CHAPTER 2
LITERATURE SURVEY

2.1 LITERATURE REVIEW

This chapter reviews the research work and studies that have been done by different authors and published in journals. It presents some of the work related to applied voltage, frequency, resonant converters, electrical strength, gap width, dielectric constant, fly back transformer, ferrite core transformer, ozone concentration measurement methods and materials used for DBD tube to improve the concentration of ozone.

Yukihiro Kamase et al (1991), suggests that the high voltage source generating the fast rising square wave voltage, has been developed for high efficiency ozone generator. The voltage source incorporates a rotating spark gap switch. Life time of the voltage source is determined by erosion of the spark gap switch. In order to obtain a long life time, various electrode materials have been experimentally tested. Sintered tungsten with thorium dioxide has the smallest erosion rate among the materials tested in the experiment. Using this material as the switch, the high voltage source was constructed. A reliable pulsed high voltage source has been developed for high efficiency ozone generator. The inferences are: smallest erosion rate among the materials tested in the experiment is about 0.078 mg/h at the ozone generation rate of 20 gm/h. In order to obtain longer life time, the electrode surface should be flat and the surface area should be large.
Kerwin Rakness et al (1996) explains the guideline for ozone concentration measurement in the gas phase particularly for commercial ozone generators. The ozone concentration reading of record may be determined by wet-chemistry only (method A) or by UV meter verified by wet-chemistry (method B). In method A, the ozone concentration reading of record shall be the average of at least three wet chemistry test results and the standard deviation percentage for the measurements shall be less than ±2%. For method B, the UV meters display results can be calibrated independently for sample cell temperature and pressure.

Kogelschatz et al (1997) states that Dielectric Barrier Discharges have ideal properties for establishing non-equilibrium plasma conditions in high pressure gases in a controllable way. Operation close to atmospheric pressure is an absolute necessity when large combustion flue gas streams or large mass flows have to be treated and when the reaction kinetics requires high pressure operation. Also the handling and DBD treatment of large parts is facilitated at atmospheric pressure. The properties of individual micro discharges can be tailored to suit a given application. In the micro discharges transient electron energies can be obtained that are comparable to those of low pressure volume discharges. In many applications the free radicals generated by electronic collisions are more important than the electrons and ions themselves. Free radical chemistry at atmospheric pressure is extremely fast and thus allows high production or destruction rates as well as high speed treatment of surfaces. The novel applications described in that paper were brought about by a better understanding of the discharge physics and the plasma chemistry involved on one side and on recent developments of power electronics on the other side. There is no doubt that the described industrial applications of dielectric-barrier discharges will continue to grow at a fast rate and that additional novel applications will emerge in the future.
Gerhard et al (1998) developed the discharge structure and the transferred charge of dielectric barrier discharges (DBD) in arrangements with a gas gap (volume discharge, VD) and in such cases pure surface discharges (SD) are compared. On the basis of the properties of DBD some parameters influencing efficiency and ozone production like field strength distribution and energy density are discussed. In order to get high efficiencies of the ozone synthesis, from a physical point of view the field strength within the discharge structures should be near the optimal value which has been found experimentally. The field strength distribution during the main charge transfer can be tailored to a certain extend by appropriately choosing the gap width and the specific capacity of the dielectric. These parameters influence the transferred charge and energy density in the discharge. From a chemical point of view high temperatures in the process gas have to be avoided because at elevated temperatures the equilibrium between atomic plus molecular oxygen and ozone is shifted to oxygen. Apart from this, other parameters like process gas humidity, its purity, surface resistance of the dielectric influence the ozone yield. High ozone production rates (and concentrations) can be achieved by high energy densities as long as the cooling facility is sufficient and efficient. Comparing VD with SD ozone generators it is probable that SD devices will not exceed the efficiency of well optimized VD generators. The field strength distribution in SD leads in general to an average field strength which is farther from the optimal value than that in VD. Unexpected low ozone yields from SD generators fed with air may follow from enlarged concentrations of low nitrogen oxides.

Samaranayake et al (2000) describes that production of ozone was investigated using a dielectric barrier discharge in oxygen, and employing short-duration pulsed power. The dependence of the ozone concentration (ppm) and ozone production yield (g(O₃)/kWh) on the peak pulsed voltage (17.5 to 57.9 kV) and the pulse repetition rate (25 to 400 pulses, pps) was
investigated. In the study, the following parameters were kept constant: a pressure of 1.01~10Pa, a temperature of 26 K 4T, a gas flow rate of 3.0 l/min and a gaseous gap length of 1.1 mm. A concentric coaxial cylindrical reactor was used. A spiral copper wire (1 mm in diameter) was wound on a polyvinylchloride (PVC) cylindrical configuration (26 mm in diameter) and placed centrally in a concentric coaxial electrode system with 4 mm thick PVC dielectric layer adjacent to a copper outer electrode of 5.8 mm in internal diameter. HV and current pulses were provided by a magnetic pulse compressor power source. Positive pulsed corona in a dielectric barrier discharge has shown promising results that can be implemented readily in industrial applications using coaxial cylindrical ozonizers. The concentration of ozone increased with increasing peak pulsed voltage at a fixed gap length and a constant gas flow rate. The ozone concentration showed an increasing rate with increasing peak pulsed voltage at a fixed gap length and with a constant gas flow rate. A pulse repetition rate of 25 pps using a fixed gap length of 3.1 mm and a constant flow rate of oxygen of 3.0 l/min produced the highest production yield of ozone (202 g/kWh).

Robert M. Del Vecchio et al (2001) presents the theory of transformer operation and the methods and techniques of designing them. It emphasizes the physical principles and mathematical tools for simulating transformer behavior, including modern computer techniques. The scope includes types of construction, circuit analysis, mechanical aspects of design, high voltage insulation requirements, and cooling design. The test procedures and reliability methods assure successful design and discuss the economic analysis of design.

Sabate et al (2002) presents a steady-state analysis with complete characterization of the converter operation. A small-signal model of the converter is established. The design procedures based on the analysis are
presented and the various losses in the circuit assessed. Critical design considerations for a high-power, high-voltage application are analyzed. The results of the analysis are verified using high-voltage 2 kW prototypes.

Mika Sippola et al (2002) gives the first published study on high frequency power transformer design where core and winding losses are combined with thermal models and validated successfully in circuit operation using statistical methods. The analytical convective and radiative thermal models, estimation of thermal model using DC-generated core losses and combined loss and thermal calculation spreadsheet can be regarded as particularly useful results. The use of regression analysis to validate each and all design issues proved to be very efficient in providing confidence and eliminating possible errors in models, parameter values and calculations in spreadsheet. Such quantitative methods to compare design calculations and actual measurements have been quite seldom used in electrical engineering literature. It can be concluded that the developed transformer design procedure itself provides an appropriate method to predict transformer core and winding losses and resulting temperature rise but the availability of material loss parameters and conductive thermal resistance from transformer to printed circuit board (PCB) may become a practical problem. The good correlation between calculated and measured values was to some extend result of a simple core and winding geometries. For lower profile planar transformers the current and flux crowding should be taken into account by 2D/3D FEM analysis and measurements based correction factors. Rac/Rdc-functions for more complex winding geometries and converter topologies should also be developed using FEM analysis and impedance analyzer measurements. On the other hand it might be more beneficial to develop winding geometries with Rac/Rdc (f) \~1 using these methods in the first place.
The effect of DC-bias on core losses should also be taken into account in particular for inductor design. Transformer parasitic (leakage inductance, inter and intra-winding capacitance) were not treated adequately. The losses caused by these are inflicted mainly into switching components while the inter-winding capacitance contributes to the electromagnetic interference (EMI) as well. These should be considered in the converter level design analysis which was beyond the scope of Mika Sippola work. Although the design equations developed in Mika Sippola work may be valid for power transformers with similar operational conditions and comparable dimensions, the idea of developing design equations for losses and heat transfer first by analytical, numerical or empirical means and then combining these for design analysis may be expanded to design optimization of other inductive components and power converters as well. For practical engineering the most important issue is often the cost - performance obtainable with different manufacturing methods and design optimization algorithms. However, the manufacturing and material costs are often not considered in literature. This is obviously due to non-availability and confidentiality of cost information.

A quantitative cost - performance analysis was considered only briefly in Sippola and Siren (1998). However, the design spreadsheet could be quite easily upgraded to include material costs in order to provide similar analysis for practical transformer design optimization as well.

Junming Zhang et al (2004) highlights about novel zero voltage switch (ZVS), pulse-width modulation (PWM), DC/DC converter for high power, high output voltage applications. By using two active switches in the secondary side of a transformer, the proposed converter achieves not only ZVS of the active switches in the entire load ranges but also soft commutation of the output rectifier diodes. The proposed topology has simple structure and
control strategy. Simulation results and experimental results of a 2.8 kW 200 kHz DC/DC converter are presented.

Kudryavtsev Oleg et al (2004) proposes the simulation for DBD load. Though this method implies rather complicated mathematical transformations for the algorithm the calculations are many times faster than when using the numerical solution of circuit state differential equations. Due to the drastically reduced calculation time, the load characteristic of the accurate electric circuit model of the DBD can be evaluated easily. Based on this proposed method, the frequency dependence of various circuit characteristics, influence of the load parameters and other analysis important for designing the power supply can be accomplished at a rapid pace. As an application example, optimal driving parameters for the UV generation tube have been derived and such load characteristics as consumed power and equivalent impedance have been calculated. These evaluations for an accurate model of the DBD load have been done for the first time and are very helpful for understanding the electrical behaviour of this load.

Jane M. Van Doren et al (2005) state the rate coefficient and branching fraction data were determined for the gas phase reaction of \( \text{O}^- + \text{O}_3 \) over the temperature range 123–500 K using the temperature variable selected ion flow tube technique. The reaction rate coefficient is large and relatively insensitive to temperature; reaction takes place on every collision. In contrast, the product distributions are sensitive to temperature. Charge transfer is the major reactive pathway (\( \simeq 67\% \)) at all temperatures, and its importance increases with increasing temperature. Atom transfer, forming \( \text{O}_2^- + \text{O}_2 \), constitutes approximately 33\% of the products at 123 K. The temperature dependence of the branching fraction explains an apparent discrepancy between product data from room temperature flow tube experiments and low energy beam experiments. A reaction mechanism is proposed to qualitatively
explain the product branching fraction temperature dependence. Reaction between oxide ion and ozone is efficient over the temperature range of 123–500 K. Product channels include charge transfer and atom transfer. At all temperatures, charge transfer is the dominant reactive channel and becomes increasingly important with increasing temperature. This temperature dependence explains the apparent discrepancy between low energy ion beam and room temperature flow tube experimental results. The product branching fraction temperature dependence is most easily explained by a common mechanism in which atom transfer products are formed from the initially formed charge transfer products.

Fukawa et al (2006) says that a nanosecond pulsed power generator has been developed and the ozone production experiment is conducted. As the width pulsed power shortens, the efficiency of production improves, but the load matching becomes difficult. Then, the parallel connection of the reactors is adopted. The discharge volume increases with parallel reactors. The reactor is coaxial and consists of wire and cylindrical electrodes. Since arc discharges are controlled due to nanosecond pulsed power discharge on the parallel reactors, the improved shape of insulators prevents surface discharges. The 8 parallel and 12 parallel reactors give ozone yield of about 280 g/kWh for system efficiency (500 mm reactor). Ozone generation using nanosecond pulsed power discharge were studied upto 16 parallel reactors and the following conclusions were obtained: Parallel reactors induce distribution of discharge energy in each reactor, and arc discharge is reduced. Load matching between pulsed power generator and the reactor is important to obtain a large discharge volume. The ozone yield of 280 g/kWh is obtained with the ozone Energy Density (J/L) concentration of 2 g/m³ in using 8 and 12 parallel Energy density Vs Ozone yield. By connecting reactors in parallel, arc discharges are controlled and matching between pulsed power generator and the reactor is, therefore, improved.
Ivenes et al (2006) develop two soft switching DC-DC isolated converters for the design of the power electronic interface for fuel cell applications. One is based on the half-bridge capacitive converter and operates in ZVS mode. Another, in ZCS mode, is issued from the half-bridge inductive converter. Each structure has its own advantages and drawbacks. The ZVS converter can, actually, overcome the drawbacks of the original structure but is more complicated. As for the ZCS converter, the duty cycle is limited greater than 0.5 but more simple and suitable for the fuel cell applications thanks to the inductive feature of the input. Operation principle, characteristics and components sizing and losses estimation of each converter show that both of these structures allow optimizing the choice of components.

Valentin I. Gibalov et al (2006) the parameters, which determine the performance of ozone generators, are efficiency and maximum ozone concentration. The efficiency from oxygen has been found to be nearly independent on the kind of barrier discharge arrangement (volume, surface, coplanar), while the ozone concentration saturation level depends on the specific design of the generator. These phenomena are explained with features of the discharge process and the properties of chemical reactions, respectively. The importance of a limit in the energy density of the discharge is highlighted. The efficiency of ozone synthesis and the ozone saturation level depend on the features of barrier discharges and constructive peculiarities of the ozone generator design, respectively. The efficiency of ozone synthesis is determined during the electron phase of the discharge, when electrons interact with the working gas. The micro discharges of DBDs are self-sustaining phenomena, which consist of a series of discharge processes such as streamer appearance, formation of cathode layer, development of a conductive channel, charge accumulation on the dielectric surface and, by this, discharge extinction. These processes are well reproducible and defined by gas properties, not by the discharge arrangement
itself. Because of this, the field configuration and the average energy in the conductive channel, the region of maximum energy release, is reproducible as well. The appearance of a certain ozone saturation level depends on the chemistry of ozone synthesis. A chain of chemical reactions including oxygen and ozone dissociation is initiated during discharge pulses. The rate constants of the chemical reactions depend on the mean gas temperature. That is why cooling conditions of the ozone generator become crucial for the ozone saturation level. It appears that the rise of the ozone saturation level of industrial ozone generators with decreasing discharge gap can be explained by advanced cooling conditions.

Skalny et al (2007) give the physical and chemical processes of ozone generation in both positive and negative corona discharges DC corona, both operated in glow regime, feed by dry CO$_2$ has been studied. Higher ozone concentrations were observed in negative corona discharges. Ozone formation was found to be strongly dependent upon both the flow rate of the gas and on the radius of the outer electrode. The physical characteristics of the discharge were monitored through measurement of the discharge current. Small increases in the gas flow rate were observed to cause a significant increase in the discharge current of a negative corona discharge but little/no effect was observed in positive corona. Hence, the average ozone concentration must decrease with R. Of course, also an increase in probability of reactions due to an increase in the drift path of electrons through the drift region is a factor, which has to be considered. The detail analysis of importance of those two factors, or some others, requires further data. The average ion mobility was found to be larger in the negative corona. This can be ascribed to decreasing ozone concentrations at larger R and constant retention time of gas in the discharge gap. In contrast to negative polarity, the high values of mobility found in positive polarity are the consequence of the
conversion of CO\textsubscript{2} + ions to more mobile O\textsubscript{2} + ions via the ion-molecule reaction within the discharge region.

Hothongkham et al (2008) has dealt with the analysis and modelling of an ozone generator using a phase-shift pulse width modulation (PWM) full bridge inverter as a power supply. The proposed technique offering high voltage and high frequency is capable of generating ozone. The simulation and experimental results show good agreement and the validity. This technique allows constant output voltage while the inverter frequency varies.

Suksri et al (2009) revealed that ozone generation by using only AC high frequencies alone yield great ozone concentration. On the other hand, a method of superimposed high voltage source produced low ozone concentration as well as low efficiency on energy consumption concerned. Therefore, in an application that needs ozone concentration below 600 ppm, the choice of suitable high voltage source is AC 50 Hz. For an industrial application that needs more concentration of ozone gas, the choice of high voltage with high frequency power supply is much more attractive due to the efficiency of ozone concentration and reasonable power consumptions. Also, for an industrial application that needs more concentration of ozone gas, the choice of high voltage with high frequency power supply is much more attractive configuration due to the ozone concentration obtained.

Allan Flores-Fuentes et al (2009) gives a model of the typical dielectric barrier plasma discharge at atmospheric pressure, structured as an equivalent electric circuit whose elements are identified with, and deduced from, the main influential variables of the process, namely, the applied gas, the geometry of the reactor, the breakdown parameters, as well as the power supply associated to the dielectric barrier discharge cell. Considering a parallel-plate reactor and a high-voltage sinusoidal power supply, an electrical
A comprehensive MATLAB/Simulink model has been developed in order to reveal the interaction between these two elements. The main components of this discharge model are: 1) a double dielectric capacitance; 2) a voltage-controlled current source; and 3) a gas capacitance associated to the ionized gas. The flexibility of the proposed model enables one to adjust several parameters like the applied power, the $\alpha$ factor, and the breakdown voltage $V_b$ in order to obtain a faithful simulation outcome. External model parameters such as the excitation frequency and applied voltage amplitude $\nu_\text{S}(t)$ can also be changed so as to check their effects on discharge parameters like the breakdown voltage $V_b$, total voltage $\nu_\text{T}(t)$, current $i_\text{T}(t)$, and, in particular, those which are not measurable in the real process such as the dielectric voltage $\nu_\text{d}(t)$ and the gas voltage $\nu_\text{g}(t)$. These advantages considerably facilitate the design of an appropriate HV power supply for DBD applications.

Pal et al (2010) says that Dielectric Barrier Discharges (DBDs) are characterized by the presence of at least one insulating layer in contact with the discharge between two planar or cylindrical electrodes connected to an AC/pulse power supply. The dielectric layers covering the electrodes act as current limiters and prevents the transition to an arc discharge. DBDs exist usually in filamentary mode, based on the streamer nature of the discharges. The main advantage of this type of electrical discharges is that non equilibrium and non-thermal plasma conditions can be established at atmospheric pressure. VUV/UV sources based on DBDs are considered as promising alternatives of conventional mercury-based discharge plasmas, producing highly efficient VUV/UV radiation.

The experiments have been performed using two coaxial quartz double barrier DBD tubes, which are filled with Xe / Ar at different pressures. The experiments have been performed using argon and xenon DBD tubes. The discharges are analysed in the coaxial DBD cell filled with argon and
xenon and are found to be filamentary and homogeneous respectively. An electrical circuit has been proposed to analyze internal electrical parameters for the efficiency improvement of DBD sources. For this, equations based on the equivalent electrical circuit have been formulated. The dynamic behaviour of discharge has been studied. An analogous model for the proposed electrical circuit has been implemented in the MATLAB / Simulink. A good correlation has been achieved between the dynamic behaviour of the discharge characteristics evaluated with the simulation model and experimental values.

Cheng Zhang et al (2010) elaborates on a comparative study of experiment and simulation on dielectric barrier discharge driven by 50 Hz AC power in atmospheric air. A dynamic electrical model for a plane-parallel DBD configuration is presented and the model contains a CCS to represent the micro discharges in the gap. The effect of voltage amplitude, gap spacing, and barrier thickness on the characteristic of DBD is investigated, and it is shown that all the simulated results are consistent with the experimental data. The study shows that the electrical model is a useful tool for the relationship between the reactor configuration and electrical parameters of DBD using 50 Hz AC power.

Nisoal et al (2010) says high-voltage high-frequency power supply using voltage-fed load resonant inverter with a series-compensated resonant inductor has been developed for efficient atmospheric surface glow barrier discharges (ASGBD). It produces a controllable frequency and sinusoidal alternating voltage output. The maximum output voltage is about 6 kV peak to peak. Resonant power converter can be tuned easily to the resonant frequency of the load. Operating frequency varies according to the load and voltage level typically in the range of 10 kHz and 1 MHz range. The output voltage is controlled by using pulse width modulation technique. The capacitive load RLC resonant circuit with square voltage signal input is
examined. At resonant frequency the load responds to the fundamental frequency in Fourier series expansion for the square wave. The detailed configuration of the high-voltage high-frequency resonant inverter with a series-compensated resonant inductor power supply which produces a controllable frequency and sinusoidal voltage output is discussed.

Leung et al (2010) the 3 phase Solid State Transformer (SST) is one of the key elements in the Future Renewable Electric Energy Delivery and Management (FREEDM) System where the center is headquartered on NC State University’s Centennial Campus. One of the main purposes of the Solid State Transformer is to step up or down the voltages in the power system at higher frequency than the conventional 60 Hz frequency transformer, to achieve a reduction in size while maintaining high efficiency and high reliability merits. To transform the voltages at high frequency, the Solid State Transformer needs to consist of a rectifier, dual active bridge converters, a high frequency transformer and an inverter. There are two purposed topologies for the 3 phase transformer and each topology is designs at 3 kHz and 20 kHz, therefore the design of electromagnetic, thermal and mechanical analysis of the 3 phase transformer are conducted in this thesis. The proposed design of the transformer applications are validated with the simulation of Finite Element Analysis software. A conclusion ends with a comparison of advantages and disadvantages between the transformer designs to find the best application for the 3 phase Solid State Transformer project.

Falcones et al (2010) A comparison of six representative topologies for the implementation of Solid State Transformers (SST) is performed. The objective is to help identify the most suitable topology capable of supporting additional functionalities as compared to a regular transformer, e.g. on-demand reactive power support to grid, voltage regulation, and current limiting. The comparison is based on switch loss, switch count, control
characteristics and supported functionalities. It has been concluded that a three-stage configuration comprising distinct AC-DC, DC-DC and DC-AC stages results in the most suitable implementation. A Simulink model corresponding to this three-stage configuration is developed to demonstrate the desired characteristics and functionalities of the SST.

Seunghun Baek Yu Du et al (2010) SST will allow reduction of size and weight by replacing bulky conventional transformers at frequency 60 Hz with the multi-stage converters which utilizes high frequency transformer. Operation in high frequency simply makes the transformer compact and light, but there exist many other restraints as well for the high voltage application like dry-type 12 kV SST. Additionally, the leakage inductances of the transformer in a soft switching dual active bridge (DAB) DC-DC converter play an important role as an element to determine the amount of transfer power, therefore comprehensive electromagnetic analysis is necessary to optimize the system. Here he examines entire design procedure and electromagnetic analysis of transformers at operating frequency of 3 kHz for a DAB DC-DC converter with insulation to support high voltage and also covers prospective design at operating frequency of 20 kHz with another structure eventually targeted with development of high voltage and high frequency capability devices. Three different case studies are conducted and compared to find the best fit for this specific application and the pros and cons are discussed at the end. Simulation result of Finite Element Method (FEM) and experiment results are provided to confirm the validity and availability of the proposed designs. He states that the partial discharge high voltage insulation test at voltage 15 kV is to be done and high frequency and high voltage transformer to prevent electric discharge and high voltage issues care should be taken.
Sainct et al (2011), carried out in synthetic air at atmospheric pressure with four different power sources applied to a DBD reactor. The ozone production has been chosen to monitor the chemical efficiency of the power sources. In this experiment, the power measurement is the critical parameter, for which the compensation between the voltage and the current signals delay has been taken into account carefully. At a fixed frequency (1800 Hz), the discharges with very short rise time are found to improve the ozone generation efficiency. This is consistent with simulations that show that a discharge with a high reduced electric field is expected to be more efficient. Further investigations are underway in order to verify these experimental facts and quantitatively refine the physical interpretation.

Fernando et al (2011) illustrate the Nitric oxide is generated by anthropogenic activities such as combustion and is generally regarded as a hazardous pollutant. It is focuses on the gas-phase oxidation of Nitric oxide by ozone under typical diesel exhaust concentrations. Experimental studies were conducted in which a stream of NO was mixed with ozone in a tubular reactor.

From the survey the following finding are evident: there was no increase of the O$_3$/NO concentration ratio beyond 1.5 at reaction temperatures of 200°C and 300°C. A rapid reaction was observed for residence times of up to 150sec, and the system reached approximately constant nitric oxide concentrations after 150sec of reaction time. The highest conversion rate achieved was 98% at this point. It was observed that the optimal residence time for the reaction of nitric oxide with ozone was 150 sec at 200°C to 300°C when an O$_3$/NO concentration ratio of 1.5 were used. It is expected that higher O$_3$/NO ratios would lead to excess ozone remaining in the system, making this excess portion ineffective for NO oxidation. The study focused on the oxidation of nitric oxide by ozone inside a reactor. The experiments were conducted to study the effects of temperature, residence time and O$_3$/NO concentration ratio.
The results showed that the optimum temperature of 200°C was favorable for achieving high conversion rates of nitric oxide. An optimal residence time of 150 sec was also required to achieve a high oxidation rate. It was also noted that oxidation reactions proceeded most rapidly with an O₃/NO ratio of 1.5. A Response Surface Methodology (RSM) approach was used to obtain the optimum parameters for the oxidation of nitric oxide with ozone. A quadratic model was proposed based on the central composite design (CCD). The significant factors affecting oxidation rate were found to be temperature, residence time and O₃/NO concentration ratio.

The optimal operating conditions obtained from the Design of Experiment software were 200°C with a residence time of 204 sec and an O₃/NO concentration ratio of 1.5. These conditions resulted in a nitric oxide conversion rate of 97%. A reliable pulsed high voltage source has been developed for high efficiency ozone generator. In order to obtain a long life time of the rotating spark gap switch, various electrode materials have been tested experimentally.

Following conclusions were obtained. Sintered tungsten with thorium dioxide has the smallest erosion rate among the materials tested in the experiment and its value is about 0.078 mg/h at the ozone generation rate of 20 gm. The erosion rate of the switching materials was measured for 2 months continuous operation period of the ozone generator.

In order to obtain longer life time, the electrode surface should be flat and the surface area should be large. A high voltage source generating the fast rising square wave voltage will be developed for high efficiency ozone generator. The voltage source incorporates a rotating spark gap switch. Life time of the voltage source is determined by erosion of the spark gap switch.
2.2 INFERENCE

As ozone is used extensively for many commercial and Industrial applications, a comprehensive study is needed, based on the literature survey, establishing various operative parameters which influence the improvement of ozone concentration and ozone production is carried out in this work.