INTISARI

Teknik pengelasan semakin banyak digunakan untuk penyambungan logam di industri yang memproduksi mesin dan struktur seperti: industri perkapalan, pesawat terbang, otomotif, perpipaan, bangunan lepas pantai, dan konstruksi teknik lainnya. Permasalahan yang sering muncul dalam sambungan las adalah timbulnya distorsi, tegangan sisa, dan mudah terjadinya retak fatik, sehingga setelah selesai pengelasan diperlukan pekerjaan tambahan yaitu *post weld heat treatment* dan perlakuan mekanik untuk meluruskan distorsi dan mengurangi tegangan sisa. Pengendalian distorsi dan tegangan sisa sangat penting, akan tetapi pengendaliannya rumit dan memakan waktu lama. Salah satu teknik pengelasan yang banyak dipakai untuk penyambungan pada konstruksi baja adalah las busur dengan kawat las yang berintikan fluks atau *flux cored arc welding* (FCAW. Penelitian ini melakukan pengembangan metode *stress relief* berbasis efek pemanasan dengan Metode *secondary heating*, kombinasi *cooling rate*, *static thermal tensioning* (STT) dan *transient thermal tensioning* (TTT) untuk memperbaiki perilaku perambatan retak fatik".

Material yang digunakan adalah baja seri ASTM A 36, dengan kekuatan luluh 248 MPa, kekuatan tarik 400 MPa dan perpanjangan 23 %. Elektoda yang digunakan jenis K-71T (AWS A5.20/ASME SFA-5:20 E71T-1C) dengan diameter 1,2 mm. Pengelasan menggunakan kecepatan gerak maju sebesar 3,846 mm/s, tegangan 40 volt, arus 210 Amper dan masukan panas 2,184 kJ/mm. Suhu maksimum diukur dengan termokopel (TC) dari pusat las diataranya TC 1, TC 2, TC 3 dan TC 4 dengan jarak masing-masing 10 mm, 35 mm , 55 mm dan 80 mm. temperatur divariasi masing-masing 100, 200 dan 300 ºC ditempatkan pada jarak 80 mm. Pengujian distorsi dilakukan dengan dial indikator dengan arah longitudinal dan transversal, pengujian kekuatan tarik menggunakan mesin Servo pulser, pengujian kekerasan menggunakan *Vickers micro hardness*, Pengujian laju rambatan fatik di uji dengan mesin Servo pulser. pengujian *residual stress* dengan *neutron defraction* dan foto SEM hasil patahan.

Hasil dari penelitian diperoleh diantaranya adalah Temperatur tertinggi pada jarak 10 mm dari pusat las diikuti jarak 35, 55 dan 80 mm. Temperatur pada jarak 10 mm juga meningkat dengan peningkatan penggunaan penambahan *secondary heating*. Perlakuan *stress relief* pada pengelasan mampu meredusi distorsi dan tegangan sisa. Perlakuan disekitar pengelasan mampu menurunkan nilai kekerasan di logam las dan daerah HAZ dan naik di logam induk. Kekuatan tarik luluh dan maksimum meningkatkan dengan penambahan perlakuan. Perlakuan *stress relief* dapat meningkatkan bentuk struktur kolumnar yang didominasi ferit acicular kemudian ferit Widmanstatten dan ferit batas butir. Perlakuan tersebut juga dapat meningkatkan kemampuan menahan laju rambatan retak fatik dan perlakuan terbaik dengan TTT 200 ºC. Hasil foto radiografi menunjukkan perlakuan *secondary heating*, STT dan TTT menunjukkan kerataan dan kualitas penyambungan lebih baik.

Kata kunci : Proses FCAW, *secondary heating*, pendinginan, STT, TTT, distorsi dan ketahanan fatik

ABSTRACT

Welding technique is one of the main fabrication techniques that joint two metal parts in industry. Some applications of this technique are shipping industry, aerospace, automotive, piping, offshore building, and other constructions. Some problems after weld metal joint are distortion, residual stress, and easy for crack fatigue. So additional work known as post weld treatment is required after the welding, post weld heat treatment and mechanical treatment to improve distortions and reduce the residual stresses. To control distortion and residual stress is very essential, but it complicated to control and takes a long time to solve. Distortion and residual stress tend to reduce the quality of the metal joints; it will be expensive to repair every construction that imprecise. One of the welding techniques that is widely used for steel joining in construction is an arc welding that has filler containing flux or flux cored arc welding (FCAW). This experiment is to develop methods of stress relief based secondary, cooling rate, static thermal tensioning (STT) and transient thermal tensioning (TTT) that can be affecting to improve behavior of fatigue crack propagation.

The materials used in this study were marine ASTM A36 steel, with yield strength of 248 MPa, a tensile strength of 400 MPa and elongation of 23%. Electrode used was a type of K-71T (AWS A5.20/ ASME SFA-5: 20 E71T-1C) with a diameter of 1.2 mm. The welding parameters used in this experiment were speed wielding of forward movement is 3,846 mm/s, voltage is 40 volt, current is 210 ampere and heat input is 2,184 kJ/mm. The maximum temperature was measured by thermocouples (TC) installed from the center of weld were TC 1, TC 2, TC 3 and TC 4 with 10, 35, 55 and 80 mm, respectively. The varying temperatures were 100, 200 and 300 ^{o}C, respectively and placed at 80 mm from the welding center. The distortion was measuring by dial indicator with longitudinal and transverse directions and material hardness tested by Vickers's micro-hardness. The tensile strength and fatigue crack growth rate tested by Servo pulser machine. Residual strength is done by neutron diffraction and fractue surface by SEM photos.

The results show that highest temperature was obtained at 10 mm from center weld and followed by 35, 55, and 80 mm. Temperature at 10 mm is increased as secondary heating temperature increases. The welding process by stress relief can reduce distortions and residual stress. The welding treatment around welding location can reduce the hardness value in weld metal, HAZ region and increase in base metal. The tensile is increasing by the addition of treatment. The treatment by stress relief can increase columnar structure formed in the welded metal and dominated with ferrite acicular, then ferrite Widmanstatten and ferrite grain boundaries. Those treatments also can improve the ability to restrain of fatigue crack propagation rate and the best value found by TTT method at 200 ºC. The radiographic result shows that secondary heating, STT and TTT treatments have been better in the metal joint quality.

Key words: FCAW process, secondary heating, cooling rate, STT, TTT, distortion and fatigue strength