FINAL DRAFT REPORT

THE IMPORTANCE OF NICKEL COMPOUNDS:

CATALYSTS IN OIL REFINING

Prepared for

European Nickel Institute

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1. INTRODUCTION

The oil refining industry produces a wide range of refined oil-based products that meet the needs of motorists, homeowners, truck fleets, industry, farmers, and users of commercial premises for movement, heat, light, power, lubrication, and raw materials. It does this by processing crude oil, using complex and modern facilities, producing a wide range of essential refined petroleum products with different technical properties and performance characteristics.

Catalysis is one of the principal enabling technologies used in the oil refining sector. Used in a wide range of processes, catalysts improve the selectivity and efficiency of the refining industry. Catalysts based on nickel are some of the most important employed within a modern oil refinery. Through their use in reforming, and de-sulphurisation, for example, they help refinery operators meet increasing demand for transportation fuels (gasoline and diesel) and for cleaner products from increasingly difficult feedstocks, in an efficient and flexible way. Nickel compounds play a vital role in the production of many modern nickel-based catalysts used in the oil refining industry.

2. NICKEL AND CATALYSTS IN OIL REFINING

In chemistry as well as in biology, catalysis is the acceleration of a chemical reaction by means of a ‘catalyst’ which is itself not consumed by the overall reaction. Catalysts work by providing an alternative mechanism involving a different transition state and lower activation energy. The effect of this is that more collisions of educt molecules have the energy needed to reach the transition state and subsequently form more products. Hence, catalysts can perform reactions that would not run without the presence of a catalysts, or perform them much faster, more specific, or at lower temperatures. This means that catalysts reduce the amount energy needed to create a specific chemical reaction.

Catalysts are suitable in industrial processes if they are selective, stable and have high activity under the conditions of the process. A catalyst is selective when it increases the yield of the favoured reaction product. In heterogeneous catalysis reactions such as those predominantly used in petroleum refining, a catalyst is highly active if it has the capacity through its large inner surface to adsorb large amounts of reaction gas.

Nickel-based catalysts meet these criteria in a whole range of chemical reactions involved in petroleum refining are therefore often the preferred choice. Amongst others, nickel-based catalysts find applications in hydro-treating (e.g., hydro-denitrogenation, hydro-desulphurisation); hydro-cracking and hydro-processing; and steam reforming. In these processes, the active nickel species is typically nickel metal that is finely dispersed over porous aluminium or silica-based carrier resulting in a large catalytically active surface. In these catalysts, nickel has the characteristic of being able to adsorb huge quantities of hydrogen and being cost effective relative to competing materials of the platinum group.

While the exact chemical processes involved in synthesising the nickel-based catalyst vary by manufacturer and are typically highly confidential, it is well documented that nickel compounds with varying solubilities such as nickel nitrate, nickel hydroxide, nickel carbonate or nickel acetate are used in the preparation of the complex catalysts used in oil refining processes. For example, in a reaction path, a silica-(SiO_2) or aluminium (Al_2O_3) supported nickel catalyst has been prepared by initially impregnating the SiO_2 or Al_2O_3 carrier with nickel nitrate or nickel acetate. The impregnated catalyst is then calcinated to form nickel hydroxide and following hydrogen reduction the catalytically active NiO/Ni mixture on the carrier.

3. IMPORTANCE OF OIL INDUSTRY NICKEL CATALYSTS FOR THE EU

3.1. Economic Impacts

Nickel catalyst technology helps the oil refining industry achieve three important goals: first, it supports efficient and effective up-grading of heavy crude oils into lighter, refined products needed to meet transport demand; second, it helps improve the effectiveness of important de-sulphurisation processes, meeting the need for cleaner transport fuels; and, finally, it facilitates greater flexibility of choice of input materials, enabling greater use of heavier crude oils. Taken together, these benefits have a significant positive impact on the competitiveness of the oil refining industry in the EU.

Oil refining is an important industry for the EU. Oil is the most important source of fuel for primary energy in the EU (over 40% of traded fuels in 2006), and the refining sector, because of its scale, modernity, profitability, and competitiveness, ensures that Europeans benefit from the process of converting this important raw material into products needed by customers. In 2006, there were over 109 oil refinery sites in the EU with a production capacity in excess of 15 million barrels per day. This is equivalent to 18% of global production capacity and sufficient to meet EU demand. These sites produced output of over Euro 320 billion in 2006; supported direct employment (including contractors) of over 110,000 jobs, many of them highly skilled and well-paid; and generated gross value added (GVA) of Euro 29 billion. Major EU-based oil refiners include Agip (Italy), BP (UK), ENI (Italy), ERG (Italy), Galp (Portugal), Hellenic (Greece), Ineos (Belgium), MOL (Hungary), Neste (Finland), Nynas (Sweden), OMV (Austria), Repsol (Spain), Shell (UK/Netherlands), and Total (France).

Moreover, the oil refining sector sustains an extensive and complex value chain, including suppliers of goods and services to oil refineries, as well as ‘downstream’ distribution, marketing, selling, technical support, and retailing of refined petroleum products. This includes more than 110,000 petrol filling stations throughout the EU. Taking this value chain as a whole, over 1 million jobs and Euro 70 billion of GVA depends on the oil refining sector, including induced and indirect economic impacts.

Included within this overall value chain is the catalyst industry, part of the speciality chemicals sector. In 2006, EU sales of refining catalysts exceeded Euro 500 million. Development, production, and supply of refinery catalysts is a complex, global business, and EU companies are amongst the world's leaders. Major EU-based companies involved in this sector include BASF (Germany), Degussa (Germany), Haldor Topsoe (Denmark), Johnson Matthey (UK), Saint Gobain (France), Shell (UK/Netherlands), and Sud Chemie (Germany).

3.2. Other Impacts

Nickel catalyst technology generates sustainability and efficiency benefits for Europeans, alongside its substantial socio-economic contribution.

Sustainability - the EU, along with other parts of the OECD, has taken action to improve air quality by mandating reductions in sulphur and other emissions from road transport vehicles. From 2005, for example, levels of sulphur in diesel should fall to 50 parts per million (ppm). At the same time, this should be accompanied by the widespread availability of other 'ultra low sulphur diesel' (ULSD) products with sulphur levels of 10 ppm. These requirements build on legislation passed in 2000 that imposed limits on sulphur levels in gasoline and diesel. Nickel catalyst technology, in partnership with changes in process equipment and other technologies, helps EU oil refineries meet these rules effectively and efficiently.

Nickel catalyst technology also plays a key role in de-nitrification, removing nitrous oxide and further improving air quality.

Efficiency - oil refining is a global industry. Raw material and finished product prices are set by commodity markets, products are traded globally, and most capital is supplied by multi-nationals. These factors limit inefficiencies, forcing operators to meet global standards of cost, capital intensity, and yield. At the same time, EU-based oil refineries must respond to increased demand for transport fuels, increased regulatory requirements for cleaner products, and greater availability of heavy, high sulphur raw materials.

Nickel catalyst technology plays a vital role in helping EU oil refiners meet these challenges. It helps minimise raw material costs by facilitating greater use of lower cost crude oils, and by enhancing energy efficiency. It facilitates improvements in yield by supporting advanced conversion and up-grading technologies used to maximise output of lighter transport fuels. Finally, it helps ensure that existing production capacity is used more efficiently to meet market needs, limiting the need for additional investment in new facilities. Alongside these benefits, nickel catalyst technology helps raise overall throughput, reduce downtime, and extend the operating cycle of refining operations.

4. CONCLUSIONS

The EU oil refining sector, and its value chain, generates major socio-economic gains for Europeans, as well as supplying the most important source of primary energy for the transport sector. Nickel catalyst technology plays a vital role in helping the EU oil refining sector to maximise its competitiveness and at the same time meet continuing green house gas emission reduction goals for both installations and products. They also help to reduce local air pollutants such as particulates, sulphur dioxide and nitrous oxide from oil-refinery products thus contributing to improved air quality for Europe's citizens.

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