



An Investigation to verify Sulphur content in Nickel Sulphate Hexahydrate for the Hydrogen Reduction of Nickel Oxide

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Introduction

The report attempts to identify opportunities that may improve the efficiency of a continuous chemical process that uses equipment which consumes Natural Gas. The primary reason for this topic was to establish financial savings which may defend profit margins against the rise of fixed costs associated with manufacturing, helping to ensure the longevity of production of class 1 Nickel products at Vale Europe Ltd.

A thorough understanding of a complex continuous Chemical process was a requirement to find opportunities this, was achieved with extensive research of technical reports from authors who specialise in their field. Research established knowledge which, was used in conjunction with a suite of continuous improvement tools that identified that; a deficiency in Sulphur added to a process which performed the function of removing Oxygen from Nickel Oxide, may be the cause of additional heat requirements and, therefore an increase in consumption of Natural Gas.

Methodology

Nickel Sulphate Hexahydrate was used as an additive to introduce Sulphur into the Hydrogen Reduction process to refine Nickel Oxide. An analytical method was used to estimate the proportion of Sulphur added to the process by calculating the ratio of; the Molar Mass of a Sulphur atom to the total Molar Mass of a Nickel Sulphate Hexahydrate molecule which it is contained within. The ratio of Sulphur was then considered as a ratio of the total hourly mass of Nickel Sulphate Hexahydrate and Nickel Oxide which are blended together whilst being fed into the Hydrogen reduction process.

An experimental method was designed to validate the analytical process by confirming the actual content of Sulphur

contained in one mass unit of Nickel Sulphate Hexahydrate. Samples were taken from selected consignments of Nickel Sulphate Hexahydrate which were dissolved then, analysed using a X-ray fluorescence spectrometry analyser. In addition, the samples were analysed to determine their acidity.



Samples taken from four consignments of Nickel Sulphate Hexahydrate

Experimental Findings

when we compare the percent of Sulphur obtained by experiment to the analytical method we have used to estimate, we see that actual Sulphur content for each sample is higher than we expected for both manufacturers. We also see variation about the mean value for the four samples which, has a range between -0.09% to +0.1%. Furthermore, we see that there are variations between the result of each pH test with both deliveries received from Umicore being 33% more acidic than the deliveries received from Bluestone.

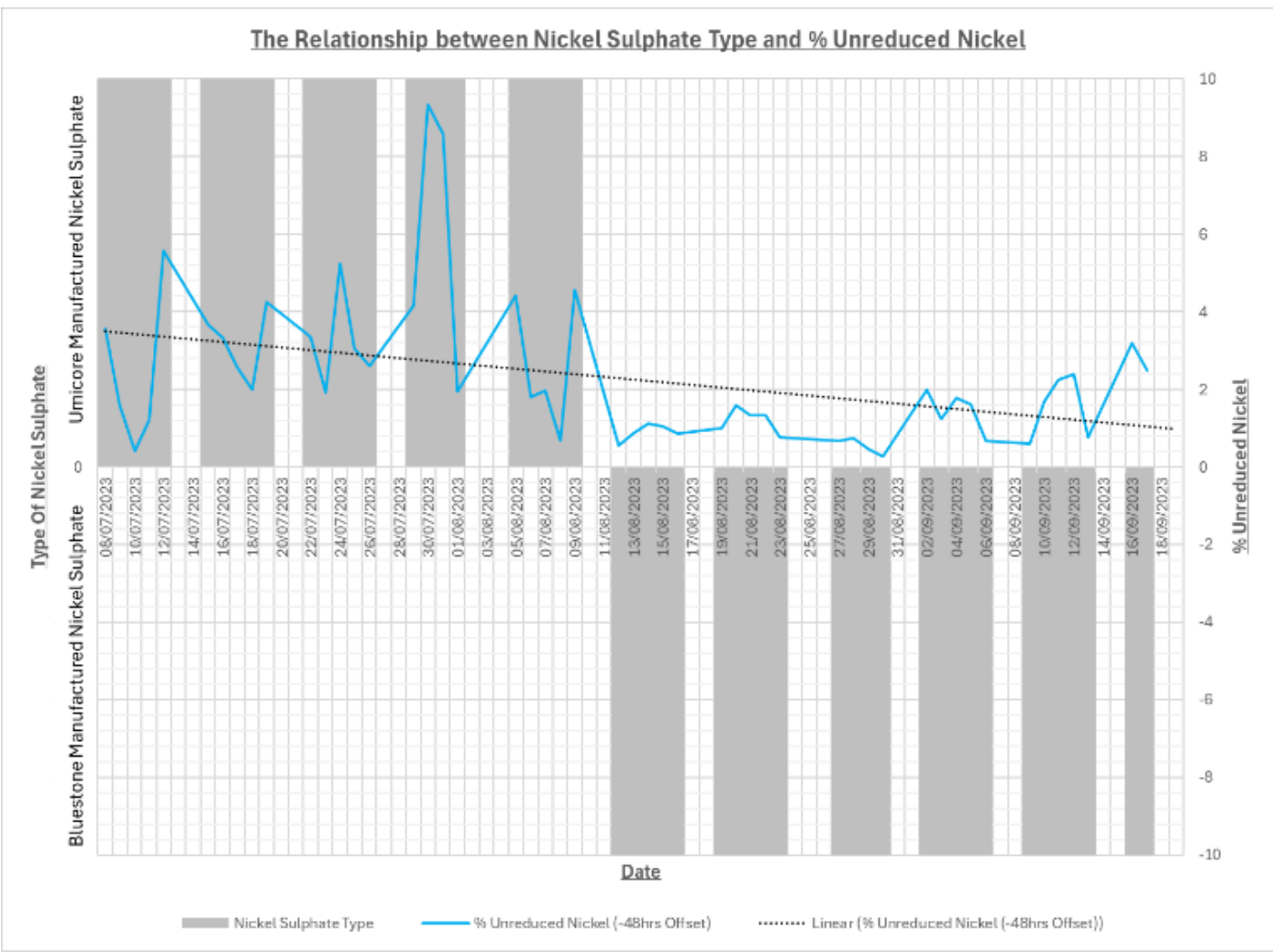
Actual Sulphur proportion of the total material fed into the Hydrogen Reduction Process

Batch Number	Manufacturer	pH	%S
23-143V	Bluestone	6.1	12.7
23-399V	Bluestone	6.1	12.8
2940502620	Umicore	4.1	12.6
2940502697	Umicore	4.1	12.7

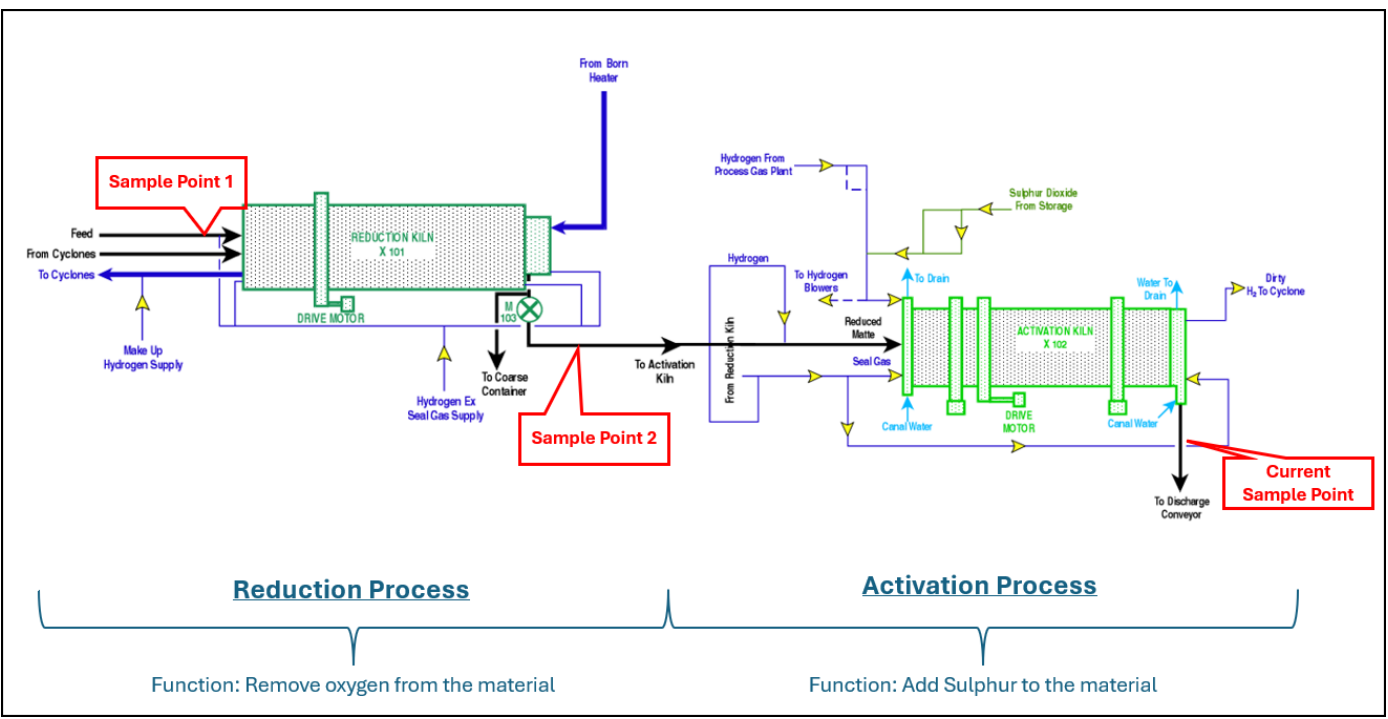
Conclusion

The data suggests that there is a tangible link between the manufacturer of Nickel Sulphate Hexahydrate used in the Hydrogen Reduction process and, the percentage of Nickel Oxide reduced,

However, our analysis does not prove inadequate Sulphur content within the compound therefore, additional heat to compensate would not be required. We have deemed our results to be inconclusive, as a population sampling scheme was used to perform experimental analysis which provided limited evidence to endorse a change. We suggest the use of a process sapling plan at various locations in the process as further work.



Graph showing the relationship between the manufacturer of Nickel Sulphate Hexahydrate and the quantity of unreduced Nickel Oxide



Identification of proposed and current sample point in the Reduction and Activation Step

References

Laker, R., 2008. *Reduction/Carbonylation testwork of FMW with Nickel Sulphate from Different Suppliers*, Swansea: INCO Europe Limited.

Lascelles, K., 1986. *Sulphur and the carbonylations of Nickel*, Swansea: Vale Europe Ltd.

Lascelles, K., 2004. *Alternatives to the present nickel sulphate in the kiln plant*, Swansea: Vale Europe Ltd.

Vale Europe Ltd., 2023. *PSO202 Reducing & Activating Process Manual*, Swansea: Vale Europe Ltd..

Vale Europe Ltd., 2023. *OV200 Overview Process Training Manual*, Swansea, Wales: Vale Europe Ltd..

Vale Europe Ltd., 2024. *Bonham*, Swansea, Wales: Vale Europe Ltd..