



DESIGN AND THERMAL ANALYSIS OF IC ENGINE PISTON WITH AND WITHOUT CERAMIC COATING

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ABSTRACT

A piston is a disc that reciprocates within a cylinder. Piston is moved by the mixture of Air and Fuel or it moves the mixture of Fuel and Air which enters in to the combustion chamber of cylinder. The main application or use of the piston of an Internal Combustion Engine External Combustion Engine is to take the impulse from the expanding gases and to transmit the energy to the crank shaft through the connecting rod. The piston must also transfer a huge amount of heat from the combustion chamber to cylinder walls. The Aluminium, Cast iron, and Cast Steel etc. are the most commonly used materials for making the piston of an Internal Combustion Engine. In this project we took steel is an existing material and aluminium is another material. Here the materials used are Aluminium alloy and steel. The best material to manufacture the piston is selected with the help of Finite Element Method. In this project we use Aluminium alloy as the piston material. In this we design two designs and we analyze both of them.

In order to get the better results we are going to add 0.4 mm ceramic layer which is made up of Zirconium on the top of the piston. The piston with and without coating is analyzed with the same conditions of the combustion chamber and calculate results like stress, safety factor, deformation, total temperature and heat flux etc. The main aim or objective of the piston investigation is to analyze the thermal stress distribution of the piston at the real engine conditions during the combustion process inside the cylinder. In this analysis process we applied temperature and convection process as boundary conditions and we determine the total temperature on the piston and total heat flux values.

Keywords: Aluminium alloy, cast iron, cast steel.

1.0 INTRODUCTION:

Practically reviewed materials are of across the board intrigue on account of their prevalent properties, for example,

consumption, disintegration and oxidation resistance, high hardness, compound and warm steadiness at cryogenic and high temperatures. These properties make them valuable for some of the applications, including Thermal Barrier Coating - TBC on metallic substrates utilized at high temperatures in the fields of air ship and aviation, particularly for warm assurance of segments in gas turbines and diesel motors. The utilization of TBC decreases the warmth misfortune to the motor cooling-coat through the surface presented to the warmth exchange, for example, the chamber head, liner, cylinder crown and cylinder rings. The protection of the burning chamber with fired covering influences the ignition procedure and, consequently, the execution and fumes outflows qualities of the motors move forward. Then again, the want of expanding the warm effectiveness or diminish fuel utilization of motors prompts the reception of higher pressure proportions, specifically for diesel motors, and lessened in-chamber warm dismissal. Both of these components cause expanded mechanical and warm worries of materials utilized as a part of ignition chamber.

The use of TBC to the surfaces of these segments improves high hot strength or high temperature strength by decreasing the warmth exchange and bringing down the temperature of the fundamental metal. Run of the mill TBCs disappointment is by

spalling of the artistic best coat from the bond coat. **Applications:**

The primary fruitful utilization of the free-cylinder motor idea was as an air compressor. In these motors, air compressor barrels were coupled to the moving cylinders, frequently in a multi-arrange design. Some of these motors used the air staying in the compressor barrels to restore the cylinder, in this manner disposing of the requirement for a bounce back gadget. Free-cylinder air compressors were being used among others by the German Navy, and had the upsides of high effectiveness, conservativeness and low clamour and vibration.

2.0 LITERATURE REVIEW:

1. Mr. G.S. and Mr. Sherman A.M in 1995 The cast press cylinders were superseded by aluminum compound cylinder around the year Cole clarified that an extensive intrigue had been developed in supplanting cast iron and steel in car segment like cylinder with lightweight aluminum amalgam throwing to enhance the execution and effectiveness.

2. Mr. Haque M.M and Mr. Youthful J.M in 2001 Alluded the low extension gathering of aluminum– silicon combination as cylinder compound, since this gathering of composite gives the best general adjust of properties. Close eutectic aluminum silicon cylinder compound display complex weakness conduct due to their multi part microstructure.

3. Mr. Hanbey Hazar "Portrayal of MoN coatings for cylinders in a diesel engine" Materials and Design Volume 31, Issue 1, January 2010 In this examination, the surface of a cylinder in a diesel motor was covered with molybdenum nitride (MoN) by utilizing the circular segment PVD strategy, and its surface conduct was accordingly dissected. Investigations of miniaturized scale hardness, SEM, X-beam and surface harshness were completed so as to look at

surface attributes of cylinders. It is discovered that the hardness of covered cylinder is 2000 ± 400 HV while hardness uncoated cylinder 123 HV. The outcomes indicate less disfigurement and less scratches because of wear on the MoN-covered cylinder when contrasted with uncoated one.

4. Mr. Ekrem Buyukkaya "Warm examination of practically evaluated covering AlSi alloy and steel cylinders" Volume 202, Issue 16 15 May 2008 Practically reviewed coatings are covering frameworks used to build exhibitions of high temperature parts in diesel motors. These coatings comprise of a progress from the metallic bond layer to cermet and from cermet to the earthenware layer. In this examination, warm conduct of useful reviewed coatings on Al-Si and steel cylinder materials was explored by methods for utilizing a business code, to be specific ANSYS.

5. Mr. Ravindra Prasad, N.K. Samria "Transient warmth move investigation in a inside ignition motor cylinder" Computers and Structures Volume 34, Issue 5, 1990 In this paper, the isothermic dissemination in the cylinder body and warmth stream rates to cooling water and air beneath the cylinder at four distinctive motor burdens are portrayed for cases both with and without protection covering. The outcomes show a 6% decrease in warm misfortune through the cylinder with the utilization of a protection covering on the barrel divider

6. Mr. Taymaz, K. Çakır, A. Mimaroglu "Test investigation of compelling efficiency in an earthenware covered diesel motor" Surface and Coatings Technology Volume 200, Issues 1– 4, 1 October 2005 The burning chamber surfaces (barrel head, valves and cylinder crown faces were covered with earthenware materials. Clay layers were made of CaZrO₃ and MgZrO₃, by utilizing plasma-covering strategy onto



the base of the NiCrAl security coat. The earthenware covered research motor was tried at an indistinguishable conditions from the standard (without covering) motor. The outcomes demonstrated a decrease in warm misfortune to the coolant and an expansion in compelling proficiency.

3.0 INTRODUCTION TO CATIA & ANSYS

CATIA began as an in-house advancement in 1977 by French air ship producer Mr. Avions Marcel Dassault, around then client of the CADAM programming to build up Dassault's Mirage contender fly. It was later embraced in the car, aviation, shipbuilding and different enterprises.

CATIA is planning programming which is utilized to outline the items in 3D. It is a Computer Aided Design remains for CAD programming. The principle CAD delicate products are two sorts one is parametric another is non-parametric programming. Illustrations are AutoCAD, ProE, UniGraphics, CATIA and Solid Works. CATIA and ProE are the parametric software's.

CATIA remains for Computer Aided Three Dimensional Interactive Application. It is Well known programming for 3D outlining and demonstrating for various complex shapes. Normally alluded to as a 3D Product Lifecycle Management programming suite, CATIA programming underpins different pages of an item advancement i.e. CAX, including conceptualization, Design-CAD, Engineering-CAE and assembling CAM.

CATIA encourages cooperative building crosswise over orders around its 3DEXPERIENCE stage, including surface and shape outline, electrical, liquid and electronic framework plan, mechanical designing and frameworks designing.

CATIA encourages Designs of every department like electrical, electronic circulated Frameworks in an easy way. That

is why we prefer Catia for Many designing problems.

Description about ANSYS

ANSYS is business Finite Element Analysis – FEA programming bundle. Limited Element Analysis is a numerical technique for deconstructing an unpredictable framework into little pieces (of client assigned size) called components. The product executes conditions that oversee the conduct of these components and unravels them all; making a far reaching clarification of how the framework goes about all in all.

These outcomes at that point can be exhibited in classified or graphical structures. This sort of investigation is ordinarily utilized for the plan and advancement of a framework very mind boggling to explain logically. Frameworks that may fit into this class are excessively unpredictable due, making it impossible to their geometry, scale, or administering conditions.

Why to Use ANSYS?

ANSYS gives a financially savvy approach to investigate the execution of items or procedures in a virtual situation. This sort of item improvement is named virtual prototyping. With virtual prototyping methods, clients can repeat different situations to streamline the item well before the assembling is begun. This empowers a diminishment in the level of hazard, and in the cost of incapable outlines.

4.0 MODELING AND MESHING

The geometric displaying should be possible by the help of PC supported programming resembles SolidWorks, Pro-E, and Catia and Auto Cad. In this examination the model or prototype is designed with the help of Catia V5 and the design is spared as step document or iges record. Iges record is having less information misfortune when contrasted with other document groups. When display is created in Catia, the record

is sent out from Catia in the required arrangement for facilitate examination.

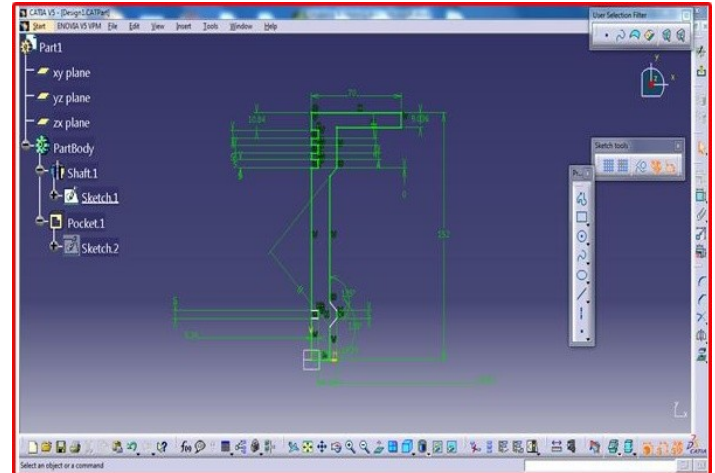
Modeling of Piston Design

The cylinder is outlined by the methodology and determination which are given in machine plan and information hand books. The measurements are computed as far as SI Units. The weight connected on cylinder head, temperatures of different territories of the cylinder, warm stream, stresses, strains, length, distance across of cylinder and gap, thicknesses, and so forth., parameters are thought about

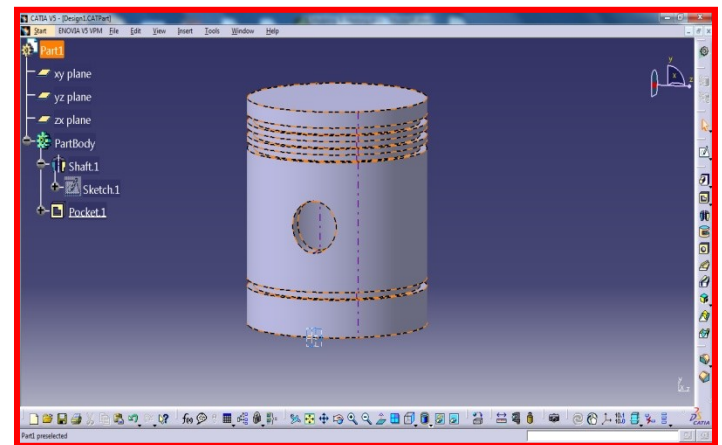
Design Considerations for a Piston

In outlining a cylinder for a motor, the accompanying focuses ought to be mulled over:

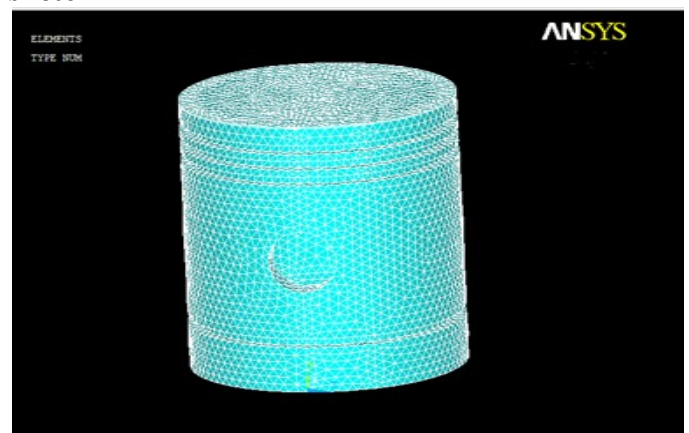
- It should have tremendous quality to withstand the high weight.
- It should have least weight to withstand the inactivity powers.
- It should shape viable oil fixing in the barrel.
- It should give adequate bearing zone to avert undue wear.
- It should have fast response without commotion.
- It must be capable of adequate unbending development to withstand warm and mechanical contortions.
- From the sketcher environment, the plane XY is selected as the basic sketch plane. From the profile toolbar the required sketch is constructed as follows



Sketch of Piston in CATIA



3D Model of Piston by revolving the sketch

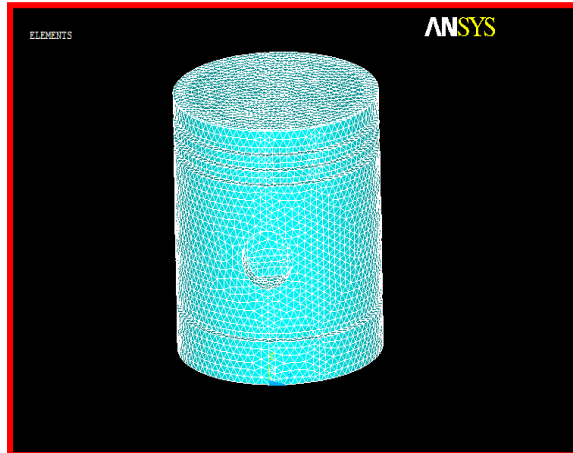


Piston after Free Meshing

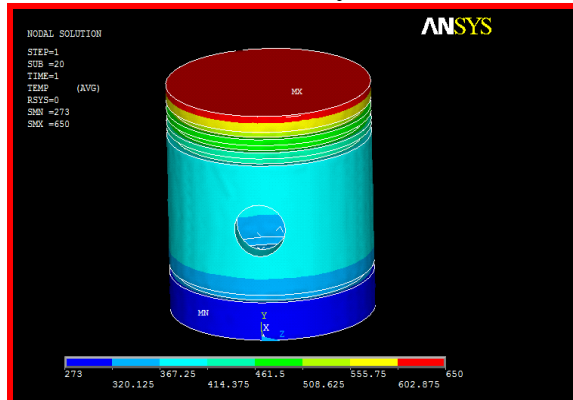
5.0 ANALYSIS RESULTS & DISCUSSIONS

Examination is the way toward breaking an intricate theme or substance into littler parts to pick up a superior comprehension of it. The present model is experienced Thermal

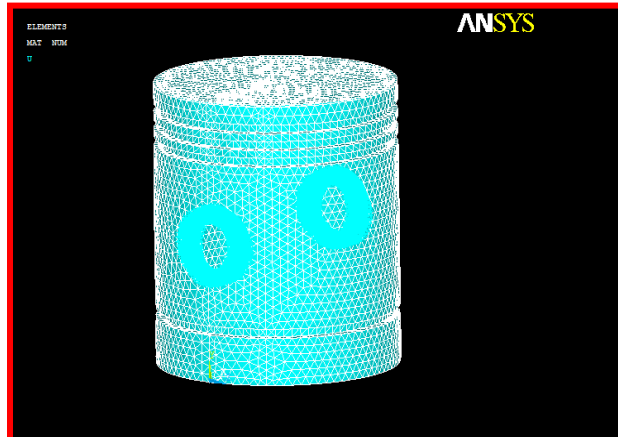
Analysis and took after by Static Analysis, together called as Coupled Filed Analysis. The Steps required with the warm examination are clarified as underneath.



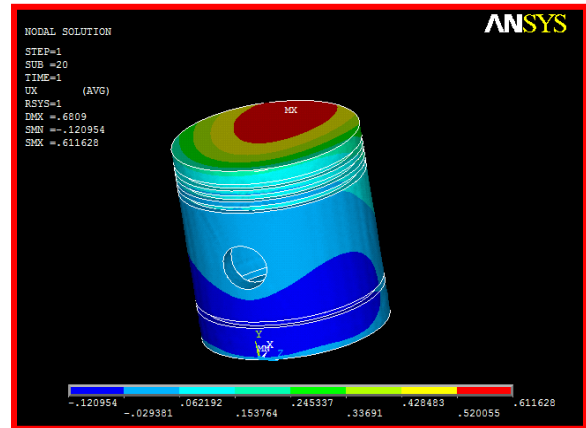
Piston for Thermal Analysis



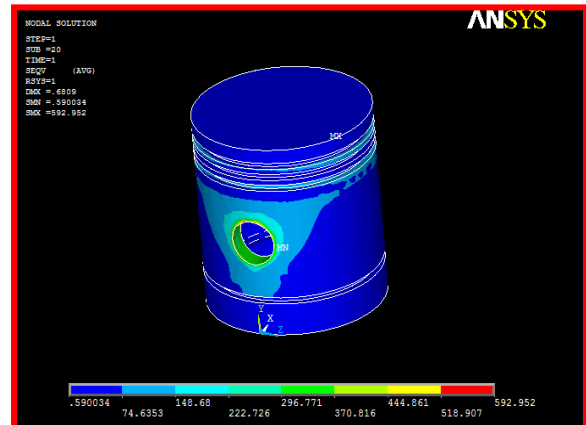
Temperatures at Different Nodes after Thermal Analysis



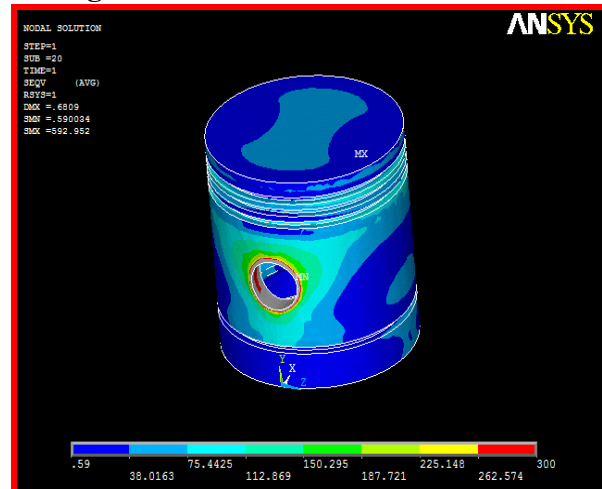
Piston for Static Analysis



Displacement of thepiston without coating in X-direction



Vonmises Stress plots of the piston without coating

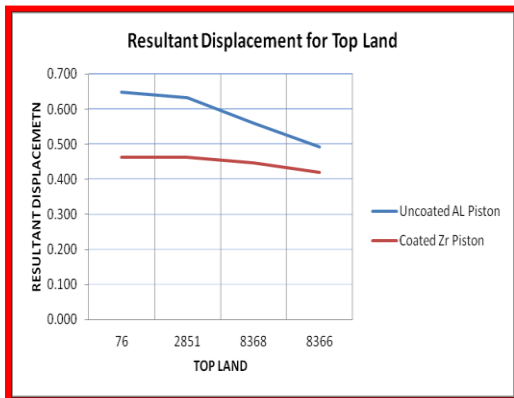


Fringe plot of Vonmises Stress plots of the uncoated piston

6.0 CONCLUSIONS

A limited component model of the cylinder with and without fired covering layer is made in ANSYS and dissected in the impact of thermal load on the best surface of the cylinder. The outcomes are investigated and finished up as takes after

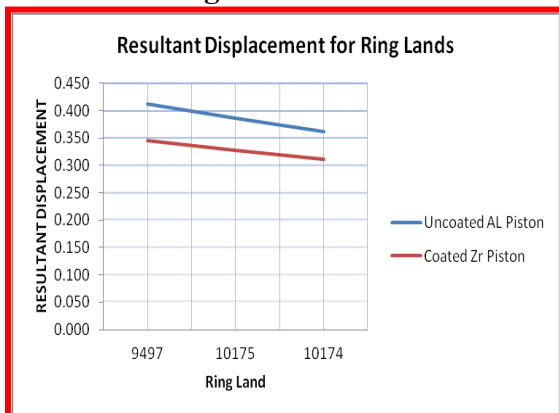
Comparison of Results for Piston with and without Ceramic coating Resultant Displacement comparison for Top Land of Piston with and without Ceramic coating



Resultant Displacement comparison for Top Land of Piston with and without Ceramic coating

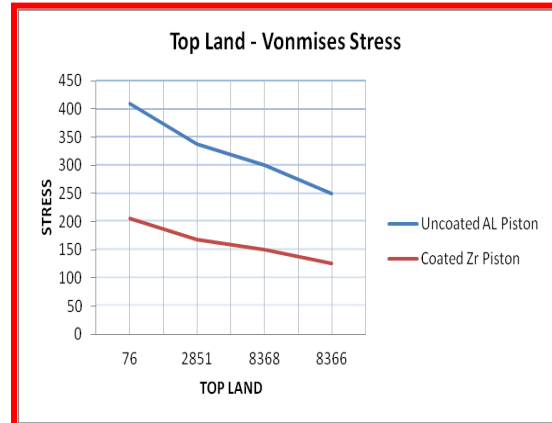
From the above graph it can be concluded that coated zirconium piston has less resultant displacement when compared to the Al Piston without ceramic coating.

Resultant Displacement comparison for Ring Land of Piston with and without Ceramic coating



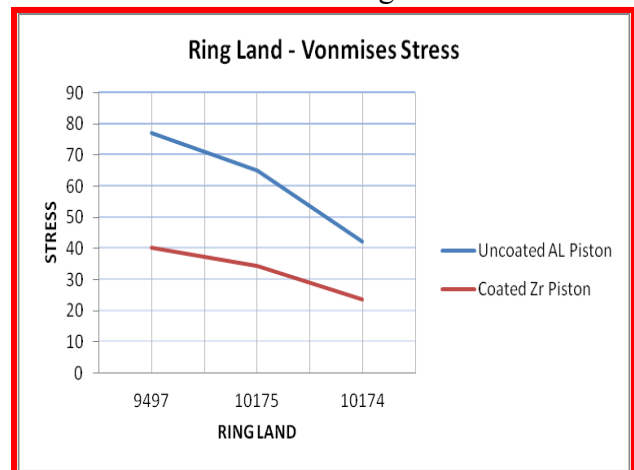
Resultant Displacement comparison for Ring Land of Piston with and without Ceramic coating

From the above graph it can be concluded that coated zirconium piston has less resultant displacement when compared to the Al Piston without ceramic coating.



Vonmises Stress comparison for Top Land of Piston with and without Ceramic coating

From the above graph it can be concluded that coated zirconium piston has less resultant Vonmises Stress when compared to the Al Piston without ceramic coating.



Vonmises Stress comparison for Ring Land of Piston with and without Ceramic coating

From the above graph it can be concluded that coated zirconium piston has less resultant Vonmises Stress when compared to the Al Piston without ceramic coating.

CONCLUSIONS

1. When we contrast Coated Aluminum cylinder and uncoated cylinder, the covered piston has the great outcomes those are:

- Less removal or disfigurement for covered Zr Piston
- Less Vonmises Stresses on covered Zr Piston

2. The warm worries of both covered and uncoated cylinders are acquired and thought about. The most extreme warm weight on Zirconium covered cylinder is low when contrasted with the greatest warm anxiety acquired on the uncoated aluminum cylinder.

3. The Contour plots for the distortions and additionally for stresses as of now appeared in the before part. As the warm anxieties are lessened, the warmth move in the cylinder is additionally diminished bringing about expanded burning which should come about with the expansion in motor power and that builds the motor proficiency.

4. Friction is likewise lessened and because of more warmth over cylinder finish ignition happens and subsequently it diminishes particular fuel utilization and it decreases the un consumed carbon discharges this lessens the contamination.

FUTURE SCOPE OF THE WORK

The proficiency of diesel motor can be expanded by utilizing of earthenware

covering technique however it is hard to perform it tentatively. At the point when clay covering is utilized as a part of IC motor, the distinctive sorts of down to earth issues are happen, for example, warm befuddle because of uncalled for grip and contrast in warm extension coefficient between bond coat and cylinder materials and it needs to withstand with wear and tear. In future attempt to grow new material or select appropriate material to keep away from the above.

REFERENCES

1. Mr. Ekrem Buyukkaya, "Warm Analysis of practically evaluated covering AlSi amalgam and steel cylinders", *Surface and coatings innovation* (2007)
2. Mr. Reinhold H. Dauskardt, "Warm BARRIER COATINGS" (1999).
3. Mr. M. Foy, Mr. M. Marchese, Mr. G. Jacucci, *Engineering plasma shower movies by knowledge based recreations procedures of IFIP meeting on*, in: Arthur B. Baskin, et al., (Eds.), *Cooperative Knowledge Processing for Engineering Design*, Kluwer Academic Publishers, The Netherlands, 1999, p. 289.
4. Mr. J.S. Lee, Mr. T. Matsubara, Mr. T. Sei, Mr. T. Tsuchiya, Mr. J. Mater, *Preparation and properties of Y2O3-doped ZrO2 thin movies by the sol-gelprocess*, *Coating Technology* (1997).
5. Mr. J.N.Reddy, "A prologue to limited component examination".
6. Mr. Zhang T, Mr. Xu L, Mr. Xiong W. *Exploratory research on the warm contact resistance between Cu-Cu in vacuum and low temperature*. *Cryogenics*, 1999.