

**PENGARUH SILIKON TERHADAP KARAKTERISTIK KIMIAWI
PADUAN Fe₁₂,5Cr₄,5Al: OKSIDASI, KEMISORPSI SESIUM, DAN
KERAPUHAN HIDROGEN SERTA POTENSINYA SEBAGAI *ACCIDENT
TOLERANT FUEL***

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INTISARI

Pada penelitian ini, dilakukan kajian pengaruh penambahan silikon (Si) terhadap karakteristik oksidasi, kemisorpsi sesium (Cs), dan kerapuhan hidrogen pada paduan Fe₁₂,5Cr₄,5Al dengan variasi kadar Si 0–8 wt.% sebagai kandidat material kelongsong *accident tolerant fuel* (ATF). Tujuan penelitian ini adalah mengevaluasi pengaruh Si terhadap ketiga karakteristik tersebut serta menentukan kadar Si optimal yang menghasilkan kombinasi sifat terbaik.

Paduan disintesis menggunakan kombinasi metode *powder metallurgy* dan *arc melting*. Uji oksidasi dilakukan pada 950 °C selama 144 jam dilanjutkan 1100 °C selama 24 jam, uji kemisorpsi Cs dilakukan dengan mencelupkan sampel yang teroksidasi ke dalam larutan CsOH pada 950 °C selama 12 jam, dan uji kerapuhan hidrogen menggunakan alat hidriding pada 600 °C dengan tekanan H₂ 300 mbar selama 48 jam. Karakterisasi meliputi mikroskop optik, SEM/EDS, XRD, STA, *neutron diffraction*, dan uji kekerasan Vickers.

Berdasarkan hasil penelitian, penambahan Si meningkatkan ketahanan oksidasi dengan membentuk lapisan permukaan oksida α – Al₂O₃ dan SiO₂ yang protektif. Penambahan Si pada kadar rendah hingga menengah meningkatkan ketahanan material terhadap kemisorpsi sesium melalui lapisan oksida yang menunjukkan penghambatan interaksi dengan CsOH, sedangkan pada kadar Si tinggi kecenderungan tersebut tidak lagi teramati, ditandai dengan munculnya fase sesium seperti Cs₂CrO₄, CsFeO₂, CsFeSiO₄, Cs₂FeO₄, dan CsAlSiO₄. Penambahan Si meningkatkan kekuatan material, ditandai dengan kekerasan yang meningkat seiring penambahan Si baik pada kondisi pra maupun pascahidriding, disertai penurunan porositas (*void*), meskipun pada setiap kadar Si kekerasan pascahidriding tetap lebih rendah dibandingkan prahidriding sebagai indikasi kerapuhan akibat hidrogen. Kombinasi pengaruh silikon terhadap ketahanan oksidasi, retensi sesium, dan kerapuhan hidrogen konsisten teramati pada semua variasi penambahan Si.

Kata kunci: *accident tolerant fuel*, FeCrAlSi, kemisorpsi sesium, kerapuhan hidrogen, oksidasi

***THE INFLUENCE OF SILICON ON THE CHEMICAL
CHARACTERISTICS OF FE12.5CR4.5AL ALLOY: OXIDATION,
CESIUM CHEMISORPTION, AND HYDROGEN EMBRITTLEMENT
AS POTENTIAL ACCIDENT TOLERANT FUEL***

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ABSTRACT

This study investigates the effects of silicon (Si) addition on the oxidation resistance, cesium (Cs) chemisorption, and hydrogen embrittlement characteristics of the Fe12.5Cr4.5Al alloy, with Si content varying from 0 to 8 wt.%, as a candidate cladding material for accident tolerant fuel (ATF). The objective of this research is to evaluate the effect of Si on these three characteristics and to determine the optimal Si content that yields the best combination of properties.

The alloys were synthesized using a combination of powder metallurgy and arc melting methods. Oxidation testing was conducted at 950 °C for 144 hours, followed by testing at 1100 °C for 24 hours. Cs chemisorption testing was performed by immersing the oxidized samples in CsOH solution at 950 °C for 12 hours, and hydrogen embrittlement testing was carried out using a hydriding apparatus at 600 °C under 300 mbar H₂ pressure for 48 hours. Characterization included optical microscopy, SEM/EDS, XRD, STA, neutron diffraction, and Vickers hardness testing.

The results show that Si addition increases oxidation resistance by forming a protective α – Al₂O₃ and SiO₂ surface oxide layers. At low to medium Si content, Si addition improves the material's resistance to cesium chemisorption, as evidenced by an oxide layer that inhibits interaction with CsOH; however, this trend is no longer observed at high Si content, where cesium phases such as Cs₂CrO₄, CsFeO₂, CsFeSiO₄, Cs₂FeO₄, and CsAlSiO₄ are found to form. Si addition increases the material's strength, indicated by hardness that increases with increasing Si content in both pre- and post-hydriding conditions, accompanied by a decrease in porosity (void), although at every Si content the post-hydriding hardness remains lower than the pre-hydriding hardness, indicating embrittlement caused by hydrogen. The combined effect of silicon on oxidation resistance, cesium retention, and hydrogen embrittlement was consistently observed across all Si additions.

Keywords: accident tolerant fuel, cesium chemisorption, FeCrAlSi, hydrogen embrittlement, oxidation