THE INFLUENCE OF HYDRODYNAMIC AND KINETIC FACTORS ON THE OXIDATION RATE OF PARAFFIN WAX IN A FOAMED CONDITION

N. M. Lebedeva, V. V. Nesmelov, L. D. Rysaeva, O. V. Maminov, and R. Sh. Latypov

Study of the oxidation kinetics of paraffin wax in a foamed condition in the temperature range 120 to 150°C has shown that the oxidation temperature can be raised (130°C) without impairing the quality of the final oxidation products. When oxidizing under foam conditions the oxidation time, 3 to 4 h, is much shorter than up to 16 h under bubbling conditions. This high process rate is achieved by a combination of higher temperature and hydrodynamic factors which maximize the rate of oxygen access to the oxidizing wax.

In modelling hydrocarbon oxidation processes one of the most important factors is the quantity of oxygen which is absorbed per unit weight of hydrocarbon per unit time at a given temperature. The oxygen absorption rate depends on the reaction conditions: temperature, nature and amount of catalyst, and hydrodynamic conditions of the process. The concentration of hydrocarbons being oxidized has no significant influence on the oxidation rate as it remains high throughout the oxidation time as compared with the oxygen concentration in the reaction zone.

Paraffin wax can absorb very little oxygen in the temperature range 120 to 150°C. The work [1] recommends the provision in industrial installations of 50 m³ air per ton of paraffin wax per hour. It appears that in this temperature range even with low specific air flow rates (50-60 m³/ton h) oxidation occurs in a region which is near to kinetic. As the temperature is raised the oxidation rate increases sharply. In order that oxidation should occur in the kinetic region under these conditions the oxygen supply and dissolution rates in paraffin wax should be equal to or greater than the oxygen consumption rate in the oxidation reactions.

In the general case the amount of oxygen absorbed by paraffin wax per unit time is given by the mass transfer equation [2]

\[ q_{O_2} = k \cdot F \Delta C \]

where \( q_{O_2} \) is the quantity of oxygen (kg/h) absorbed by the wax; \( k \) is the mass transfer coefficient, m/h; \( F \) is the total phase contact surface, m²; \( \Delta C \) is the motive force of the process, kg/m³.

In this equation the total phase contact surface in generalized form reflects the hydrodynamic state of the paraffin-air system which depends on the linear velocity of the air, its bubble size, the magnitude of the wax load and the presence of surface active substances in the system. It would, however, be erroneous to suppose that the oxidation rate depends only on the linear velocity of the air. A second important factor which influences the rate is the motive force of the process which depends on the specific air flow rate. The object of the present work was to elucidate the influence of these two factors on the oxidation rate under foam conditions.

In the first series of tests the conditions were selected in such a way that reaction took place with large excess of...
It was shown (Fig. 1) that the oxidation rate depends mainly on the linear velocity of air in the column. With high paraffin loads (h > 100 mm) plate geometry had no significant influence on oxidation. The specific phase contact surface and oxidation rate are maximum with a column air velocity of about 0.2 m/sec.

In the second series of tests a study was made of the influence of specific air flow rate on oxidation rate. The linear air velocity was maintained constant (0.04 m/sec). The specific air flow rate was varied in the range 0.27 to 2.16 m³/kg·h by altering the load of paraffin. The feed was a mixture of fresh wax (grade "A") and returned paraffin wax of the Grozny refineries with the following characteristics: neutralization value 0.2 mg KOH/g, ester number 5.6 mg KOH/g, carbonyl number 6.7 mg KOH/g. The oxidation time was always three hours. The test results were worked out by the formulas given above.

Analysis of the experimental data shows that with increase in the specific air flow rate from 0.27 to 2.16 m³/kg·h per kg of paraffin wax the oxidation rate increases sharply (Fig. 2). Undoubtedly the increase in oxidation rate is associated with increase in the oxygen concentration in the reaction zone (Fig. 3) but calculations have shown that other factors also influence the oxidation rate. With increase in the specific air flow rate the specific phase contact surface f increases. The value of f calculated by Eq. (3) is given in the work [4]:

\[ f = \frac{G}{d} \left( 1 - \frac{h}{H} \right) \]

The increase in specific surface is greatest in the specific air flow rate range 0.27 to 1.08 m³/kg·h. In this range