CERTIFICATE

This is to certify that the work contained in the thesis entitled **"Exergy & Energy Analysis of Three Stage Cascade Refrigeration System for Biomedical Application using Natural Refrigerant"** by **Mr. Rahul Kumar** in partial fulfillment of the requirements for the award of the degree of Master of Engineering in Thermal Engineering has been carried out under my supervision.

Date: 25-05-2012

Place: New Delhi

(Dr. R.S.Mishra)
Professor
Department of Mechanical Engineering
Faculty of Technology
University of Delhi

STUDENT DECLARATION

I hereby certify that the work which is being presented in the major project entitled **"Exergy & Energy Analysis of Three Stage Cascade Refrigeration System for biomedical applications Using Natural Refrigerants"**, in partial fulfillment of the requirements for the award of the degree of Master of Engineering in Thermal Engineering, is an authentic record of my own work carried under the supervision of **Dr R. S. Mishra Professor** of Mechanical Engineering Department, University of Delhi, Delhi.

I have not submitted the matter embodied in this major project for the award of any other degree.

Rahul Kumar
ME (Thermal)
Univ. Roll No: 14051

ACKNOWLEDGEMENT

"If brain is the nucleus of thoughts, teacher is the source of energy to run the operation of solving cross puzzles of doubts that often poise the mind of students."

It is my privilege to express my deep sense of gratitude and sincere thanks to my able and versatile guide **Professor** (**Dr.) R.S.Mishra** for his invaluable guidance. I am highly indebted for his critical discussion and continuous encouragement. His critics and suggestions on my experiments have always guided me towards perfection. Moreover, his ways of analyzing the results have given a new dimension to my scientific aptitude. This work is simply the reflection of his thoughts, ideas, concepts and above all his efforts. Working under his guidance has been a privilege and an excellent learning experience that I will cherish for a long time.

I would also like to express my deep gratitude to Professor B D Pathak, Professor Samsher, Professor S.Maji, Professor Naveen Kumar & Professor S K Garg , Mechanical Engineering Department, Delhi College of Engineering, Delhi, for his moral support and help whenever needed.

My special thanks to all the faculty members and friends for their continuous support, motivation and enthusiastic help in every difficult situation of this work.

Finally, the blessing of God, the love, care, expectations and encouragement from my parents and family have invaluable contribution in successful completion of my degree.

Date: 25-05-2012 **(RAHUL KUMAR)**

Place: New Delhi Roll No. 16/THR/08

Univ. Roll no.-14051

ABSTRACT

Biomedical preservation requires the temperature for the storage of stem cell, blood, sperm & organs at a storage temperature of below -80°C.We can achieve effectively cooling of about -35°C with the help of simple vapour compression refrigeration system. With the help of compound vapour compression refrigeration system, temperature up to –50 °C is achievable.

The cascade refrigeration system is widely used where low temperatures are needed. The natural refrigerant CO2 makes it possible to achieve temperatures as low as -54°C in the low temperature stage. In this case propene is the refrigerant for the upper cascade stage.Using other refrigerants (e.g. ethane) in low temperature circuit temperatures as low as -88^{o}C can be realized.

So the required evaporating temperature below -80 °C can be achieved by cascade refrigeration system.

Present work deals with thermodynamic analysis of cascade refrigeration system using ozone friendly hydrocarbon refrigerants Iso-butane (R-600a), Propane(R-290) & Ethane (R-170). Iso-butane (R-600a), Propane (R-290) & Ethane (R-170) are the natural refrigerants. These are hydrocarbons. These refrigerants are used as replacement to CFC refrigerant in low temperature applications. These refrigerants have zero ozone depletion potential and less global warming potential. Hydrocarbons are flammable but non toxic. System with charge mass sizes of 0.15 kg or less can be installed in any size of room. Since these

refrigerants are pure natural gases, there is no problem of temperature glide as it occurs in azeotropic mixture.

This study deals thermodynamically analysis of R-600a, R-290 & R-170, three stage cascade refrigeration system to optimize the operating parameters of the system. The operating parameters include: Condensing, evaporating, sub cooling and superheating temperatures in the high temperature circuit, temperature difference in the cascade heat exchanger, Condensing, evaporating, sub cooling and superheating temperatures in the low & medium temperature circuit.

This article presents a thermodynamic analysis to optimize a cascade refrigeration system to be used for biomedical cold-storage application. It can also be used successfully for rapid freezing and storage of frozen food and liquidification of petroleum vapor. A combination of hydrocarbon refrigerants i.e. Isobutene, Propane and Ethane–(R600a, R290 & R170) cascade system has been promoted as a prospective alternative solution to the use of HFC refrigerants.