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# Evaluation of Ammonia-Based Direct Reduced Iron (NH3-DRI) and Its Implications for Subsequent Steel Making Process

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Ammonia (NH3) has emerged as a promising low-CO2 reductant for ironmaking, attracting growing interest in recent years. Unlike hydrogen, ammonia provides practical benefits for long-distance transport and storage, including a much lower liquefaction temperature and a higher volumetric hydrogen density that minimises losses during handling. Our previous thermodynamic evaluation demonstrated that low-temperature NH3 reduction of iron oxides (T < 850 oC) represents a highly promising pathway for decarbonising the ironmaking. A kinetics study at Swinburne further showed that using 100% NH3 leads to a faster reduction rate than the 40% NH3 –Ar gas mixture, with the strongest effect observed between 650 and 850 oC. The study showed a strong temperature dependence on the kinetics, where complete reduction can be achieved in 45 minutes at 850 oC, while reactions at 650 oC progressed more slowly. Iron and iron nitride phases were clearly present in DRIs reduced at 750 ℃ and below, with a thicker nitride layer forming in samples reduced at 650 ℃, whereas pellets reduced at 850 oC consisted only of metallic iron as the final product phase. A previous study reported that the presence of an iron nitride layer enhanced the reoxidation resistance of the pellets, offering potential benefits for passive storage, transport, and handling of DRI. However, it is well known that nitrogen can negatively influence the steel quality, therefore control of nitrogen inputs into the EAF is a critical consideration. Preliminary preheating experiments at 900 oC under an argon atmosphere confirmed that the iron nitride phase can be eliminated within 15 minutes. However, further investigation was conducted in this study to assess the NH3 preheating concept in more detail, particularly because current industrial preheating systems operate at relatively low temperatures (300 to 700 oC), where iron nitrides are likely to remain stable. This study also examined the stability of NH3-DRI under prolonged exposure to ambient conditions (25 oC of temperature and 50% of humidity) to determine its reoxidation behaviour. In addition, the mechanical strength was also determined using the laboratory scale tumble tests to evaluate its ability to withstand handling and transport. These findings will be discussed along with the implications for subsequent transport/handling of DRI and the steel-making process.

Key words: ammonia direct reduction, ammonia ironmaking, NH3-DRI, decarbonization, ironmaking

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