer Peening Pass

In order to determine the most effective number of passes of hammer peening, hammer peening treatments of 1 to 5 passes were carried out on the surface of the specimen, as shown in **Fig.18** under the conditions listed in **Table 4**. The changes in the depth of the dent induced by hammer peening, the roughness of the hammer peened surface and the compressive residual stress on the surface are examined with respect to the number of passes.

The depths of the dents were measured using a replica, and the residual stress was measured on the peened surface by the saw-cutting method. The results of measurements are shown in **Fig.19**. Both the depth of dent and compressive residual stress increase with increasing number of hammer peening passes, but the rate of increase tends to decrease as the number of passes increases.

The surface is hollowed deeply and large plastic deformation is introduced by the first pass. The large plastic deformation hardens the peened surface. Therefore, the deformation induced by later passes is small compared to that of the first pass. This result agrees with those presented in a study by Maddox[28] on the relationship between the number of hammer peening passes and the fatigue strength of the cruciform welded joint specimen. Maddox reported that the depth of dent and fatigue strength increase with the increase in the number of hammer peening passes but both tend to saturate.

Fig.20 shows the peened surfaces as observed using a microscope. The surface on which 4 or 5 passes of hammer peening are applied is much rougher compared to that on which 1 or 3 passes of hammer peening are applied. In the present study, fatigue cracks of the hammer peened specimen initiated from the source of higher stress concentration, such as the ditch or the weld root, so that the change in roughness of the peened surface does not appear to be a factor in fatigue crack initiation. However, the increase in roughness is one of a drawback associated with the increase in the number of hammer peening passes.



＊ Marks on the ruler below the each photo indicates 1 mm

Fig.20 Peened surface (observation with microscope)

(2) Prevention of Ditch

A steep ditch is always introduced by blows of a hammer at the location of the weld toe. All fatigue cracks of 1-pass hammer peened specimens were initiated from these ditches. Therefore, in order to increase the effectiveness of hammer peening, the occurrence of the ditch must be prevented.

Kawai[29] reported that the application of grinding treatment before wire peening was an efficient method to improve fatigue strength. Therefore, in the present study, grinding treatment at the weld toe before hammer peening is attempted in order to prevent the occurrence of the ditch. Not only base metal but also weld bead must be ground, and the local radius of the ground surface must be larger than hammer tip. **Fig.21** illustrates this new hammer peening method and shows a photograph of a treated region.

(3) Prevention of Crack Initiation from the Weld Root

As shown in **Fig.4**, all fatigue cracks initiated from the weld root in the 3-pass hammer peened specimen. It indicates that the fatigue strength at the weld toe becomes higher than that at weld root by applying 3-pass hammer peening. When fatigue cracks occur from the weld root, the fatigue strength of the welded joint is dominated by that of the weld root, and further improvement by toe treatment can not be expected[30]. Hence, in order to prevent fatigue crack occurrence from the weld root, partial penetrate welding was performed. The details of the partial penetration weld are shown in **Fig.22**. Although a full penetration weld is generally recognized to be better quality weld, the workability of full penetration weld is worse than those of the fillet or partial penetration weld, so full penetration welding was not examined in the present study.

The stress concentration at the weld root by application of the partial penetration weld is calculated using the COSMOS/M FEM code taking into account the remaining root face of width S. The FEM analysis results are shown in **Fig.23**. Compared to full penetration welds, a high stress concentration is observed at the weld root, even after partial penetration welding is performed. However, the stress concentration at the weld root decreases with increasing weld penetration. Furthermore, in order to avoid any change in the stress concentration at weld toe between partial penetrate welding and fillet welding, welding is performed as the appearance of boxer weld bead was same with fillet welding.

Test specimens were fabricated with above treatment (2) and (3), and fatigue tests were performed under same condition used for the fillet welded specimen.

Fig.24 shows the fatigue test results. The fatigue strength of as-welded specimen fabricated by the partial penetrate welding is almost equal to that by the fillet welded specimen. It's because the profiles of the weld beads made by both types of welding are same.

No ditch was observed on any hammer peened surface, and no fatigue crack initiated from a hammer peened surface. Therefore, application of grinding before hammer peening appears to be very effective in preventing the occurrence of the ditch and to develop the effectiveness of hammer peening. Sufficient improvement of fatigue strength can be obtained even by 1-pass hammer peening if grinding is applied before hammer peening.

Fatigue cracks of all 1-pass and 3-pass hammer peened partial penetrate welded specimens initiated from the weld root. The fatigue strengths of the partial penetrate welded specimens, in which fatigue cracks initiated from the weld root, are equal to or higher than those of the fillet welded specimens. However, fatigue crack occurrence from the weld root can not be prevented by partial penetrate welding under the conditions examined in the present study.

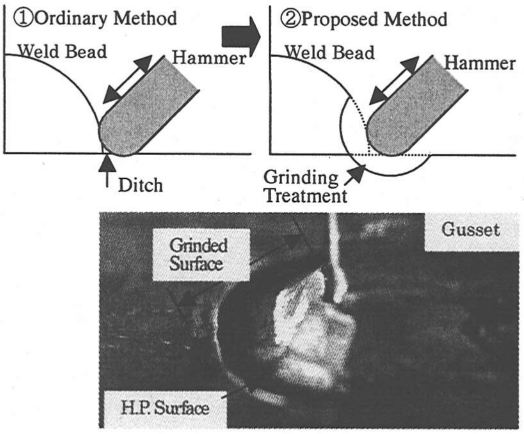
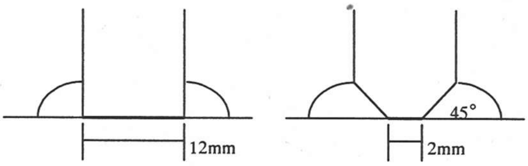


Fig.21 Hammer peening after burr grinding



1)Fillet Welding 2)Partial Penetrate Welding

Fig.22 Welding detail

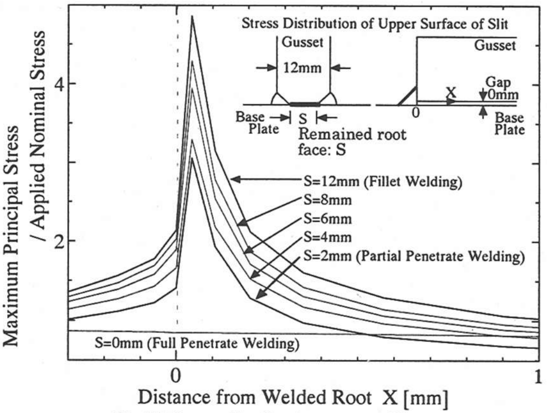


Fig.23 Stress distribution near weld root

6. CONCLUSIONS

In the present study, methods for improving fatigue strength by toe treatment were examined using the out-of-plane gusset welded joint, and the following conclusions were obtained.

1) By TIG-dressing, the fatigue strength is increased one or two classes of JSSC fatigue design curve, and no dependence of the improvement on the applied stress range was observed. The improvement resulted from the decrease in the stress concentration by the improvement of the local configuration of the weld toe. The improvement was found mainly when the fatigue crack depth is small.
2) By hammer peening, fatigue strength is greatly increased, but the dependence of the improvement on the applied stress range was found to be large. In addition, a steep ditch was always induced by blows of the hammer and fatigue cracks of 1-pass hammer peened specimens initiated from the ditch. In the present study, in order to prevent the occurrence of the ditch, the applicability of grinding before hammer peening was examined. Grinding before hammer peening resulted in a larger improvement and no ditch.
3) The primary reasons for fatigue strength improvement by hammer peening are the decreases in residual stress and stress concentration. Improvement of the fatigue strength was observed not only for N_c but also for N_p.
4) In order to prevent fatigue crack initiation from the weld root, partial penetrate welding was examined. However, fatigue cracks initiated from the weld root of partial penetrate welding.

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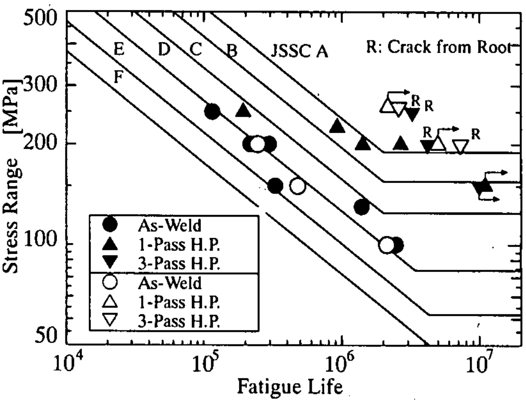

●▲▼ : Fillet Weld ○△▽ : Partial Penetrate Weld

Fig.24 Fatigue test results

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ハンマーピーニング及びTIG処理による溶接継手部の疲労強度向上法

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本研究では，高強度鋼溶接継手部の疲労強度向上を目指して，面外ガセット継手を対象に，溶接止端部処理による疲労強度向上法である，TIG処理，ハンマーピーニング処理による疲労強度向上効果を検討した．また各処理による疲労強度向上メカニズムを主に溶接止端部における応力集中，残留応力の低減効果の面から検討した．