This project consists of a series of studies, that are related to hydrotreating of diesel. Hydrotreating is an important refinery process, in which the oil stream is upgraded to meet the required environmental specifications and physical properties. Although hydrotreating is a mature technology it has received increased attention within the last decade due to tightened legislations regarding the sulfur content, e.g. the demand for Ultra Low Sulfur Diesel (ULSD) with a maximum sulfur content of as low as 10 ppm S has increased. The process is complex, as the performance of a hydrotreating reactor is governed by intrinsic kinetics, diffusion in the pores of the catalyst, mass transfer between the phases and the equilibrium between the gas and the liquid phase. In order to optimize the process and develop better simulation tools, a detailed understanding of the different processes and phenomena is needed. The hydrogenation of aromatics during hydrotreating is important, as the aromatics content of the product influences the properties of the product, and since the conversion is important for the hydrogen consumption. It is well-known that saturation of fused aromatic rings can be limited by thermodynamic equilibrium at typical industrial hydrotreating conditions. Equilibrium constants have been calculated based on experimental measurements for the hydrogenation of naphthalene and phenanthrene. The kinetics of hydrogenation of a model compound, naphthalene, has been studied on a commercial CoMo catalyst, and a simple kinetic model is presented. Hydrogenation of fused aromatic rings are known to be fast, and it is possible, that the reaction rates are limited by either internal or external mass transfer. An experiment conducted at industrial temperatures and pressure, using naphthalene as a model compound, have shown, that intra-particle diffusion resistance are likely to limit the reaction rate. In order to produce ULSD it is necessary to remove sulfur from some of the most refractive sulfur compounds, such as sterically hindered dibenzothiophenes. Basic nitrogen compounds are known to inhibit certain hydrotreating reactions. Experimental results are presented, showing the effect of 3 different nitrogen compounds, acridine, 1,4-dimethylcarbazole and 3-methylindole, on the hydridesulfurization of a real feed and of a model compound, 4,6-dimethyldibenzothiophene. It is shown, that a basic nitrogen compound is the strongest inhibitor, and that it not only inhibits the hydridesulfurization reaction, but also the hydronitrogenation of other nitrogen compounds. The nitrogen compounds are shown to mainly inhibit the hydrogenation pathway rather than the direct desulfurization route due to a stronger adsorption on hydrogenation sites. Since feeds used in the hydrotreating process, usually gas-oils, are complex mixtures with a large number of compounds, analysis of the reactions of individual compounds can be difficult. In this work a model-diesel feed consisting of 13 different compounds, representing the most important component classes, has been hydrotreated on a commercial NiMo catalyst. The difference of the reactivity and behavior of the different compounds in the mixture have been investigated. A steady-state trickle-bed reactor model has been been set-up. The heterogeneous model considers co-current flow of two fluid phases, gas and liquid. The model takes internal and external mass transfer into account. It considers mass transfer between the 2 fluid phases (gas and liquid), and the equilibrium between them. As reactor models is becoming an important tool to understand the process, detailed kinetics models are needed in order to simulate hydrotreating of complex mixtures. A Robinson-Mahoney reactor is a three-phase reactor that behaves as a continuous stirred tank reactor, and therefore allows for the direct measurement of reaction rates, which can be used to develop kinetic models. Hydrogenation reactions are quite fast, and in order to avoid mass transfer limitations, and only measure intrinsic rates, experiments are often conducted, at conditions that are milder than in industrial units. A reactor model for a Robinson-Mahoney reactor that takes mass transfer into account is presented, and it has been used to test a set of kinetic models at industrial conditions.