Synopsis

Diesel engines contribute to a large percentage of oxides of nitrogen (NOx) emission in the atmosphere. The NOx primarily consists of nitric oxide (NO) and nitrogen dioxide (NO_2). With depleting fossil fuel supplies increasing efforts are being made to introduce plant oil based substitutes, popularly known as biodiesels, in the conventional diesel engines. The biodiesel is a renewable, non-toxic, biodegradable and environment friendly fuel. Its use reduces the concentration of Volatile Organic Compounds (VOCs) in the exhaust. However, an increase in the concentration of NOx in the exhaust has been reported in these engines. Therefore, combating the NOx concentration in the diesel engine, run by either diesel or biodiesel is a major field of research and the increasingly stringent restrictions imposed on the emission of harmful gases from industrial/automobile/stationary engine exhaust around the world have led to the development of a number of new technologies to address this issue.

The electrical discharge based cleaning appears to be one such promising technology for treating the gaseous pollutants. In particular, the dielectric barrier discharges have been very effective in NOx abatement. It is well known that discharge plasma processes allow us to induce gas phase reactions. However, they do not permit us to selectively enhance one reaction over the other necessitating use of additional catalysts/adsorbents along with the discharge plasma. However, the exhaust temperatures of the stationary engines are too low for the effective functioning of most of the commercially available catalysts. Additionally, the expenses involved in preparing rare metal catalysts may be quite high. In this context, any attempt to treat the stationary engine exhaust at lower or reduced temperatures is a welcoming step as it excludes the temperature-dependent catalysts and facilitates the usage of inexpensive adsorbents. Further, the advantage with stationary exhausts is that the associated high temperatures can be reduced to a lower level by mechanical means with one time capital investment.

The thesis work begins with the design and fabrication of new gas treatment corona reactors that were later tested for their effectiveness in treating NOx. Studies were conducted under various high voltage sources cascaded by catalyst/adsorbents. The use of 100 % biodiesel in the major part of these experiments is a step towards use of renewable energy resources in diesel engines. A first time initiative has been taken up in this research work by blending several industrial waste–derived materials, such as red mud, fly ash and copper slag, cascaded with electric discharge plasma to study their effectiveness in the abatement of NOx. It should be noted here that these industrial wastes are abundantly available in our country, India at no cost. It was observed that the oxidizing atmosphere of the plasma reactor has a synergistic effect on enhancing the NOx reduction capabilities of the cascaded system. The final part of the thesis concentrates on the estimation of the power consumed by the discharge plasma reactors. Some of the plasma reactors used in the current study have double dielectric geometries and an accurate estimation of their capacitance through analytical means is difficult. A semi-experimental approach of estimating the capacitance for such reactor geometries has been introduced to arrive at the power estimation, which was further validated with measured ones.