# Interaksi hidrogen dengan kelongsong bahan bakar nuklir berbasis zirkaloi-4 pada kondisi awal loca (loss of coolant accident) = Hydrogen zircaloy 4 cladding based interaction on early loca (loss of coolant accident) condition / Rohmad Sigit Eko Budi Prasetyo

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Abstrak

[ABSTRAK<br>
Degradasi sifat mekanik zirkaloi-4 sebagai kelongsong bahan bakar nuklir akibat interaksinya dengan hidrogen tidak bisa dihindari bahkan selama periode operasi normal reaktor. Penelitian ini mengidentifikasi fasa hidrida dengan mengkondisikan zirkaloi-4 berada pada lingkungan hidrogen (hidrogenasi) pada beberapa tingkatan suhu serta efeknya terhadap zirkaloi-4 berdasarkan perubahan mikrostruktur dan sifat mekanik. Potongan material kelongsong bahan bakar nuklir berbasis zirkaloi-4 pra iradiasi digunakan dalam penelitian ini. Karakterisasi sebelum proses hidrogenasi meliputi massa,komposisi,fasa, mikrostruktur dan kekerasan mikro dilakukan sebagai data awal. Potongan material zirkaloi-4 dipanaskan pada beberapa tingkatan suhu, antara lain 3500C, 5000C, 5500C dan 6000C selama 2 jam sebelum dihidrogenasi dengan tekanan mencapai 1200 mbar selama kurang lebih 2 jam. Hasil perhitungan yang diplot pada diagram Pressure-Composition-Isotherm (PCI) menunjukkan bahwa penyerapan hidrogen pada suhu 3500C sebesar 0,17 persen berat dan mencapai nilai 0,74 persen berat pada suhu 6000C. Hal ini dikonfirmasi dengan ONH Analyzer yang mengukur kandungan hidrogen dalam rentang 10 ppm pada 3500C dan 1357 ppm pada 6000C. Keberadaan hidrogen dalam zirkaloi-4 terdeteksi pada munculnya puncak lemah δ-hydride pada identifikasi material uji yang dihidrogenasi pada suhu 6000C dan perubahan mikrostruktur yang memunculkan pertumbuhan struktur yang tampak seperti jarum pada setiap kenaikan suhu hidrogenasi. Kekerasan mikro pada pemanasan tanpa hidrogenasi pada suhu 6000C bernilai 150,66 HV sedikit dibawah nilai kekerasan pada material uji tanpa perlakuan yang bernilai 155,14 HV, sedangkan nilai kekerasan pada material uji yang dihidrogenasi pada suhu 6000C mengalami kenaikan cukup signifikan yang mencapai 194,04 HV sehingga pada kondisi awal LOCA, degradasi sifat mekanik akibat pengaruh hidrogen memerlukan evaluasi menyeluruh terkait dengan keselamatan operasi reaktor nuklir.
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ABSTRACT<br>
Degradation of zircaloy-4 mechanical properties as nuclear fuel cladding due to its interaction with hydrogen during reactor normal operation is inevitable. This experiment identifies hydrides phase after gaseous hydriding at elevated temperature and its effect based on microstructure and mechanical properties evolution. Characterization before hydrogenation process include mass, composition, phase, microstructure and microhardness performed as the initial data. The unirradiated zircaloy-4 cladding materials were annealed 3500C, 5000C, 5500C and 6000C for couple hours before hydrided under hydrogen pressure until 1200 mbar for couple hours too. Calculation results are plotted on the Pressure-Composition-Isotherm (PCI) diagram that shows the hydrogen absorption only 0,17 %wt at 3500C and reach a 0.74 %wt at 6000C. This result is confirmed by the ONH Analyzer that measures the hydrogen content in the range of 10 ppm at 3500C and 1357 ppm at 6000C. Observation using X-Ray Diffractometer shows very weak of δ-

hydride peaks based on fitting with hydride database. The optical microscope and scanning electron microscope confirms the presence of hydrides by describing the growth of needle-like as the increase in temperature. Results of microhardness test on annealed zircaloy-4 at 6000C without hydrogen have value about 150,66 HV, lower than as received material (155,14 HV), but material microhardness start to increase from the hydriding at 3500C and reach a significant increase when hydriding at 6000C (194,04 HV). Based on the data that shown in this study indicate that under early LOCA condition, degradation of mechanical properties due to the influence of hydrogen requires a evaluation related to the safety of nuclear reactors operation., Degradation of zircaloy-4 mechanical properties as nuclear fuel cladding due to its interaction with hydrogen during reactor normal operation is inevitable. This experiment identifies hydrides phase after gaseous hydriding at elevated temperature and its effect based on microstructure and mechanical properties evolution. Characterization before hydrogenation process include mass, composition, phase, microstructure and microhardness performed as the initial data. The unirradiated zircaloy-4 cladding materials were annealed 3500C, 5000C, 5500C and 6000C for couple hours before hydrided under hydrogen pressure until 1200 mbar for couple hours too. Calculation results are plotted on the Pressure-Composition-Isotherm (PCI) diagram that shows the hydrogen absorption only 0,17 %wt at 3500C and reach a 0.74 %wt at 6000C. This result is confirmed by the ONH Analyzer that measures the hydrogen content in the range of 10 ppm at 3500C and 1357 ppm at 6000C. Observation using X-Ray Diffractometer shows very weak of δ-hydride peaks based on fitting with hydride database. The optical microscope and scanning electron microscope confirms the presence of hydrides by describing the growth of needle-like as the increase in temperature. Results of microhardness test on annealed zircaloy-4 at 6000C without hydrogen have value about 150,66 HV, lower than as received material (155,14 HV), but material microhardness start to increase from the hydriding at 3500C and reach a significant increase when hydriding at 6000C (194,04 HV). Based on the data that shown in this study indicate that under early LOCA condition, degradation of mechanical properties due to the influence of hydrogen requires a evaluation related to the safety of nuclear reactors operation.]