TUGAS AKHIR

ANALISIS PENGARUH VARIASI TEKANAN *LANCING* TERHADAP RESPONS MEKANIK DAN KERUSAKAN *WEAR PLATE SINTERED SILICON CARBIDE* PADA *ELECTRIC ARC FURNACE* MENGGUNAKAN SIMULASI NUMERIK

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ABSTRACT

The wear plate in the tapping hole area of PT Vale Indonesia's electric arc furnace functions to protect the cover block and copper cooler from high-temperature exposure, nickel matte flow, and impact loading caused by the oxygen lancing process. Under actual operating conditions, this component works in an extreme environment because the nickel matte temperature can reach approximately 1,300-1,600 °C. The currently used wear plate material, ASTM B152 copper, has limitations because the operating temperature exceeds the melting point of copper. This condition causes the material to experience thermal degradation, local melting, wear, and premature failure, increasing the frequency of component replacement and potentially affecting maintenance costs and furnace operational reliability. Sintered Silicon Carbide (SSiC) is considered an alternative material because it has good high-temperature resistance, hardness, and wear resistance. However, the brittle nature of SSiC under impact loading requires further analysis before it can be applied under actual operating conditions. This study aims to determine the effect of lancing pressure variations on the mechanical response and damage of Sintered Silicon Carbide wear plates in an electric arc furnace. This study also evaluates the potential of SSiC as an alternative wear plate material through computational analysis, particularly by observing the material's ability to maintain its macroscopic structure and the potential for microscopic damage caused by impact loading. The methodology used in this study is a numerical simulation based on the Finite Element Method using Abaqus/CAE software. The SSiC wear plate model was analyzed using the Dynamic, Temperature-Displacement, Explicit scheme so that the effects of impact loading and high temperature could be modeled simultaneously. The parameter variations were arranged using the Taguchi L9 Orthogonal Array method with three levels of lancing pressure, namely 150, 260, and 450 psi, and three temperature levels, namely 1,500, 1,600, and 1,800 °C. The observed response parameters included maximum stress, total strain, maximum displacement, stiffness degradation, and material damage variables. This approach was selected because it can represent extreme operating conditions more safely, efficiently, and systematically than direct testing on the furnace. The simulation results show that the SSiC wear plate was able to maintain its macroscopic structure

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under all loading variations. This was indicated by the absence of total stiffness degradation in the plate and relatively low total strain values. However, the analysis also showed the potential for microscopic crack initiation due to maximum tensile stress in the area receiving impact loading. The clay refractory material used as a plug also experienced total damage and played a role in absorbing most of the impact energy, thereby reducing the direct load on the SSiC plate. Overall, Sintered Silicon Carbide has the potential to be used as an alternative wear plate material in an electric arc furnace because it can maintain its macroscopic structure under the combination of high temperature and impact loading. However, since this material still has a risk of microscopic crack initiation, lancing pressure control is an important factor in its application. Further experimental validation is required to ensure the suitability of the simulation results with actual field conditions.

Keywords: *electric arc furnace, lancing, mechanical response, Sintered Silicon Carbide, numerical simulation, wear plate.*

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ABSTRAK

Wear plate pada area *tapping hole electric arc furnace* PT Vale Indonesia berfungsi melindungi *cover block* dan *copper cooler* dari paparan temperatur tinggi, aliran *nickel matte*, serta beban kejut akibat proses *oxygen lancing*. Pada kondisi operasi aktual, komponen ini bekerja pada lingkungan ekstrem karena temperatur *nickel matte* dapat mencapai sekitar 1.300-1.600 °C. Material *wear plate* yang digunakan saat ini, yaitu tembaga ASTM B152, memiliki keterbatasan karena temperatur operasi tersebut melebihi titik leleh tembaga. Kondisi ini menyebabkan material mudah mengalami degradasi termal, pelelehan lokal, keausan, dan kegagalan dini, sehingga frekuensi penggantian komponen meningkat dan dapat berdampak pada biaya perawatan serta keandalan operasi *furnace*. *Sintered Silicon Carbide* (SSiC) dipertimbangkan sebagai material alternatif karena memiliki ketahanan temperatur tinggi, kekerasan, serta ketahanan aus yang baik. Namun, sifat getas SSiC terhadap beban kejut perlu dianalisis lebih lanjut sebelum diterapkan pada kondisi operasi aktual. Tujuan penelitian ini adalah untuk mengetahui pengaruh variasi tekanan *lancing* terhadap respons mekanik dan kerusakan *wear plate* berbahan *Sintered Silicon Carbide* pada *electric arc furnace*. Penelitian ini juga bertujuan mengevaluasi potensi SSiC sebagai material alternatif *wear plate* melalui analisis komputasional, khususnya dalam meninjau kemampuan material mempertahankan struktur makroskopis serta potensi terjadinya kerusakan mikroskopis akibat pembebanan *impact*. Metodologi yang digunakan dalam penelitian ini adalah simulasi numerik berbasis *Finite Element Method* dengan bantuan perangkat lunak Abaqus/CAE 2022. Model *wear plate* SSiC dianalisis menggunakan skema (*Dynamic, Temperature-Displacement, Explicit*) agar pengaruh beban impact dan temperatur tinggi dapat dimodelkan secara bersamaan. Variasi parameter disusun menggunakan metode Taguchi Orthogonal Array L9 dengan tiga level tekanan lancing, yaitu 150, 260, dan 450 psi, serta tiga level temperatur, yaitu 1.500, 1.600, dan 1.800 °C. Parameter respons yang diamati meliputi tegangan maksimum, regangan total, perpindahan maksimum, *stiffness degradation*, dan variabel kerusakan material. Pendekatan ini dipilih karena mampu merepresentasikan kondisi operasi ekstrem secara lebih aman, efisien, dan sistematis dibandingkan pengujian langsung pada furnace. Hasil simulasi menunjukkan bahwa *wear plate* berbahan SSiC mampu mempertahankan struktur makroskopisnya pada seluruh variasi pembebanan. Hal ini ditunjukkan oleh tidak terjadinya degradasi kekakuan total pada pelat serta nilai regangan total yang relatif kecil. Meskipun demikian, hasil analisis menunjukkan adanya potensi inisiasi retak mikroskopis akibat tegangan tarik maksimum pada area yang menerima beban *impact*. Material *clay refractory* sebagai sumbatan juga mengalami kerusakan total dan berperan menyerap sebagian besar energi *impact*, sehingga beban langsung terhadap pelat SSiC dapat berkurang. Secara keseluruhan, *Sintered Silicon Carbide* berpotensi digunakan sebagai material alternatif *wear plate* pada *electric arc furnace* karena mampu mempertahankan struktur makroskopisnya terhadap kombinasi temperatur tinggi dan beban *impact*. Namun, karena material ini tetap memiliki risiko inisiasi retak mikroskopis, pengendalian tekanan lancing menjadi faktor penting dalam penerapannya. Penelitian lanjutan berupa validasi eksperimental diperlukan untuk memastikan kesesuaian hasil simulasi dengan kondisi aktual di lapangan.

Kata kunci: *electric arc furnace*, *lancing,* respons mekanik, *Sintered Silicon Carbide*, simulasi numerik, *wear plate*.

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