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Highlights

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Internal Combustion Engine

Analysis of Filament Wound

Discovering Thoughts, Inventing Future

VOLUME 14 ISSUE 2 VERSION 1.0

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Mechanical and Mechanics Engineering

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Selection of Precise vacuum Pumps for the Systems with Diverse Vacuum Ranges

By H. M. Akram
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Abstract- Basically a vacuum pump is the most essential component of any vacuum system which is accountable to bring into being the required vacuum in the sealed setup, to accomplish a certain process. But for the broad vacuum range, all the vacuums cannot be generated by a single vacuum pump. Consequently, various pumps of distinct types are used to properly generate the vacuum of diverse ranges. Therefore, the selection of suitable vacuum pump or pumps to produce the required vacuum, for a particular vacuum work, is of primary importance. There are many factors that affect the suitable pump selection. In this paper, proper guidelines highlighting key criteria for selecting an appropriate vacuum pump, supportive for proper vacuum production has briefly been discussed that can make the task of pump selection simpler and exact.

Keywords: selection criteria, vacuum pumps, vacuum systems, diverse ranges.

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Strictly as per the compliance and regulations of:

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H. M. Akram

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I. Introduction

The vacuum technology is indispensable as well as immeasurably used as a parent one for the rapid progress of many other modern and sophisticated technologies, because it is the most useful tool for a common vacuum pool. From its initial association with research in physics, the range of applications has extended to important sectors of industrial activity, including pharmacy, food industry, metallurgy, mechanical, electrical, electronics, mechatronics, chemical engineering, surface engineering, particle acceleration, medical, etc. making an incalculable contribution to process effecttiveness, efficiency and quality. Therefore, it is almost impossible to list all the areas in which vacuum technology is now used. Generally group wise presentation of some vacuum applications in different fields and ranges is shown in Fig.-1[1].

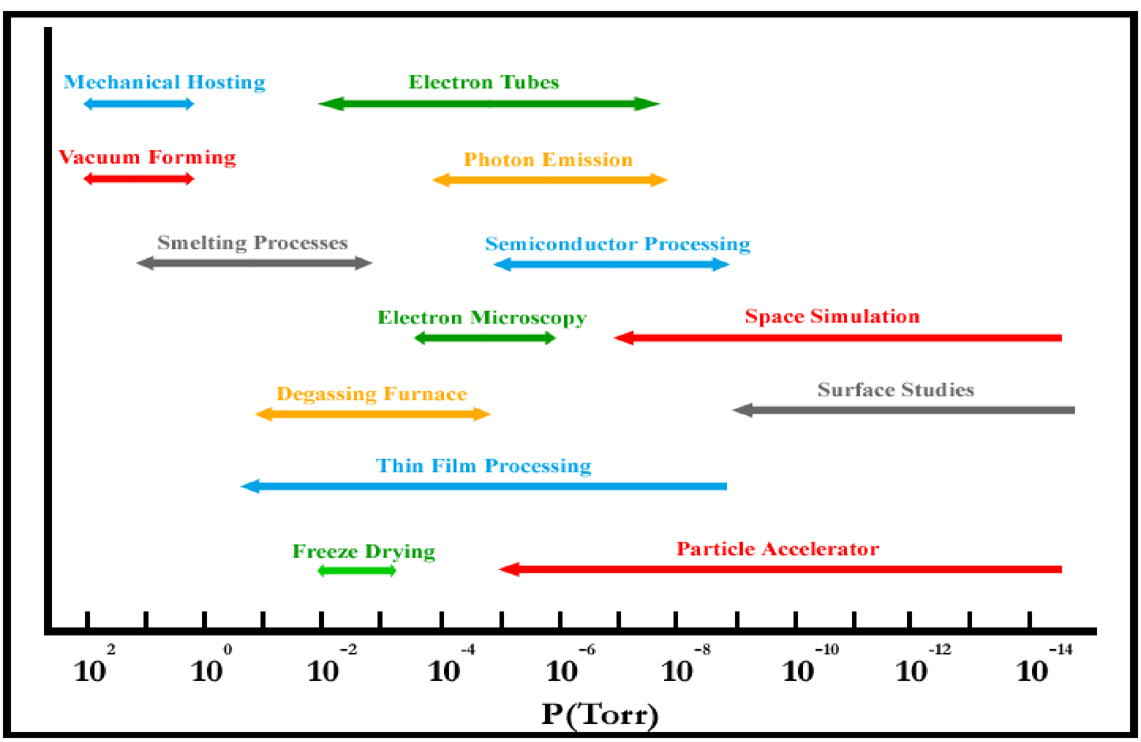

Figure 1 : Vacuum applications in different vacuum ranges [1]

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For all vacuum concern modern and sophisticated technologies, appropriate vacuum generations are as essential as these technologies them selves. So the proper vacuum generation of broad vacuum range is of prime interest and need of the hour. For this purpose, a vacuum pump plays the major role, selection of which is an important and questionable issue. Selecting the right vacuum pump or pumping system for a vacuum process is a complex and challenging task with the realization that no single type of vacuum pump is likely to provide all the characteristics necessary to meet all the process requirements. Vacuum pump selection not only demands a thorough understanding of what you need your vacuum system to do, as important is knowing the impact the selected vacuum pump will have on the overall cost to produce your product, pertaining to cost of ownership and how the selected vacuum pumping system will impact product quality and / or yield [2]. Before the selection of an appropriate vacuum pump for a particular vacuum application, one has to come across a variety of questions which are planned in Fig.-2.

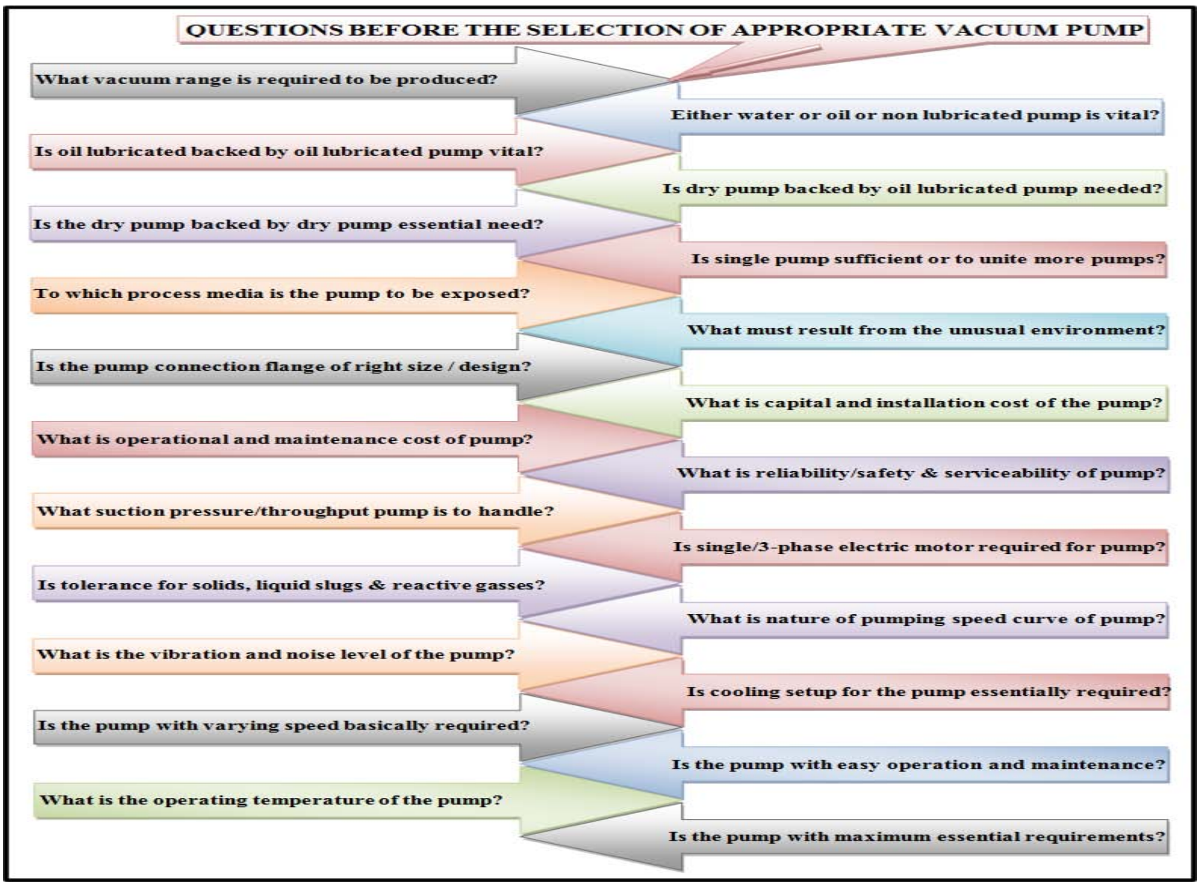

Figure 2 : Questions before the selection of proper vacuum pump

For sealed system the capacity of the vacuum pump is determined by how fast the system of certain volume can be evacuated to a certain vacuum level. This capacity is called the evacuation time of the pump for that volume. For all such considerations, the thorough understanding of vacuum generation technology is essential. Vacuum pumps are used for vacuum generation in the broad vacuum range from atmospheric to Extremely High Vacuum (XHV). Due to some physical reasons, it is not possible to construct a vacuum pump which can generate the vacuums of entire vacuum range. Consequently, a series of vacuum pumps is available, each of which has a characteristic vacuum production range that usually extends over several orders of magnitudes. A variety of pumps have to employ to generate vacuum, depending on its needed range. These pumps normally fall into three different main groups: positive displace pumps, momentum transfer pumps and local entrapment pumps. A graph of molecular density versus vacuum quality, gives up a straight line, consequently defining different vacuum levels: 'Low Vacuum', 'Medium Vacuum', 'High Vacuum', Ultra High Vacuum' & 'Extremely Ultra High Vacuum' and corresponding pump operation regions: 'positive displacement region', 'mentum transfer region' and 'local entrapment region', as shown in Fig.-3 [3]. Due to the diversity of vacuum ranges and pump regions, selection of appropriate pump for a particular region is critical.

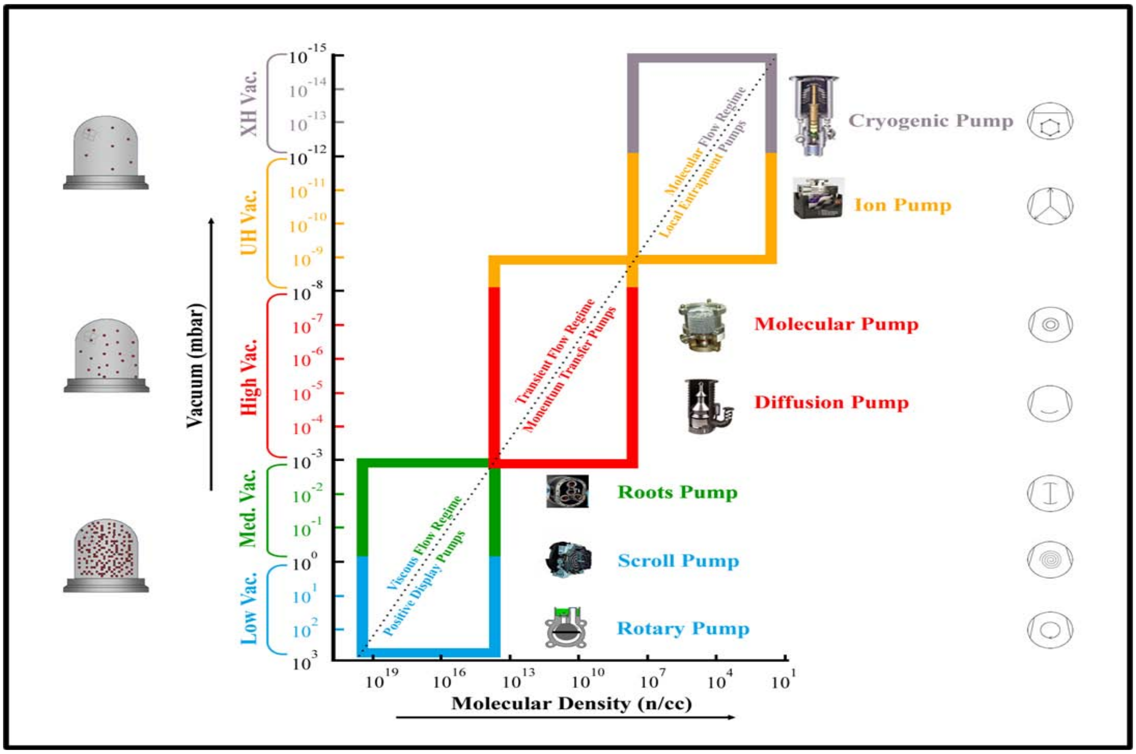

Figure 3 : Pump classification on the basis of degree of vacuum and molecular density [3]

II. Selection of Vacuum Pumps

To meet the requirements of vacuum system entirely, proper pump selection is crucial as vacuum pump has to meet up some well-studied criteria. Several factors affect proper pump selection process and by following it appropriately, the task becomes simpler and more specific. Let us now discuss some of the vacuum pumps widely employed for industrial use as well as R&D and other purposes. Special steps regarding this selection process have briefly been discussed in the manner:

a) Process Vacuum Range

Vacuum pumps can be grouped by the pressure range they measure. Diverse vacuum ranges are shown in Fig.-3. Categorically, a pump has to generate the vacuum of specific range for a particular vacuum system. For this purpose, it is essential to select the pump according to the process range of the system. For all vacuum applications, pumps are selected that are more suitable for these applications. Selection criteria of various pumps for varied vacuum ranges are briefly discussed on basis of the concept given in the graph of Fig.-3 as well as taking into consideration other relevant parameters and requirements of particular vacuum systems.

b) Pumps for Low/Medium Vacuum

The pumps used to generate the low/medium vacuum in viscous flow are usually positive displacement mechanical vacuum pumps. Viscous flow is feasible only when there is a bulk of gas molecules, and if one part of the bulk is removed, the remaining one comes to fill its space. During the evacuation process when the bulk of gas molecules reduces, the pumping speed of the pump decreases simultaneously and ultimoately becomes almost zero at the reduced pressure. To focus the stepwise discussion, we will first concentrate mainly on vacuum pumps capable of producing low vacuum from atmospheric pressure to 1 torr and medium vacuum from a 1 torr to 10^{-3}torr. The mechanical rotary vacuum pumps are positive displacement pumps that move fluids by means of the motion of rotors, cams, pistons, screws, vanes, etc. or mechanical elements in a fixed casing. The mechanical vacuum pump, historically the work horse of the industry is the oil sealed rotary piston vacuum pump. Therefore, the mostly focus is on choosing oil sealed rotary mechanical vacuum pumps [2].

In the early stages of vacuum processing, the rotary vane or piston oil-sealed vacuum pumps provided reliable performance. However, due to the demand of semiconductor, chemical, industrial and other purposes, some vacuum processing problems were soon encountered. The aggressive and hostile gases resulting from these processes demanded radical changes in vacuum pump technology. Initially the responses were the modifications to oil-sealed pumps for increased corrosion resistance, forced lubrication, and the use of expensive inert fluids, filters, traps, etc. Although these improvements did increase the compatibility and reliability of oil-sealed pumps, an alternative was still necessary.

Today, the oil-free swept volume vacuum pumps can be considered as an alternative when one or more of the following characteristics are of prime importance: (i) cleanliness, (ii) safety, (iii) corrosion resistance, (iv) cost of operation, and (v) cost of maintenance [4]. An oil-sealed vacuum pump can contaminate a vacuum system by emitting oil vapor (back-streaming and back-migration) and all lubricated vacuum pumps are potential sources of contamination. The only vacuum pumps which will never contaminate a system with oil are the oil-free pumps or dry vacuum pumps. Some oil-free pumps can be considered as safe due to the absence of oil in their design [2]. Good examples of dry pump are scroll vacuum pumps. Now-a-days many vacuum applications are unthinkable without the use of another dry mechanically driven diaphragm pumps for gases. Their particular properties such as oil-free and uncontaminated operation make them suitable for numerous fields of application [5]. Sometime rapid evacuation of the system is essentially required in the medium vacuum range. For this purpose, a roots vacuum pump in series with suitable mechanical vacuum pumps is essential. Another class of positive displacement pumps commonly known as liquid ring vacuum pumps is constantly becoming more important in modern plant production processes. Their design and principle of operation offers many advantages over other types of rotary gas pumps. Liquid Ring Vacuum Pumps can be used on a very large scale for widely divergent applications. The schematics of some of the positive displacement pumpsare shown in Fig.-4[6].

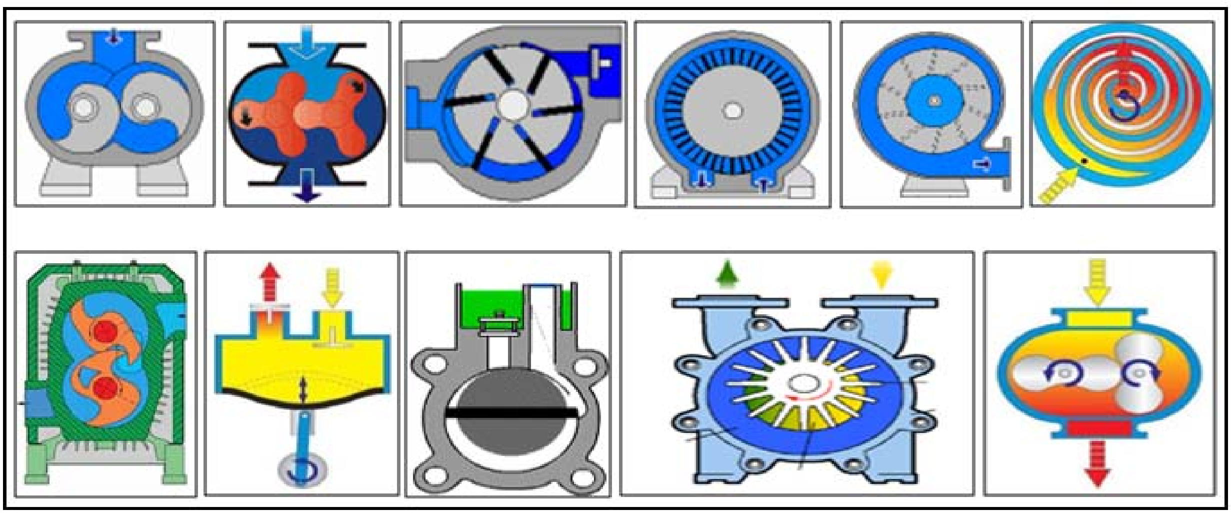

Figure 4 : Schematic of working principle of some positive displacement pumps [6]

Another significant pump of low vacuum range is the ejector vacuum pump, sometimes called a jet pump shown in Fig.-5 It is the simplest and probably most widely used for vacuum production. It works by converting pressure energy of a motive fluid into velocity energy as it flows through a diffuser. The high velocity of the motive fluid through jet nozzle creates the low pressure in the vessel to be evacuated. Ejector offer a range of attractions: Simple design with no moving parts and practically no wear. It can be mounted in any orientation and fabricated of virtually any metal, as well as various types of plastics. It provides largest throughput capacity with lowest capital cost as compared to any vacuum producing device. It does not need any special startup or shutdown procedures and requires simple repair and maintenance.

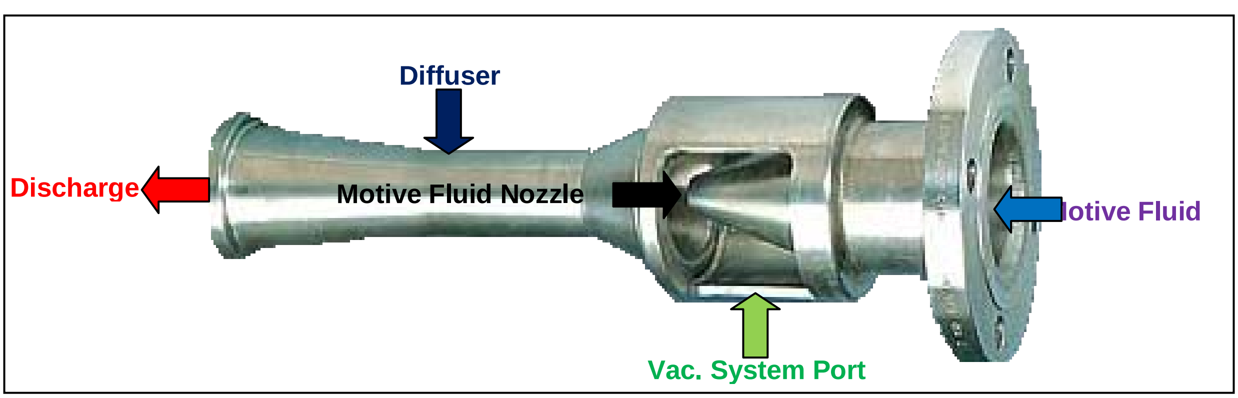

Figure 5 : Schematic of ejector vacuum pump

a) Pumps for High/ Ultrahigh Vacuum

The transient flow regime is with somewhat lesser molecular density and molecules do not behave like a bulk but act as individual particles that need to be removed individually through the process of momentum transfer. The pumps utilizing this process are called momentum transfer pumps. Two pumps in this low density region are of prime interest and are mostly used. First, the oldest one is the oil diffusion pump (backed by rotary pump), with oil or mercury as working fluid, encountering the main problems of back streaming, back migration and contamination. A good alternative, free from all these problems, with better performance, and producing clean vacuum is turbo-molecular pump (backed by dry scroll pump). The momentum transfer is the governing principle in both diffusion and turbomolecular pumps, used for various purposes in high and ultrahigh vacuum range. The schematic showing working principle of oil diffusion pump and turbomolecular pump is given in Fig.-6 and Fig.-7 respectively.

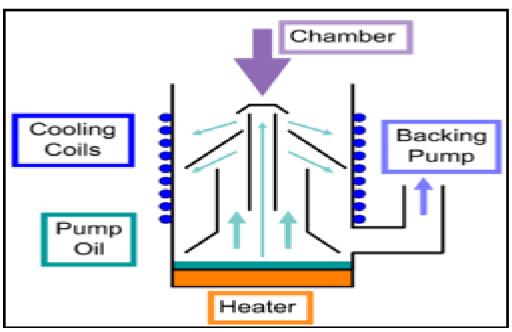

Figure 6 : Schematic of Diffusion Pump working principle

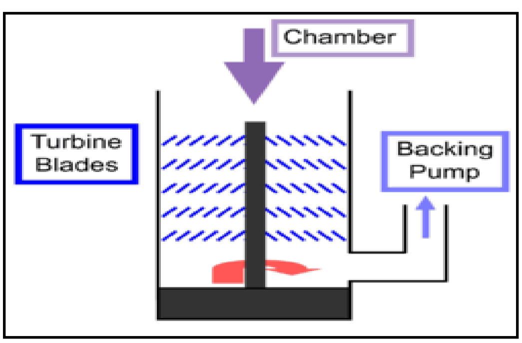

Figure 7 : Schematic ofTurbo-molecular Pump working principle

b) Pumps for ultrahigh/extreme high Vacuum

The molecular flow regime is the region of high, ultra high and extreme ultra high vacuum. The principle of entrapment of the residual molecules is used for the evacuation in this region. The pumps operating on this principle are called entrapment pumps. In this least molecular density region, the residual molecules are either wiped out by the process of ionization or condensed cryogenically. Consequently, two types of vacuum pumps namely ion pumps and cryogenic pumps are used for the production of high/ultrahigh vacuum and ultrahigh/ extreme high vacuum respectively. In an ion pump the residual molecules in the working vacuum chamber are vanished through the process of ionization. In a cryogenic pump, gas molecules are condensed on the cold surface by some suitable refrigeration arrangement. As long as the surface remains cold, the gas molecules will remain on the cold surface, creating required vacuum in the rest of the chamber. The schematic showing working principle of oil ion pump and cryogenic pump is given in Fig.-8 and Fig.-9 respectively.

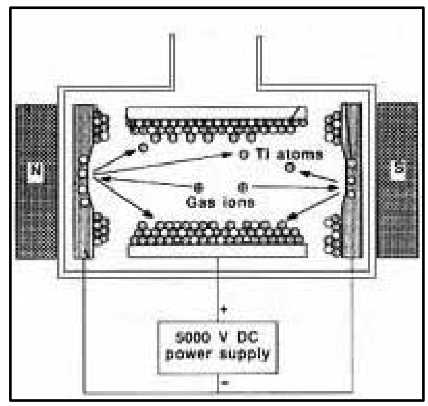

Figure 8 : Schematic ofIon Pump working principle

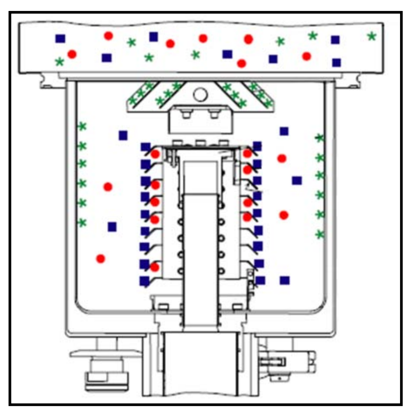

Figure 9 : Schematic of Cryo-genic Pump working principle

c) Pumping Speed

Pumping speed is one of the essential parameters to choose a vacuum pump for particular range. It would have its maximum value at the pressures which are needed for a specific application. Therefore, the knowledge of maximum pumping speed specifications of a vacuum pump is very important. Pumping speed verses pressure curve for any vacuum pump immensely useful because it describes the pump performance throughout its probable application range.

Other important information to be gained from the pumping speed verses pressure curves would make certain whether a given pump could meet and maintain a specified pressure at specified process gas flow adequately. The shape of the curve can easily help to make the decision when specific speeds at specific pressures are important for the process. Pumping speed verses pressure curves can be even more important when high vacuum pumps are considered. These curves for mostly used vacuum pumps with diverse vacuum ranges are given in Fig.-9[7].

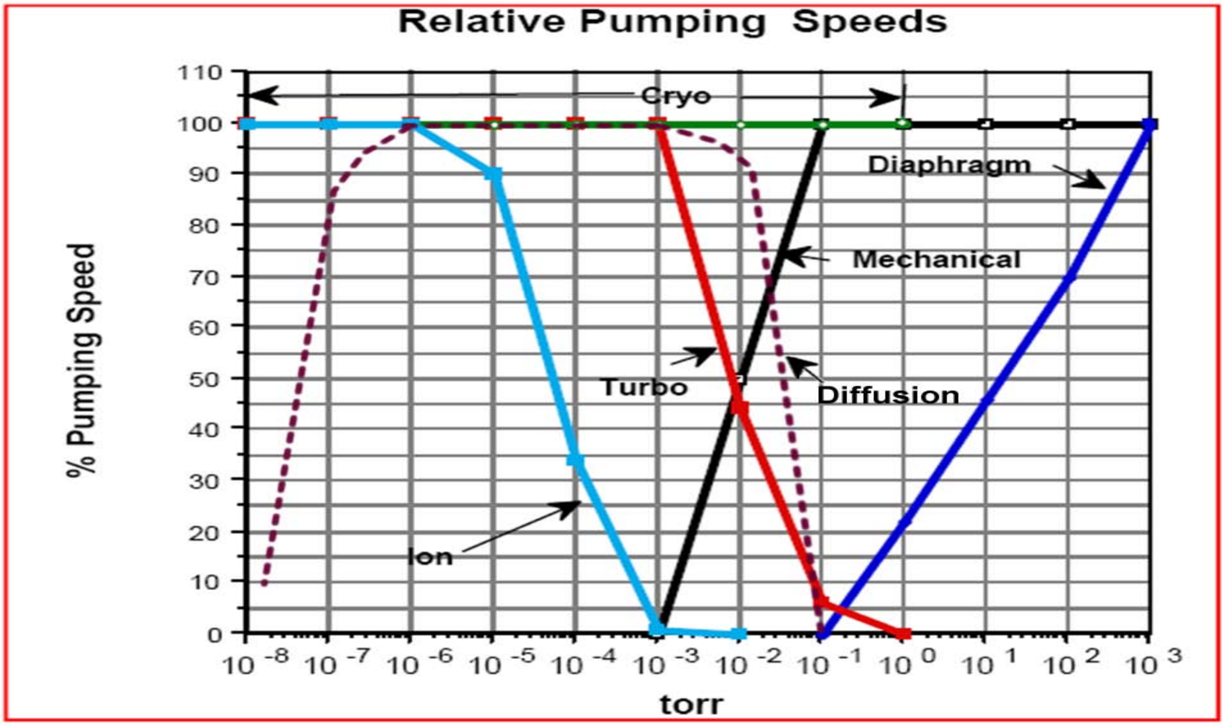

Figure 10 : The change of relative pumping speed with pressure of some common vacuum pumps [7]

d) Environment

The desired vacuum range is not the only factor considered when selecting a suitable vacuum pump. The operating conditions under which the vacuum pump has to work also play a significant role. If the vacuum pump is operated under the conditions with high risk of contamination, vibrations, temperature, pressure, etc, consequently there will be large possibility of damage to pump, worse pump performance and unnecessary maintenance. Other environmental conditions are related to health and safety (emissions and waste generation, noise, general equipment safety).

e) Process Media

While all the factors regarding proper vacuum pump selection are important, consideration for the actual process media for which the pump will be exposed, is vital too. Some gases from the process media may contaminate oil of the rotary pump or diffusion pump, consequently making the pump with poor performance and consequently low ultimate vacuum.

f) Configration

Pump with port size matching with the designed port size of the system to be evacuated should be preferred. Furthermore, pump should be connected to the vacuum system with smallest possible vacuum plumbing. It should be recognized during the design and equipment selection stage that pumping system configuration can be just as important as the pump technology and even small changes in configuration can make significant improvements to vacuum system reliability reducing overall user interference.

III. Conclusion

Vacuum pump is the back bone for any vacuum system which should be selected according to some consistent and well thought criteria to get essential output and effectiveness with required ultimate vacuum. Some basic questions should be considered before deciding which vacuum pump is the best for a particular vacuum application. These include the requirement of degree of vacuum, flow capacity and accordingly the desired horsepower and speed to meet these requirements. Nature of power available, duty cycle either continuous or intermittent, ambient conditions and space limitations should also be considered. Briefly, reducing cost, improving working, expanding applications, gaining production, improving efficiency and saving space and energy are all important

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engineeing considerations before the selection of suitable vacuum pump.

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A Computational Study of Buckling Analysis of Filament Wound Composite Pressure Vessel Subjected to Hydrostatic Pressure

By Abhijit Dey, P.L. Choudhury & K.M. Pandey
National Institute of Technology, India

Abstract- In this present study the post buckling cha-racteristics of moderately thick-walled filament-wound carbon–epoxy composite cylinders under external hydrostatic pressure were investigated through finite element analysis for under water vehicle applications. The winding angles were [±30/90] FW, [±45/90] FW and [±60/90] FW. Finite element software ANSYS 14.0 were used to predicted the buckling pressure of filament-wound composite cylinders. For the finite element modeling of a composite cylinder, an eight-node shell element is used. To verify the finite element results for comparison, three finite element software, MSC/NASTRAN, MSC/MARC and an in-house program ACOS were used. Among these software's, the finite element software ANSYS predicts the buckling loads within 1.5% deviation. The analysis and test results showed that the cylinders do not recover the initial buckling pressure after buckling and that this leads directly to the collapse. Major failure modes in the analysis were dominated by the helical winding angles. The finite element analysis shows global buckling modes with four waves in the hoop direction.

Keywords: buckling, thick-wall, composite, hydrostatic pressure.

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ACOMPUTATIONALSTUDYOFBUCKLINGANALYSISOFFILAMENTWOUNDCOMPOSITEPRESSUREVESSELSUBJECTEDTOHYDROSTATICPRESSURE

A Computational Study of Buckling Analysis of Filament Wound Composite Pressure Vessel Subjected to Hydrostatic Pressure

Abhijit Dey [α], P.L. Choudhury [σ] & K.M. Pandey [ρ]

Abstract- In this present study the post buckling cha-racteristics of moderately thick-walled filament-wound carbon–epoxy composite cylinders under external hydrostatic pressure were investigated through finite element analysis for under water vehicle applications. The winding angles were [±30/90] FW, [±45/90] FW and [±60/90] FW. Finite element software ANSYS 14.0 were used to predicted the buckling pressure of filament-wound composite cylinders. For the finite element modeling of a composite cylinder, an eight-node shell element is used. To verify the finite element results for comparison, three finite element software, MSC/NASTRAN , MSC/MARC and an in-house program ACOS were used. Among these software's, the finite element software ANSYS predicts the buckling loads within 1.5% deviation. The analysis and test results showed that the cylinders do not recover the initial buckling pressure after buckling and that this leads directly to the collapse. Major failure modes in the analysis were dominated by the helical winding angles. The finite element analysis shows global buckling modes with four waves in the hoop direction.

Keywords: buckling, thick-wall, composite, hydrostatic pressure.

I. Introduction

Filament-wound composite materials have been successfully used in underwater vehicles and ocean structures over the past few years, especially as composite pressure vessels [1–3]; the use of composite materials in civil and military aircraft has also expanded considerably over the past few decades due to their light weight and high resistance to salt wat-er corrosion [4]. Particularly, small underwater veh-icles can be manufactured in one piece with composite materials. Both the filament winding and tape lay-up methods can be used to manufacture a small vehicle without sub-assembly [6].

Although decades of R&D in composite materials have focused on aerospace engineering, new applications are opening up in various fields where weight or resistance to corrosion is critical. Particularly, caron composites are considered promising materials for future underwater vehicles and ocean structures due to their corrosion resistance [5, 7].

Buckling has become a dominant failure mechanism when compressive stresses generated by the external hydrostatic pressure reach elevated levels for subsea composite pressure vessel. For an underwater vehicle operated in deep sea, hydrostatic pressure-induced buckling tends to dominate structural performance. Furthermore, a cylindrical structure generally experiences unstable buckling, where the loadcarrying capability of the structure decreases after the buckling [7, 8].

Generally, high external pressure vessels such as submarine structures have been manufactured of high strength steel, titanium and aluminum alloy. Large buoyancy is required for the structural weight. Accordingly, the weight-sensitive structures are expected to reduce weight for faster and more efficient peformance. It was observed that the use of composite materials for underwater vehicles can reduce their total weight and expand the depth of operation because the reduced weight can allow for greater structural reinforcement [7, 9, and 10].

In the present work, relatively thick-walled composite cylinders (radius- to-thickness ratio, R/t = 18.8) were manufactured by a filament winding process to reduce the material and geometric imperfections for a high depth underwater vehicle [7]. The main objective of this paper is to investigate the buckling, post buckling behavior and failure mode of moderately thickwalled composite cylinders with various winding angles under external hydrostatic pressure for underwater vehicle applications. The helical winding and hoop reinforcement ([±30/90] FW, [±45/90] FW and [±60/90] FW) were used for the composite cylinders.

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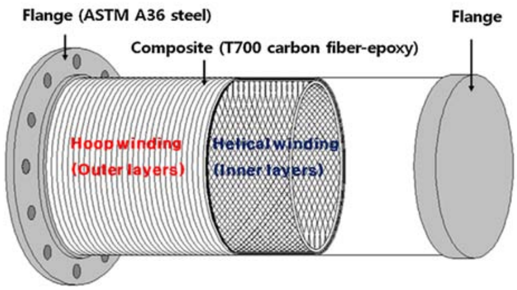

Figure (a)

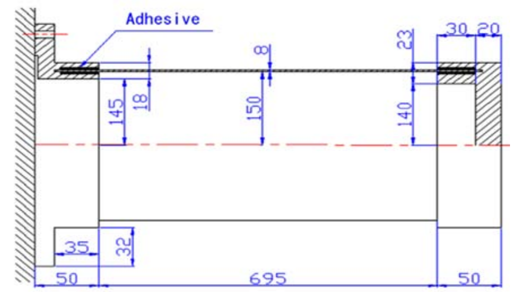

Figure (b)

Figure 1 : (a) Schematic of a filament-wound composite cylinder with flange (b) Dimension of the cylinder

II. Specimen Modeling

The specimens were manufactured by a filament winding process using T 700–24 K carbon fiber and Bisphenol A type epoxy resin. All of the cylinders have a 300-mm nominal inner diameter; a 695-mm nominal axial length and an 8-mm nominal thickness (see Fig. 1). The cylinders have three different winding angles: [±30/ 90] FW, [±45/90] FW and [±60/90] FW. The parameters ±30, ±45 and ±60 denote the helical winding angle, while 90 is the hoop winding. For creating the finite element model, ACOS [15], an in-house program, was used. The carbon composite cylinders were fabricated by a filament winding process and tested in a water pressure chamber. Two commercial software's, MSC.NASTRAN and MSC.MARC, were also used for comparison of the buckling pressure and mode shape. The nominal thickness of the hoop winding is 10% of the total thickness. This value was chosen because the best buckling pressures are obtained when the hoop ratio does not exceed 50% of the total thickness. When the hoop ratio exceeds 50%, the cylinders become very weak with respect to static strength. In this present work the finite element model of composite pressure vessel is made by ANSYS 14.0 APDL, finite element software.

Two commercial software, Msc. Nastran and Msc.Marc and Acos, an in-house program were used to create the model. The cylinders have a 300mm nominal inner diameter, 695mm nominal axial length and an 8 mm nominal thickness. The nominal thickness of the hoop winding is 10% of the total Thickness. In ANSYS 14.0 APDL a 3D shell element element 8 node 281 having 6 degree of freedom at each node is used to recreate the model.

a) *Mechanical Properties*

Property	Symbol	Rule of mixture	Unit
Elastic modulus	E1	149	GPa
	E2	10.6	GPa
	E3	10.6	GPa
Poisson's ratio	ὺ12	0.253	-
	ὺ13	0.253	-
	ὺ23	0.421	-
Shear modulus	G12	4.14	GPa
	G13	4.14	GPa
	G23	3.31	GPa

III. Finite Element Analysis

Finite element analysis was used to predict not only the buckling loads but also the post buckling behavior. Failure analysis was performed using the in-house software ACOSwin, which makes possible nonlinear and progressive failure analysis. The commercial programs MSC/NASTRAN (linear analysis) and MSC/ MARC (nonlinear analysis) were used to validate the buckling loads. The theoretical background for ACOSwin is given in [13]. In the finite element models, four node elements, CQUAD4 in MSC.NASTRAN and Element 75 in MSC.MARC, were used. The ACOS program used an 8-node laminate shell element that had 5 degrees of freedom at each node. In Ansys 14.0 APDL laminate shell element 8 node 281 having 6 degree of freedom at each node were used to predict the critical buckling pressure. For non-linear, post buckling behavior, progressive failure analysis was conducted by ACOS using complete unloading as the stiffness degradation method [16, 17]. The stacking sequence of different composite laminate with different orientation of fibers has shown in fig.2. The enlarge view of stacking sequence and different composite laminate with various thickness have been shown in fig.3.

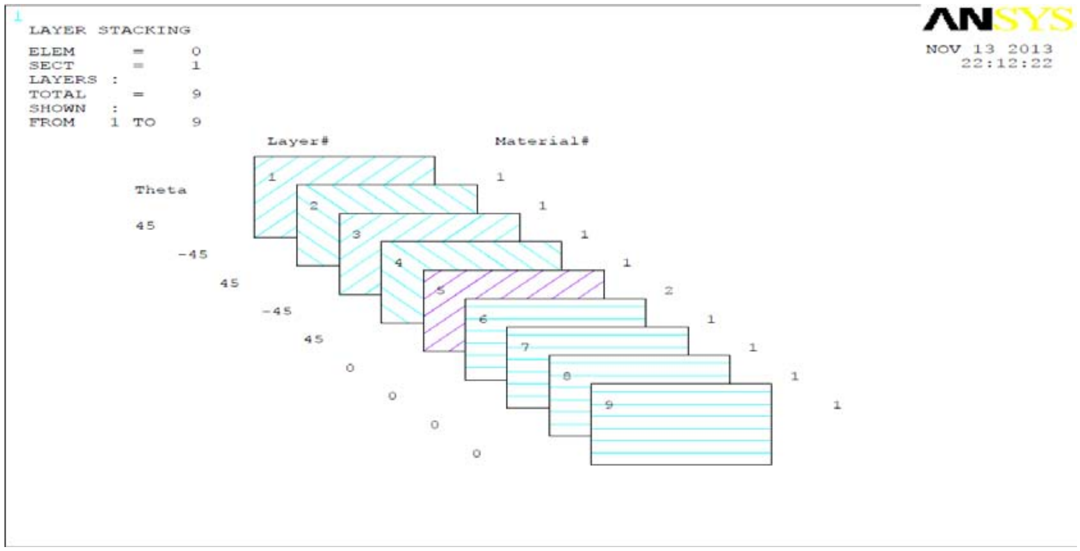

Figure 2 : Layer stacking sequence of composite pressure vessel [±45/0] FW

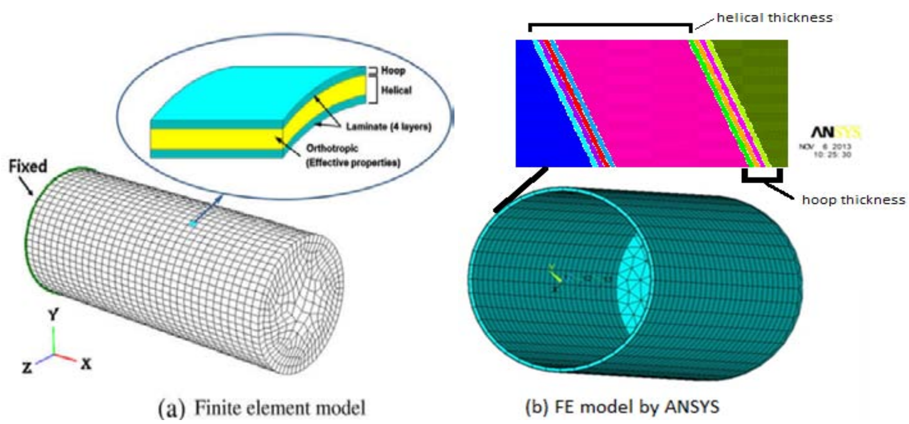

Figure 3 : (a) Finite element model by ACOS win. (b) Finite element model by ANSYS APDL

IV. Simulation

The composite structure that used in under water vehicle application, only hydrostatic pressure will consider which can apply redialy inward direction over the outer surface of the body. The equipment can apply pressures up to 10 MPa, which is equal to the pressure at a depth of 1000 meter of water. At the left end of the composite cylinder all degree of freedom can be restricted and at the right end only two degree of freedom has restricted (x direction & y direction), so that the system will undergo only axial deformation.

The finite element modeling, meshing and simulation of carbon-epoxy composite filament wound pressure vessel have shown in figure 4.

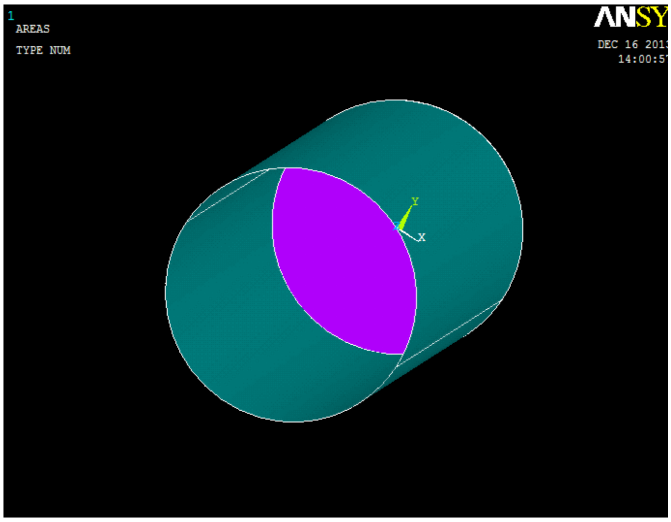

Figure 4 :(a)

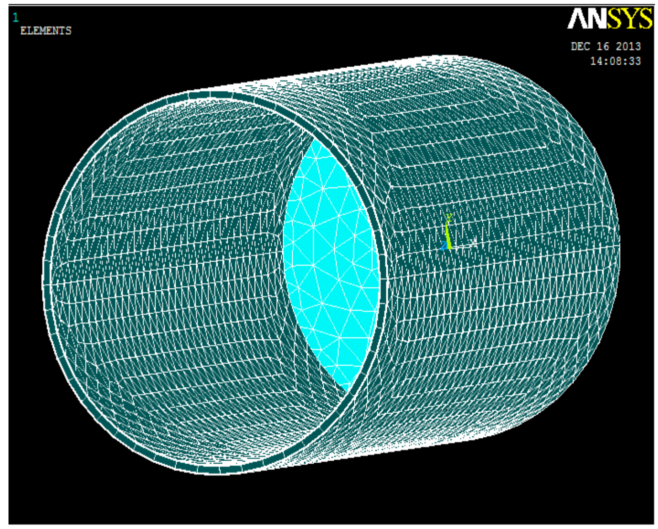

Figure 4 :(b)

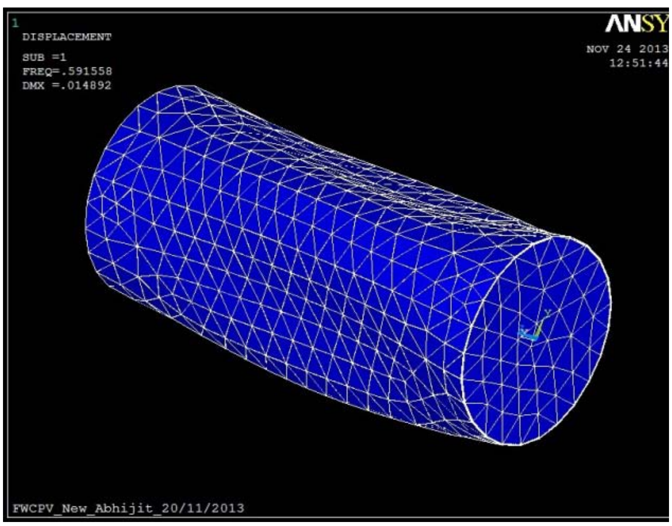

Figure 4 : (c)

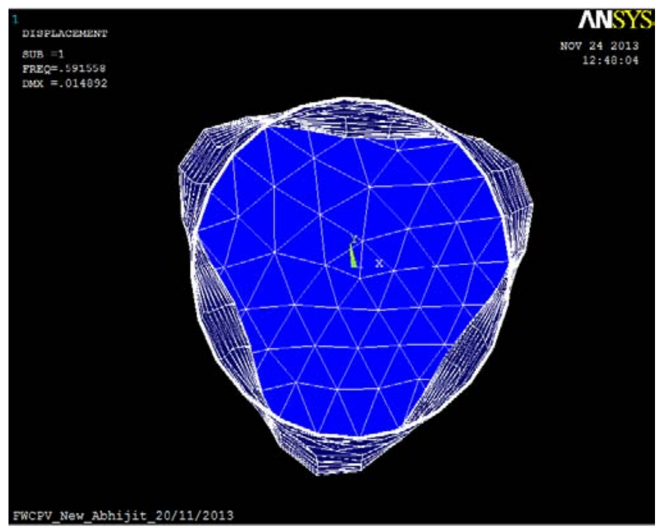

Figure 4 : (d)

Figure 4 : (a) Finite element model (b) Meshed model (c) Buckling Mode shape (d) Buckling Mode shape (Front view)

V. Results and Discussion

The buckling analysis has done by Ansys APDL. It has observed that the result for critical buckling is good matched with the existing experimental results. The figures are describing the comparison study of the composite pressure vessels. Table 3 shows the experimental and finite element buckling pressure. The ANSYS 14.0 APDL results as well as the linear and nonlinear analysis results by MSC/NASTRAN, MSC/MARC and ACO Swin are presented. In ANSYS non-linear buckling analysis has been done. Fig.5 described the different mode shape obtained by MSC/NASTRAN, MSC/MARC, ACOS win and Ansys 14.0 respectively. Here [±45/90] FW specimen was consider for the finite element analysis.

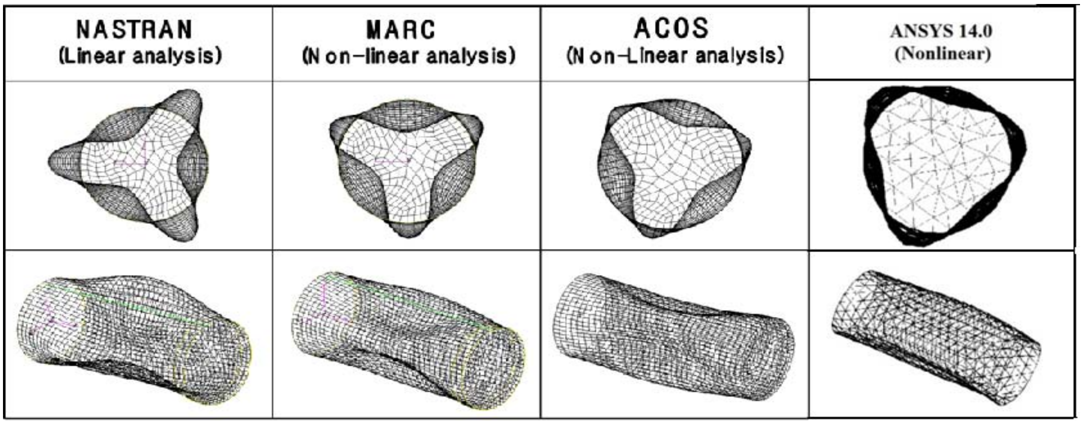

Figure 5 : Buckling modes of the [±45/90] FW composite cylinder

Table 1 : Experimental And Finite Element Buckling Pressure (Unit: Mpa)

RESULT OBTAINED	BUCKLING PRESSURE UNIT(MPa)	PERCENTAGE OF ERROR (%)
EXPERIMENTAL TEST	0.60	-
ANSYS 14.0 APDL	0.591	1.5
MSC.NASTRAN	0.677	12.08
MSC.MARC	0.691	15.2
ACOSwin	0.671	11.8

Figure 6 : Comparison of experimental and computational critical buckling pressure obtained by different software's

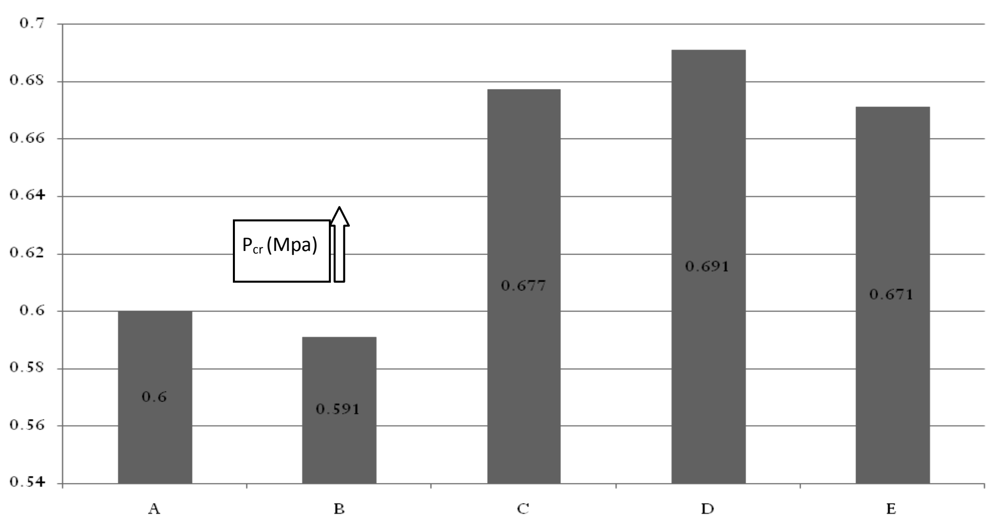

Figure 7 : Bar graph (a) experimental test result (b) result obtained by Ansys (c) result obtained by Nastran (d) result obtained by Marc (e) result obtained by ACOSwin

VI. Conclusion

The buckling behavior of moderately thick walled, filament-wound, carbon–epoxy cylinders subjected to hydrostatic pressure was investigated. A total 9 no. of composite laminates has been considered for finite element analysis. The different orientation of the composite layers has been taken [±45/90] FW. Analyses were conducted using the finite element package ANSYS 14.0 APDL. Three finite element program ACOS win, MSC/NASTRAN and MSC/MARC were used to validate the results. A shell element 8 node 281 was used to create the finite element model. The ANSYS shell element model predicted the buckling pressure with 1.5% deviation from the other three finite element results and experimental results, not considering the initial imperfections of the cylinders. The results show that finite element analysis with shell elements can be used to evaluate the buckling load of moderately thick-walled, filament-wound composite cylinders under external hydrostatic pressure.

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Drives of Pipelines' Block Valve based on the Pan Precess Gear

By V. Syzrantsev & S. Golofast
Tyumen State Oil and Gas University, Russia

Introduction- Nowadays in Russia and abroad the majority of hand and electric drives are based on a screw gear [1]. Despite the results achieved in the area of technology of screw gears production by leading domestic and international manufacturers and successful design arrangement of drive, the low performance coefficient of screw gears, limited load capacity and significant starting torque make a particular negative impact on the reliability of the drive when operating in low temperature conditions, and also the high specific metal content of drive represent the reasons for required development of drives based on other gear mechanisms. During the last few years a number of new constructions of block valves' drives were developed, among which the most promising ones are the drives based on the spiroid transmission [2], the harmonic drives with intermediate rolling elements [1] (TOMZEL, SibMash, Gusar) and eccentrically cyclo gear boxes (ZAO "Technology Market", Tomsk, Russia). In comparison with screw gear spiroid gear has a higher performance coefficient and higher load capacity and has better weight and dimensional characteristics, especially in case of steel gear wheels usage.

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I. Introduction

Nowadays in Russia and abroad the majority of hand and electric drives are based on a screw gear [1]. Despite the results achieved in the area of technology of screw gears production by leading domestic and international manufacturers and successful design arrangement of drive, the low performance coefficient of screw gears, limited load capacity and significant starting torque make a particular negative impact on the reliability of the drive when operating in low temperature conditions, and also the high specific metal content of drive represent the reasons for required development of drives based on other gear mechanisms. During the last few years a number of new constructions of block valves' drives were developed, among which the most promising ones are the drives based on the spiroid transmission [2], the harmonic drives with intermediate rolling elements [1] (TOMZEL, SibMash, Gusar) and eccentrically cyclo gear boxes (ZAO "Technology Market", Tomsk, Russia). In comparison with screw gear spiroid gear has a higher performance coefficient and higher load capacity and has better weight and dimensional characteristics, especially in case of steel gear wheels usage. At the same time, the relatively high sliding velocity of screw turn's surface and wheel tooth surface in comparison with the similar relative velocities of gear and wheel teeth surfaces of cylindrical and pan gears leads to significant starting torques during the operation of manual drives of block valves in severe conditions of operation. The harmonic drives with intermediate rolling bodies and eccentrically cyclo gear boxes have high performance coefficient [1] and hence low torque strength during the multiple contacts of rolling bodies. At the same time, in addition to much more sophisticated technology of such gears production in comparison with traditional screw gears, the gear's load capacity with intermediate rolling bodies under conditions of their significantly point contact even taking into account the multi pair catching does not reach the load capacity of cylindrical or pan gears with identical weight and dimensional requirements.

This paper presents the results of development of block valve's drives based on the usage of pan precess gear [3, 4], which provides the gear ratio of 22 to 65 at a single stage, with multi pair contact of teeth in catching (up to 8 ... 12 pairs), having a high performance coefficient (88 ... 90%) and smooth operation in comparison with increased (up to two times) starting torque in case of identical weight and gear ratio based on the screw gear, and in case of the equal load capacity up to 40% decrease of specific metal content. During the operation, the gear teeth and the gear wheels roll of, and do not slide in relation to each other as in a screw or spiroid gear, resulting in significantly lower starting torque and the ability to remain functioning even under the severe conditions of operation.

Fig. 1 shows the kinematic scheme of the reductiondrive gearbox with the precess gear. In the gearbox the bevel pinion with the number of teeth z_1 is roughly fixed. On a drive eccentric shaft a double gearwheel with gear rims z_2 and z_3 is located through a bearing unit. The output shaft is roughly connected to the pan wheel having a number of teeth $z_4 = z_3$, and set against the shaft on bearings.

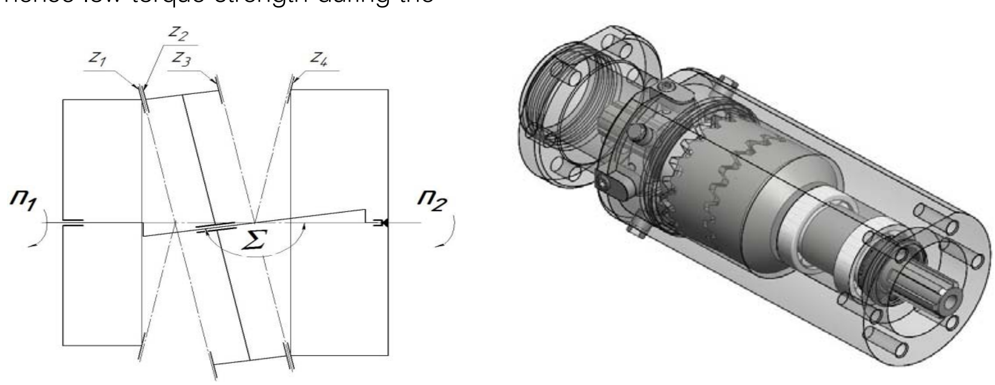

Figure 1 : Kinematic and sample layoutreducer

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Fig. 1 - Kinematic and sample layout reducer When you rotate the eccentric shaft a pan double gear-wheel performs complex motion - a rotation around its axis, and with the drive eccentric shaft around the axis of gear box, causing the rotation of tooth coupling, composed of gear rims z_3 and z_4. Thus on a double gear-wheel located at an angle of 180 ° two zones of tooth contact are formed: meshed wheels z_1 - z_2 - and in mesh wheels z_3 - z_4.The total gear ratio of gear box is performed by two gear rims z_1 and z_2 and is calculated as a dependence:

$$u = z_2/(z_2 - z_1)$$

In Fig. 2 shows the construction of a manual actuator valves using precess gear.

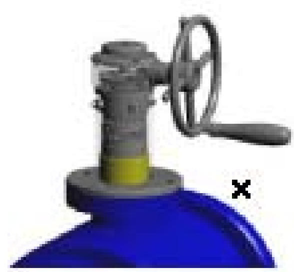

Figure 2 : Drive valves

Precess gear, which is generally pan with small interaxial angle, can be made with straight, slanting, circular, lentoid teeth on gear-wheel and concavo-concave teeth on wheel. The gear with lentoid teeth on gear-wheel and concavo-concave teeth on wheel is more preferable, because in comparison with the gear with circular teeth with mesh synthesis [5], during which the required contact localization is provided, has fewer geometric constraints on the technological process of the teeth cutting by circular cutter head on the tooth-cutting machines.

Developed on the basis of the pan precess gear with teeth manual drive for ball valve DU-300 (Fig. 3), produced by OOO Firma "STEK" (Kurgan, Russia), has a high load capacity and smooth operation. Under a force on the handle of the wheel of 28 kg the starting torque on ball valve is 2600 kg, the allowed load moment is 5000 kg M. The guaranteed service life is not less than 5000 cycles, is confirmed by the results of production tests in AK "KOR-VET" (Kurgan, Russia). A similar drive for ball valve DU-160 with elongating column is shown in Fig.4.

Figure 3 : Ball valve DU-300, the drive based on the gearbox a precess gear

Figure 4 : Drive of the ball valve DU-160 with extension column

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Study of Viscous Dissipation on Natural Convection in a Vertical Conical Annular Porous Medium

By N. Ameer Ahmad & M. Ayaz Ahmad
University of Tabuk, Saudi Arabia

Abstract- In this paper, we study the heat transfer by Natural convection in a saturated porous medium including viscous dissipation in a vertical conical annular porous medium. Finite Element Method (FEM) has been used to solve the governing partial differential equations. Results are presented in terms of average Nusselt number $(\overline{Nu})$, streamlines and isothermal lines for various values of Rayleigh number (Ra), Cone angle (C_A), Radius ratio (R_r) and Viscous dissipation(ε).

Keywords: *viscous dissipation (ε), rayleigh number (ra), cone angle (ca) and radius ratio (rr).*

GJRE-A Classification : *FOR Code: 091399p*

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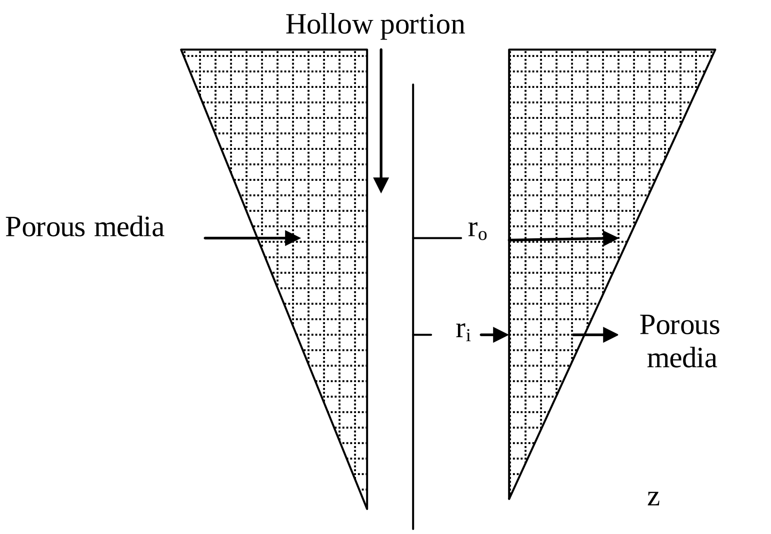

Figure (A) : Schematic diagram of Vertical Cone Filled with porous medium

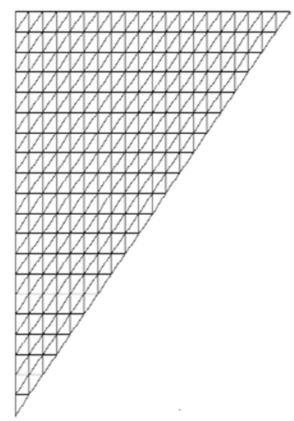

Figure (B) : Mesh Pattern of Vertical Cone embedded with porous medium

Nomenclature

a) List of Symbols

C_A Cone Angle
C_p Specific heat
D_p Particle diameter
g Gravitational acceleration
H_t Height of the vertical annular cone
K Permeability of porous media
P Pressure
$\overline{Nu}$ Average Nusselt number
q_t Total heat flux
r, z Cylindrical co-ordinates
$\bar{r}$ $\bar{z}$ Non-dimensional co-ordinates
r_i , r_o Inner and outer radius
Ra Rayleigh number
R_r Radius ratio
R_d Radiation parameter

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T Temperature

$\bar{T}$ Non-Dimensional Temperature

u Velocity in r direction

w Velocity in z direction

b) Greek Symbols

α Thermal diffusity

β_T Co-efficient of thermal expansion

ε Viscous dissipation parameter

ΔT Temperature difference

σ Stephan Boltzman constant

ρ Density

γ Coefficient of Kinematic viscosity

μ Coefficient of dynamic viscosity

ϕ Porosity

ψ Stream function

$\bar{\psi}$ Non-dimensional stream function

c) Subscripts

ω Wall

∞ Conditions at infinity

h Hot

c Cold

t Total

I. Introduction

Natural convection flow and heat transfer in a saturated porous media has gained much attention during the past two decades because of its wide range of applications in packed bed reactors, porous insulation, beds of fossil fuels, nuclear waste disposal, usage of porous conical bearings in lubrication technology, geophysics and energy related engineering problems. A good review of buoyancy driven boundary layer flows in Darcian fluid is given in Nield and Bejan [1]. When the Reynolds number is high enough for the Darcy flow model to breakdown, Pumb and Huenefeld [2] studied the fundamental problem of non-Darcy natural convection from heated vertical walls in a saturated porous medium. Later Bejan and Poulikakos [3] and Bejan [4], by dividing the flow regime into non-Darcy and intermediate regimes, studied the same problems using fluid inertia-buoyancy scaling and defined large Reynolds number-limit Rayleigh number. The non-similar boundary-layer equations resulting from the Forchheimer natural convection with power law wall variation were solved by Chen and Ho [5].

The transverse thermal dispersion effects will become important, and the analysis is dealt with at length in works by Plumb [6], Cheng [7], Hong and Tien [8], Hong et al. [9], Cheng and Vortmeyer [10], Amiri and Vafai [11] etc. All these works confirm the importance of the thermal dispersion effect. Except for Cheng and Vortmeyer [10], all other works use the linear dependence of dispersion diffusivity on stream wise velocity. In order to correlate the available experimental data concerning the packed beds, Cheng and Vortmayer [10] introduced a wall function term into the term of dispersion diffusivity.

The effect of viscous dissipation on natural convection in fluids has been studied by Gebhart [12] for power law vertical wall variation. He obtained a perturbation solution in terms of a parameter which could not be expressed in terms of either the Rayleigh number or the Prandtl number, and observed its increasing effect as the Prandtl number increases. Later Gebhart and Mollendor [13] obtained the similarity solution for the same problem when exponential wall temperature variation is used and a similar trend was observed. A comment was made by Fand and Brucker [14] that the effect of viscous dissipation might be significant in the case of natural convection in porous medium in connection with their experimental correlation for heat transfer in external flows. The validity of the comment was tested for the Darcy model by Fand et al. [15], both experimentally and analytically while estimating the heat transfer coefficient from a horizontal cylinder embedded in a saturated porous medium. Their mathematical analysis is confined to studying the dissipation effect using a steady, energy Equation, the basis of the equation is from the analogy given by Bejan [16] for the inclusion of viscous dissipation effects. The influence of viscous dissipation can be seen from the analogy given by Tucker and Dessenberger [17] to model the heat transfer

The effect of viscous dissipation on natural convection has been studied for some different cases including the natural convection from horizontal cylinder embedded in a porous media by Fand and Brucker [19] and Fand et al. [20]. They reported that the viscous dissipation may not be neglected in all cases of natural convection from horizontal cylinders and further, that the inclusion of a viscous dissipation term in porous medium may lead to more accurate correlation equations. This observation has been pointed out also by Murthy and Singh [21] for the natural convection flow along an isothermal vertical wall embedded in a porous medium. Recently, Nawaf H. Saeid and I.Pop [22] studied the viscous dissipation effects on free convection in a porous cavity.

II. Mathematical Formulation

A vertical annular cone of inner radius r_i and outer radius r_0 as depicted by schematic diagram as shown in figure (A) is considered to investigate the heat transfer behavior in the presence of viscous dissipation.

The co-ordinate system is chosen such that the r-axis points towards the width and z-axis towards the height of the cone respectively. Because of the annular nature, two important parameters emerges, which are Cone angle (C_A) and Radius ratio (R_r) of the annulus. They are defined

$$\text{as } C_A = \frac{H_t}{r_0 - r_i}, \qquad R_r = \frac{r_0 - r_i}{r_i}$$

Where H_t is the height of the cone.

The inner surface of the cone is maintained at isothermal temperature T_h and outer surface is at ambient temperature T_∞. It may be noted that, due to axisymmetry, only a section of the annulus is sufficient for analysis purpose. The horizontal surfaces of the vertical annular cone are considered adiabatic.

The flow inside the porous medium is assumed to obey Darcy law and there is no phase change of fluid. The properties of the fluid and porous medium are homogeneous, isotropic and constant except variation of fluid density with temperature. The fluid and porous medium are in thermal equilibrium with these assumptions, the governing equations are given by

Continuity Equation: $$\frac{\partial (ru)}{\partial r} + \frac{\partial (rw)}{\partial z} = 0 \qquad (2.1)$$

The velocity in r and z directions can be described by Darcy law as

Velocity in horizontal direction $$u = \frac{-K}{\mu}\frac{\partial p}{\partial z} \qquad (2.2)$$

Velocity in vertical direction

$$w = \frac{-K}{\mu}\left(\frac{\partial p}{\partial z} + \rho g\right) \qquad (2.3)$$

The permeability K of porous medium can be expressed as Bejan [24]

$$K = \frac{D_p^2 \phi^3}{180(1-\phi)^2} \qquad (2.4)$$

The variation of density with respect to temperature can be described by Boussinesq approximation as $\rho = \rho_\infty [1 - \beta_T (T - T_\infty)]$ (2.5)

Momentum Equation: $$\frac{\partial w}{\partial r} - \frac{\partial u}{\partial z} = \frac{gK\beta}{\nu}\frac{\partial T}{\partial r} \qquad (2.6)$$

Energy equation: $$u\frac{\partial T}{\partial r} + w\frac{\partial T}{\partial z} = \alpha\left(\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right) + \frac{\partial^2 T}{\partial z^2}\right) + \frac{\mu}{K(\rho C_p)_f}(u^2 + w^2) \qquad (2.7)$$

The continuity equation (2.1) can be satis-fyed by introducing the stream function ψ as

$$u = -\frac{1}{r}\frac{\partial \psi}{\partial z} \qquad (2.8)$$

$$w = \frac{1}{r}\frac{\partial \psi}{\partial r} \qquad (2.9)$$

The corresponding dimensional boundary conditions are

at $r = r_i$, $T = T_w$, $\psi = 0$ (12.10a)

at $r = r_0$, $T = T_\infty$, $\psi = 0$ (2.10b)

(except at z = 0)

The new parameters arising due to cylindrical co-ordinates system are

Non-dimensional Radius $$\bar{r} = \frac{r}{L} \qquad (2.11a)$$

Non-dimensional Height $$\bar{z} = \frac{z}{L} \qquad (2.11b)$$

Non-dimensional stream function $$\bar{\psi} = \frac{\psi}{\alpha L} \qquad (2.11c)$$

Non-dimensional Temperature $$\bar{T} = \frac{(T - T_\infty)}{(T_w - T_\infty)} \qquad (2.11d)$$

Rayleigh number $$Ra = \frac{g\beta_T \Delta T K L}{\nu\alpha} \qquad (2.11e)$$

Viscous dissipation parameter $$\varepsilon = \frac{\alpha u}{\Delta T K \rho C_p} \qquad (2.11f)$$

The non-dimensional equations for the heat transfer in vertical cone are

Momentum equation:

$$\frac{\partial^2 \bar{\psi}}{\partial \bar{z}^2} + \bar{r}\left(\frac{1}{\bar{r}}\frac{\partial \bar{\psi}}{\partial \bar{r}}\right) = \bar{r} Ra \frac{\partial \bar{T}}{\partial \bar{r}} \qquad (2.12)$$

Energy equation

$$\frac{1}{\bar{r}}\left[\frac{\partial\bar{\psi}}{\partial\bar{r}}\frac{\partial\bar{T}}{\partial\bar{z}}-\frac{\partial\bar{\psi}}{\partial\bar{z}}\frac{\partial\bar{T}}{\partial\bar{r}}\right]=\left(\frac{1}{\bar{r}}\frac{\partial}{\partial\bar{r}}\left(\bar{r}\frac{\partial\bar{T}}{\partial\bar{r}}\right)+\frac{\partial^2\bar{T}}{\partial\bar{z}^2}\right)+\varepsilon\left[\left(\frac{1}{\bar{r}}\frac{\partial\bar{\psi}}{\partial\bar{r}}\right)^2+\left(\frac{1}{\bar{r}}\frac{\partial\bar{\psi}}{\partial\bar{z}}\right)^2\right] \tag{2.13}$$

The corresponding non-dimensional boundary conditions are

at $\bar{r}=\bar{r}_i$, $\bar{T}=1$, $\bar{\psi}=0$ (2.14a)

at $r=\bar{r}_0$, $T=0$, $\bar{\psi}=0$ (2.14b)

III. Solution of Governing Equations

Applying Galerkin method to momentum equation (2.12) yields:

$$\{R^e\}=-\int_V N^T\left(\frac{\partial^2\bar{\psi}}{\partial\bar{z}^2}+\bar{r}\frac{\partial}{\partial\bar{r}}\left(\frac{1}{\bar{r}}\frac{\partial\bar{\psi}}{\partial\bar{r}}\right)-\bar{r}Ra\frac{\partial\bar{T}}{\partial\bar{r}}\right)dv \tag{3.1}$$

$$\{R^e\}=-\int_A N^T\left(\frac{\partial^2\bar{\psi}}{\partial\bar{z}^2}+\bar{r}\frac{\partial}{\partial\bar{r}}\left(\frac{1}{\bar{r}}\frac{\partial\bar{\psi}}{\partial\bar{r}}\right)-\bar{r}Ra\frac{\partial\bar{T}}{\partial\bar{r}}\right)2\Pi\bar{r}dA \tag{3.2}$$

where R^e is the residue. Considering individual terms of equation (3.2)

$$\frac{\partial}{\partial\bar{r}}\left(\left[N^T\right]\frac{\partial\bar{\psi}}{\partial\bar{r}}\right)=\left[N^T\right]\frac{\partial^2\bar{\psi}}{\partial\bar{r}^2}+\frac{\partial[N]^T}{\partial\bar{r}}\frac{\partial\bar{\psi}}{\partial\bar{r}} \tag{3.3}$$

Thus,

$$\int_A N^T\frac{\partial^2\bar{\psi}}{\partial\bar{r}^2}dA=\int_A\frac{\partial}{\partial\bar{r}}\left(\left[N^T\right]\frac{\partial^2\bar{\psi}}{\partial\bar{r}^2}\right)2\Pi\bar{r}dA-\int_A\frac{\partial[N]^T}{\partial\bar{r}}\frac{\partial\bar{\psi}}{\partial\bar{r}} \tag{3.4}$$

The first term on right hand side of equation (3.4) can be transformed into surface by the application of Greens theorem and leads to inter-element requirement at boundaries of an element. The boundary conditions are incorporated in the force vector.

Let us consider that the variable to be determined in the triangular area as "T" The polynomial function for "T" can be expressed as $T=\alpha_1+\alpha_2 r+\alpha_3 z$(3.5)

The variable T has the value T_i, T_j & T_k at the nodal position i, j & k of the element. The r and z co-ordinates at these points are r_i, r_j, r_k and z_i, z_j, z_k respectively.

Since $T=N_i T_i+N_j T_j+N_k T_k$ (3.6)

Where N_i, N_j & N_k are shape functions given by

$$N_m=\frac{a_m+b_m r+c_m z}{2A} \tag{3.7}$$

Making use of (3.7) gives $\int_A N^T\frac{\partial^2\bar{T}}{\partial\bar{z}^2}2\Pi\bar{r}dA=-\int_A\frac{\partial N^T}{\partial\bar{r}}\frac{\partial N}{\partial\bar{r}}\begin{Bmatrix}\bar{\psi}_1\\ \bar{\psi}_2\\ \bar{\psi}_3\end{Bmatrix}dA$ (3.8)

Substitution of (3.7) into (3.8) gives

$$=\frac{1}{(2A)^2}\int_A \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}\left[b_1 b_2 b_3\right]\begin{bmatrix} \bar{\psi}_1 \\ \bar{\psi}_2 \\ \bar{\psi}_3 \end{bmatrix} 2\Pi \bar{r} dA = -\frac{2\Pi \bar{R}}{4A}\begin{bmatrix} b_1^2 & b_1 b_2 & b_1 b_3 \\ b_1 b_2 & b_2^2 & b_2 b_3 \\ b_1 b_3 & b_2 b_3 & b_3^2 \end{bmatrix}\begin{bmatrix} \bar{\psi}_1 \\ \bar{\psi}_2 \\ \bar{\psi}_3 \end{bmatrix} \tag{3.9}$$

Similarly,

$$\int_A N^T \frac{\partial^2 \bar{\psi}}{\partial \bar{z}^2} 2\Pi \bar{r} dA = -\frac{2\Pi \bar{R}}{4A}\begin{bmatrix} c_1^2 & c_1 c_2 & c_1 c_3 \\ c_1 c_2 & c_2^2 & c_2 c_3 \\ c_1 c_3 & c_2 c_3 & c_3^2 \end{bmatrix}\begin{Bmatrix} \bar{\psi}_1 \\ \bar{\psi}_2 \\ \bar{\psi}_3 \end{Bmatrix} \quad 3.10)$$

The third term of equation (3.2) gives $\int_A N^T \bar{r} Ra \frac{\partial \bar{T}}{\partial \bar{r}} 2\Pi \bar{r} dA = Ra \int_A N^T \bar{r} \frac{\partial \bar{T}}{\partial \bar{r}} 2\Pi \bar{r} dA$ (3.11)

Since $M_1 = N_1, M_2 = N_2, M_2 = N_3$

Where M_1, M_2, and M_3 are the area ratios of the triangle and N_1, N_2 and N_3 are the shape functions.

Replacing the shape functions in the above equation (3.11) gives

$$\int_A N^T \bar{r} Ra \frac{\partial \bar{T}}{\partial \bar{r}} 2\Pi \bar{r} dA = \bar{r} Ra \int_A \begin{bmatrix} M_1 \\ M_2 \\ M_3 \end{bmatrix} \frac{\partial (N)}{\partial \bar{r}} \begin{bmatrix} \bar{T}_1 \\ \bar{T}_2 \\ \bar{T}_3 \end{bmatrix} 2\Pi \bar{r} dA \tag{3.12}$$

$$= Ra \frac{A}{3}\begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \frac{2\Pi \bar{R}^2}{2A}\left[b_1 + b_2 + b_3\right]\begin{bmatrix} \bar{T}_1 \\ \bar{T}_2 \\ \bar{T}_3 \end{bmatrix} = \frac{2\Pi \bar{R}^2 Ra}{6}\begin{Bmatrix} b_1 \bar{T}_1 + b_2 \bar{T}_2 + b_3 \bar{T}_3 \\ b_1 \bar{T}_1 + b_2 \bar{T}_2 + b_3 \bar{T}_3 \\ b_1 \bar{T}_1 + b_2 \bar{T}_2 + b_3 \bar{T}_3 \end{Bmatrix} \tag{3.13}$$

Now Momentum equation leads to

$$\frac{2\Pi \bar{R}}{4A}\left\{\begin{bmatrix} b^2 & b_1 b_2 & b_1 b_3 \\ b_1 b_2 & b_2^2 & b_2 b_3 \\ b_1 b_3 & b_2 b_3 & b_3^2 \end{bmatrix} + \begin{bmatrix} c_1^2 & c_1 c_2 & c_1 c_3 \\ c_1 c_2 & c_2^2 & c_2 c_3 \\ c_1 c_3 & c_2 c_3 & c_3^2 \end{bmatrix}\right\}\begin{Bmatrix} \bar{\psi}_1 \\ \bar{\psi}_2 \\ \bar{\psi}_3 \end{Bmatrix} + \frac{2\Pi \bar{R}^2 Ra}{6}\begin{Bmatrix} b_1 \bar{T}_1 + b_2 \bar{T}_2 + b_3 \bar{T}_3 \\ b_1 \bar{T}_1 + b_2 \bar{T}_2 + b_3 \bar{T}_3 \\ b_1 \bar{T}_1 + b_2 \bar{T}_2 + b_3 \bar{T}_3 \end{Bmatrix} = 0 \tag{3.14}$$

Which is in the form of the stiffness matrix $[K_s]\{\psi\} = \{f\}$

Similarly application of Galerkin method to Energy equation gives

$$\left\{R^e\right\} = -\int_A N^T \left[\frac{1}{\bar{r}}\left(\frac{\partial \bar{\psi}}{\partial \bar{r}}\frac{\partial \bar{T}}{\partial \bar{z}} - \frac{\partial \bar{\psi}}{\partial \bar{z}}\frac{\partial \bar{T}}{\partial \bar{r}}\right)\right] - \left[\frac{1}{\bar{r}}\frac{\partial}{\partial \bar{r}}\left(\bar{r}\frac{\partial \bar{T}}{\partial \bar{r}} + \frac{\partial^2 \bar{T}}{\partial \bar{z}^2}\right)\right] - \varepsilon\left[\frac{1}{\bar{r}}\left(\frac{\partial \bar{\psi}}{\partial \bar{r}}\right)^2 + \left(\frac{1}{\bar{r}}\frac{\partial \bar{\psi}}{\partial \bar{z}}\right)^2\right] 2\Pi \bar{r} dA \tag{3.15}$$

Considering the terms individually of the energy equation and following the same above steps. We get the stiffness matrix of energy equation as:

$$\left[\frac{2\Pi}{12A}\begin{Bmatrix} c_1 \bar{\psi}_1 + c_2 \bar{\psi}_2 + c_3 \bar{\psi}_3 \\ c_1 \bar{\psi}_1 + c_2 \bar{\psi}_2 + c_3 \bar{\psi}_3 \\ c_1 \bar{\psi}_1 + c_2 \bar{\psi}_2 + c_3 \bar{\psi}_3 \end{Bmatrix}\left[b_1, b_2, b_3\right] - \frac{2\Pi}{12A}\begin{Bmatrix} b_1 \bar{\psi}_1 + b_2 \bar{\psi}_2 + b_3 \bar{\psi}_3 \\ b_1 \bar{\psi}_1 + b_2 \bar{\psi}_2 + b_3 \bar{\psi}_3 \\ b_1 \bar{\psi}_1 + b_2 \bar{\psi}_2 + b_3 \bar{\psi}_3 \end{Bmatrix}\left[c_1, c_2, c_3\right]\right]\begin{bmatrix} \bar{T}_1 \\ \bar{T}_2 \\ \bar{T}_3 \end{bmatrix}$$

$$+\frac{2\Pi\overline{R}}{4A}\left\{\begin{bmatrix} b_1^2 & b_1b_2 & b_1b_3 \\ b_1b_2 & b_2^2 & b_2b_3 \\ b_1b_3 & b_2b_3 & b_3^3 \end{bmatrix}\begin{bmatrix}\overline{T}_1\\ \overline{T}_2\\ \overline{T}_3\end{bmatrix}+\begin{bmatrix} c_1^2 & c_1c_2 & c_1c_3 \\ c_1c_2 & c_2^2 & c_2c_3 \\ c_1c_3 & c_2c_3 & c_3^2 \end{bmatrix}\begin{bmatrix}\overline{T}_1\\ \overline{T}_2\\ \overline{T}_3\end{bmatrix}\right\}$$

$$+\frac{2\Pi A\in}{12\overline{r}}\left\{\begin{bmatrix}1\\1\\1\end{bmatrix}\left[b_1\overline{\psi}_1+b_2\overline{\psi}_2+b_3\overline{\psi}_3\right]^2+\begin{bmatrix}1\\1\\1\end{bmatrix}\left[c_1\overline{\psi}_1+c_2\overline{\psi}_2+c_3\overline{\psi}_3\right]^2\right\}=0 \qquad (3.16)$$

IV. Results and Discussion

Results are obtained in terms of the average Nusselt number $(\overline{Nu})$at hot wall for various parameters such as Rayleigh number (Ra), Radius ratio (R_r) Cone angle (C_A) and Viscous dissipation (ε) when heat is supplied to the vertical annular cone.

The average Nusselt number$(\overline{Nu})$, is given by $\overline{Nu}=\int_0^{\overline{z}}\left(\frac{\partial\overline{T}}{\partial\overline{r}}\right)$

a)

b)

c)

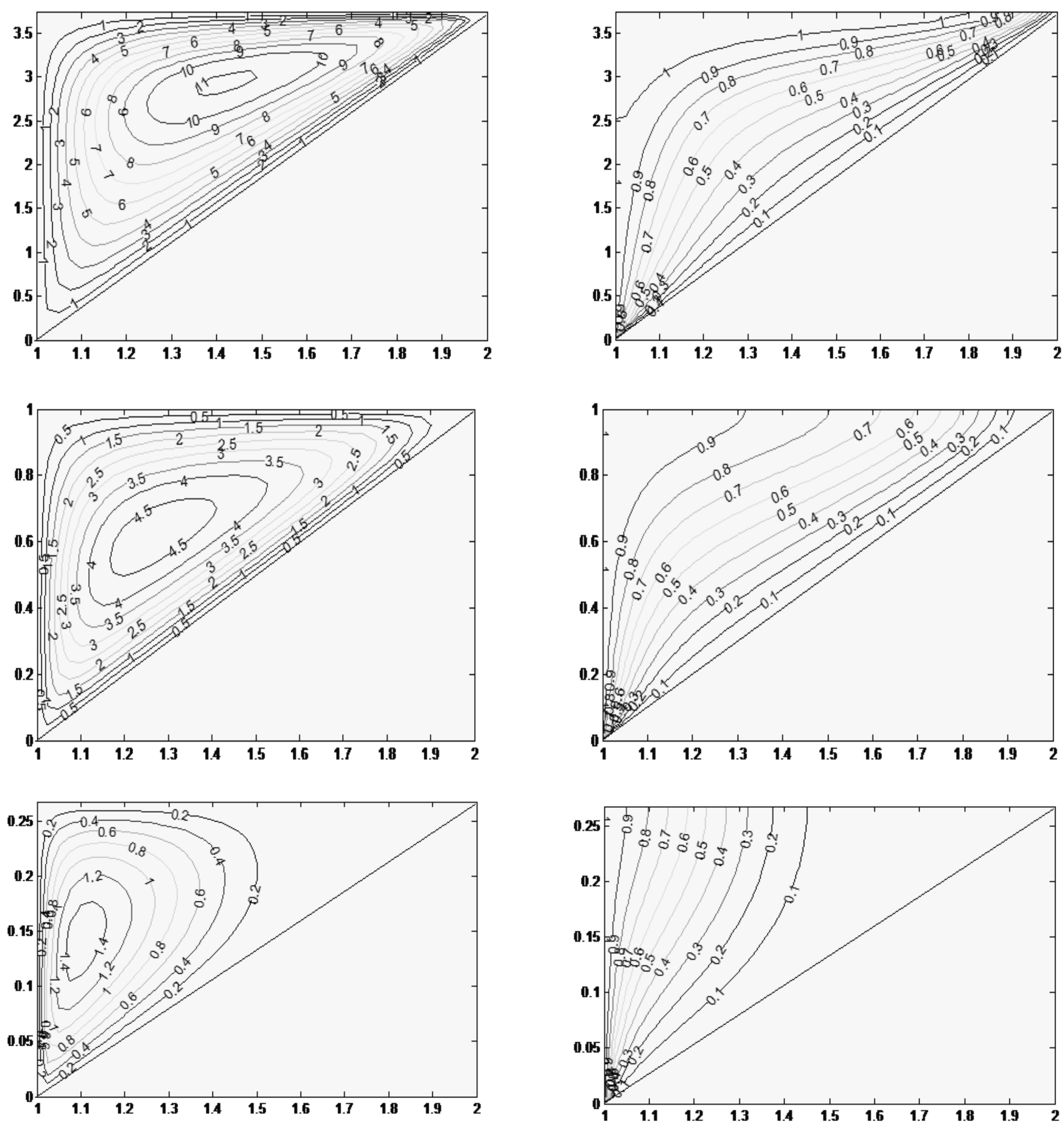


Figure 1 : Streamlines (left) and Isotherms (Right) for Ra=100, R_r=1, ε=0.01

a) C_A =15 b) C_A =45 c) C_A =75

a)
b)
c)

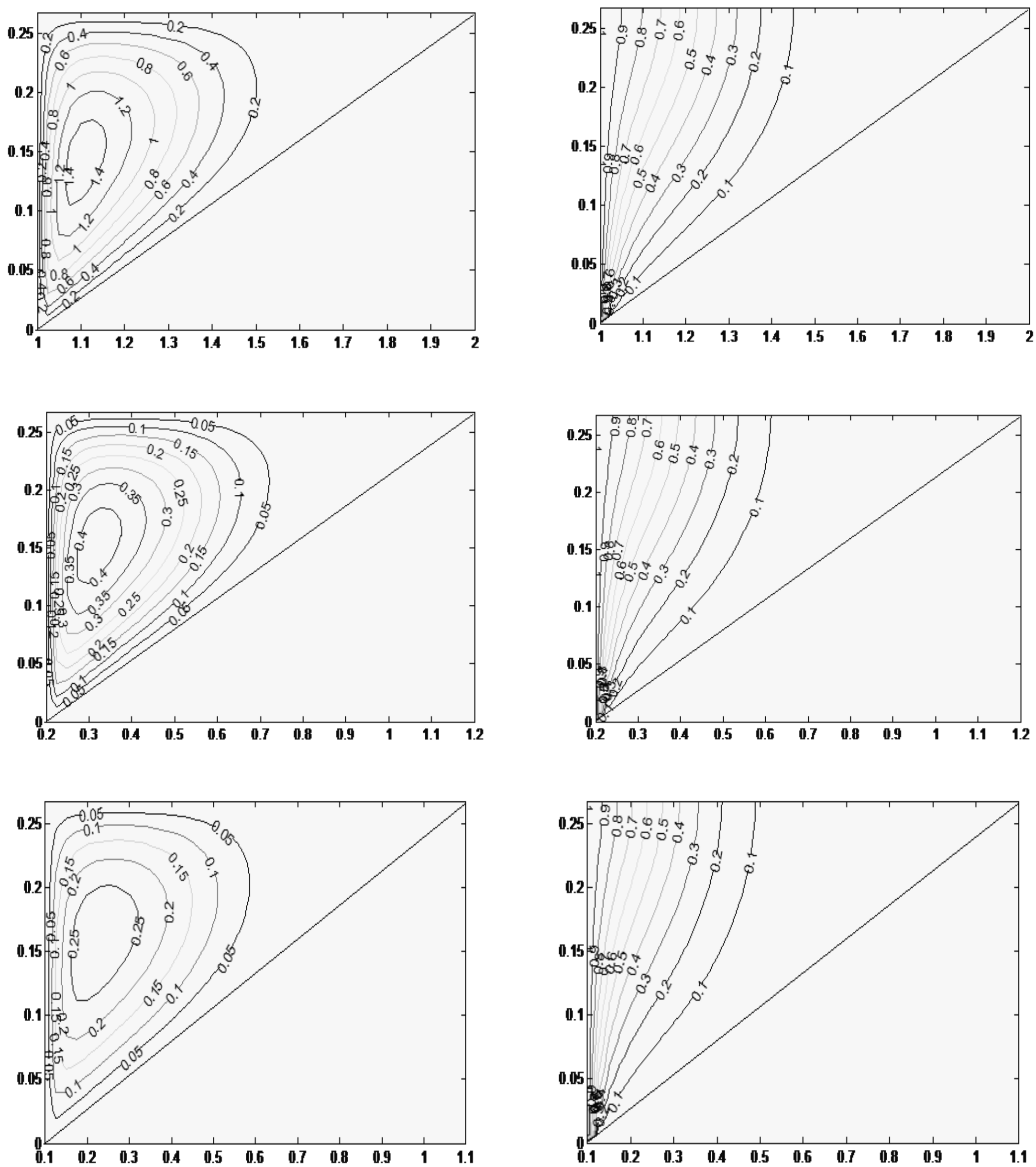
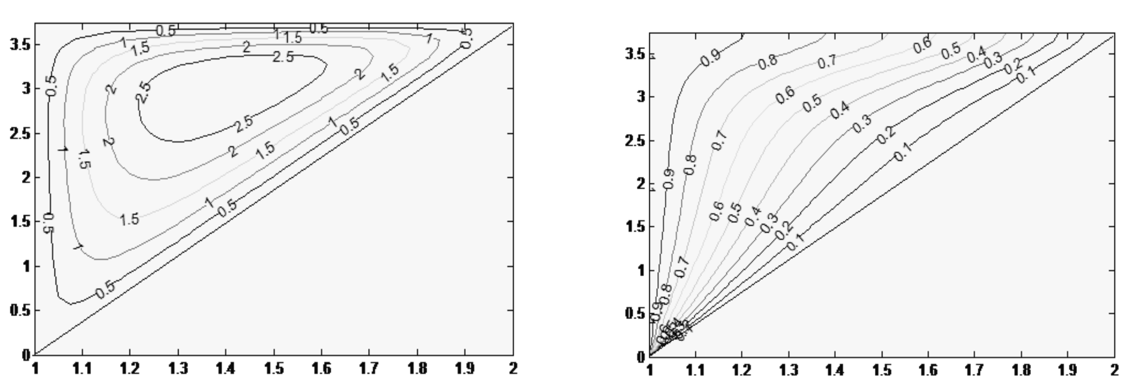


Figure 2 : Streamlines (left) and Isotherms (Right) for Ra=100, C_A =75, ε=0.01 R_r=1 b) R_r=5 c) R_r=10 a)

a)



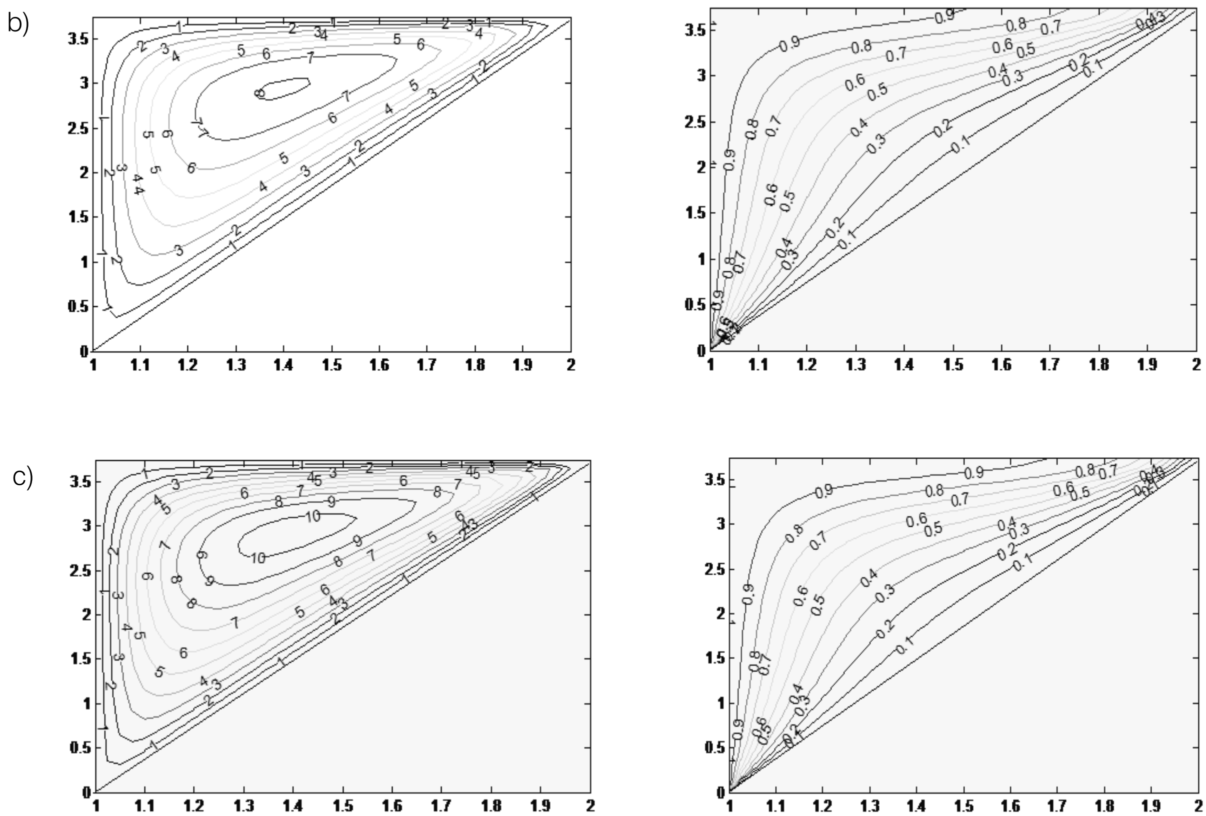


Figure 4 : Streamlines (left) and Isotherms (Right) for $\varepsilon=0.003$, $C_A=15$, $R_r=1$

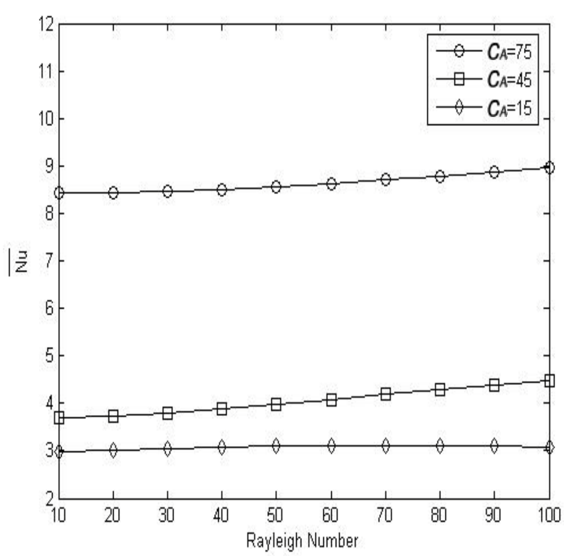


Figure 5 : $\overline{Nu}$ variations with Ra at hot surface for different values of C_A at $R_r=1, \varepsilon=0.003$

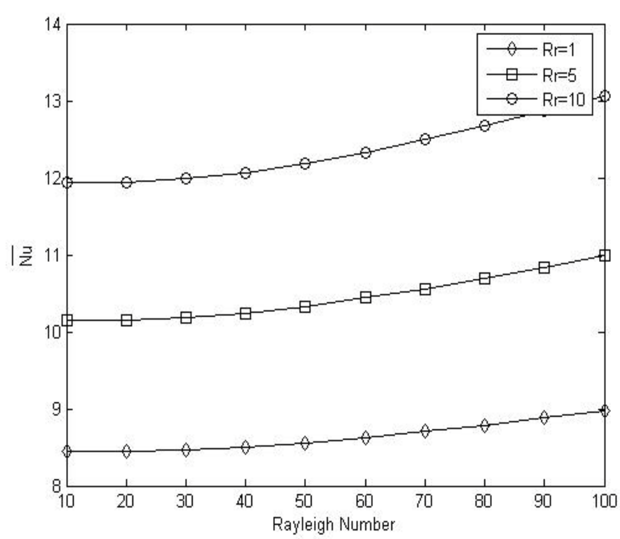


Figure 6 : $\overline{Nu}$ variations with Ra at hot surface for different values of R_r at $C_A=75, \varepsilon=0.01$

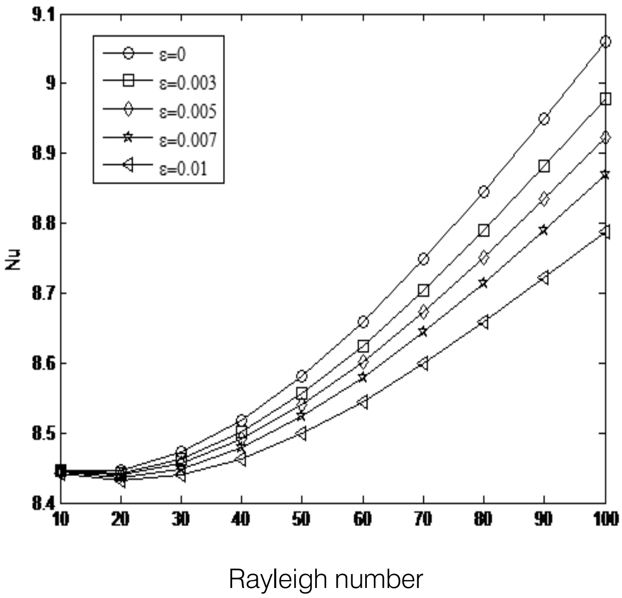


Figure 7 : $\overline{Nu}$ variations with Ra at hot surface for different values of ε at C_A = 75, R_r=1

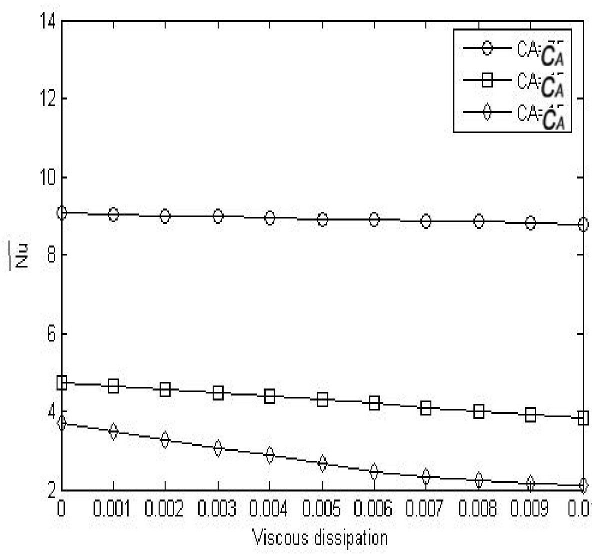


Figure 8 : $\overline{Nu}$ variations with ε at hot surface for different values of C_A at R_r=1, Ra=100

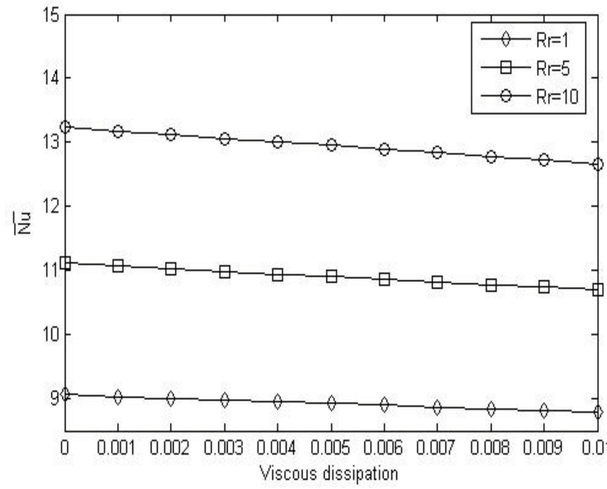


Figure 9 : $\overline{Nu}$ variations with ε at hot surface for different values of R_r at C_A=75, Ra=100

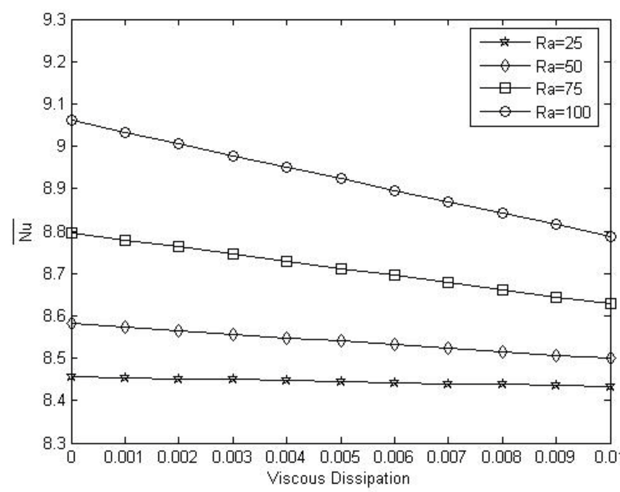


Figure 10 : $\overline{Nu}$ variations with ε at hot surface for different values of Ra at C_A = 75, R_r=1

Fig.1 (a-c) shows the streamlines and isothermal lines distribution inside the porous medium with respect of various values of Cone angle (C_A) at Ra = 100, R_r = 1, and ε = 0.01. The stream lines and isothermal lines move away from the cold wall and reach nearer to the hot wall as Cone angle (C_A) increase. It can be seen that the thickness of thermal boundary layer decreases with increasing Cone angle (C_A). The isothermal lines are evenly distributed between the two vertical surfaces at smaller Cone angle (C_A). The magnitude of stream lines decrease with increasing Cone angle (C_A) and occupies only half of the domain.

Fig.2 (a-c) illustrates the streamlines and isothermal lines distribution inside the porous medium for various values of Radius ratio (R_r) at Ra = 100, C_A = 75 and ε = 0.01. It is seen that the magnitude of streamlines decreases with the increase in Radius ratio (R_r). This happens due to the reason that at high Rayleigh number (Ra) with the viscous dissipation parameter (ε), leads to more fluid movement at the hot wall of the cone. The isothermal lines tend to move towards the hot surface of the cone as the Radius ratio (R_r) increases, because the thermal boundary layer becomes thicker.

Fig.3 (a-c) illustrates the streamlines and isothermal lines distribution inside the porous medium for various values of viscous dissipation parameter (ε) at Ra=100, C_A = 75 and R_r = 1. For increasing the values of viscous dissipation parameter (ε) no change of has been observed in the formation and occupation of the domain by streamlines and isothermal lines only half of the domain is covered with streamlines and isothermal lines.

Fig.4 (a-c) shows the streamlines and isothermal lines distribution inside the porous medium of the vertical annular cone for various values of Rayleigh number (Ra) at ε = 0.003, C_A = 15 and R_r = 1. As the value of Rayleigh number (Ra) increases the magnitude of stream lines also increases. This is due to the reason that the increased Rayleigh number (Ra) promotes the fluid movements due to higher buoyancy force, which in term allows the convection heat transfer at lower partition of the hot wall of the vertical annular cone.

Fig.5 demonstrates the effect of Rayleigh number (Ra) and Cone angle (C_A) on the average Nusselt number ($\overline{Nu}$).This figure corresponds to the values R_r = 1 and ε = 0.003. It is found that the average Nusselt number ($\overline{Nu}$) increases with increase in Rayleigh number (Ra) and Cone angle (C_A). For a given Rayleigh number (Ra), the difference between the average Nusselt number ($\overline{Nu}$) at two difference values of Cone angle (C_A) increase with Cone angle(C_A). For instance the average Nusselt number ($\overline{Nu}$) increased by 23% when Cone angle (C_A) is increased from 15 to 45 at Ra = 10. However the average Nusselt number ($\overline{Nu}$) increased by 45% when Cone angle (C_A) is increased from 15 to 45 at Ra = 100. This difference becomes more as the Rayleigh number (Ra) increases for particular value of Cone angle (C_A).

Fig.6 illustrates the effect of Rayleigh number (Ra) on the average Nusselt number ($\overline{Nu}$) for various values of Radius ratio (R_r). This figure corresponds to the values of C_A = 75, ε = 0.01. The average Nusselt number ($\overline{Nu}$) at hot wall of the vertical annular cone increases with increase in Radius ratio (R_r) and Rayleigh number (Ra).The average Nusselt number ($\overline{Nu}$) is increased by 41% at Ra = 10. Whereas at Ra = 100, it is found to be 45% with increase in Radius ratio (R_r) from 1 to 5.

Fig.7 demonstrates the effect of Rayleigh number (Ra) and viscous dissipation (ε) on the average Nusselt number ($\overline{Nu}$). This figure corresponds to the values C_A = 75, R_r = 1. It can be seen that the effect of viscous dissipation parameter (ε) is to reduce the average Nusselt number ($\overline{Nu}$) at hot wall. The temperature difference near the hot wall increases with increase in viscous dissipation parameter (ε). This happens due to the reason that the viscous dissipation leads to local heat generation, which increases the temperature in the porous medium. As the temperature of hot wall T_W is constant, the increased temperature of porous medium reduces the temperature difference between the hot wall and the near region. Due to this reason the heat transfer from hot wall to the porous medium increases which results in increasing the average Nusselt number ($\overline{Nu}$). The effect of viscous dissipation(ε) is higher at the lower values of Rayleigh number (Ra) as compared to the higher values of Rayleigh number (Ra). At Ra = 10, the average Nusselt number ($\overline{Nu}$) decreased by 4% when viscous dissipation parameter (ε) is increased 0 to 0.01. Whereas the corresponding reduction in the average Nusselt number ($\overline{Nu}$) at Ra = 100 is found to be 18%. The effect of viscous dissipation becomes more dominant at high Rayleigh number (Ra) as compared to lower Rayleigh number (Ra).

Fig.8 illustrates the effect of viscous dissipation parameter (ε) on the average Nusselt number ($\overline{Nu}$) for various values of cone angle (C_A). This figure is obtained for R_r=1, Ra=100. It can be seen that the average Nusselt number ($\overline{Nu}$) decreases with the increase in viscous dissipation parameter (ε). When there is no viscous dissipation then the average Nusselt number ($\overline{Nu}$) at hot wall always increases with increase Cone angle (C_A). This happens due to reason that higher Cone angle (C_A) leads to high buoyancy force and thus faster fluid movement. This faster fluid movement enhances the local friction between fluid and solid matrix thus increasing the local heat generation, which in turn reduces the average Nusselt number ($\overline{Nu}$). When there is no viscous dissipation parameter (ε), there is a decrease in the average Nusselt number ($\overline{Nu}$). Which is found to be 26.3 %, when Cone angle (C_A) increases from 15 to 45. At ε = 0.01, it is found that there is a decrease in the average Nusselt number ($\overline{Nu}$) by 46.2%. This shows that there is a decrease in the average Nusselt number ($\overline{Nu}$) as the viscous dissipation parameter (ε) increases.

Fig.9 illustrates the effect of Viscous dissipation parameter (ε) on he average Nusselt number ($\overline{Nu}$) for various values of Radius ratio (R_r). This figure is obtained for $C_A = 75$, $Ra = 100$. It can be seen that the average Nusselt number ($\overline{Nu}$) decreases with the increase in viscous dissipation parameter (ε). When there is no viscous dissipation (ε), at $\varepsilon = 0$, the average Nusselt number ($\overline{Nu}$) at hot wall always increase with increase in Radius ratio (R_r). Whereas at $\varepsilon = 0.005$, the average Nusselt number ($\overline{Nu}$) decreases as R_r is reduced. At $\varepsilon = 0.01$, the average Nusselt number ($\overline{Nu}$) always decreases with increase in Radius ratio (R_r). This happens due to the reason that higher Radius ratio (R_r) leads to high buoyancy force and this faster fluid movement. This faster fluid movement enhances the local friction between fluid and solid matrix thus increasing the local heat generation.

Fig.10 illustrates the effect of Viscous dissipation parameter (ε) on the average Nusselt number ($\overline{Nu}$) for various values of Rayleigh number (Ra). This figure is obtained for $C_A = 75$, $R_r=1$. It can be seen that the average Nusselt number ($\overline{Nu}$) decreases with the increase in viscous dissipation parameter (ε). At Ra=25, the average Nusselt number ($\overline{Nu}$) is linear, whereas at Ra=100, at lower viscous dissipation parameter (ε), the average Nusselt number ($\overline{Nu}$) increases and decreases with higher viscous dissipation parameter (ε).This happens due to the reason that higher Rayleigh number (Ra) leads to high buoyancy force and thus faster fluid movement. This faster fluid movement enhances the local friction between fluid and social matrix thus increasing the local heat generation.

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Performance and Emission Analysis of Diesel Engine using CNG under Dual Fuel Mode with Exhaust Gas Recirculation

By B. Nageswara Rao, B. Sudheer Prem Kumar & K. Vijaya Kumar Reddy
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Keywords: Compressed Natural Gas, Emissions, UHC.

GJRE-A Classification : FOR Code: 291801, 091399

PERFORMANCEANDEMISSIONANALYSISOFDIESELENGINEUSINGCNGUNDERDUALFUELMODEWITHEXHAUSTGASRECIRCULATION

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Keywords: Compressed Natural Gas, Emissions, UHC.

I. Introduction

Compressed Natural Gas (CNG) has become a better option as a clean burning fuel of an IC engine. In order to comply with the ever-stringent emission norms throughout the world and crunch in petroleum reserves, the modern day automobile industry is compelled to hunt for new and alternative means of fuel sources to keep the wheels spinning globally [1]. Paradoxical objectives of attaining simultaneous reduction in emissions along with high performance has provided with a few alternative. Natural gas produces practically no particulates since it contains few dissolved impurities (e.g. sulphur compounds). Moreover, natural gas can be used in compression ignition engines (dual fuel diesel– natural gas engines) since the auto-ignition temperature of the gaseous fuel is higher compared to the one of conventional liquid diesel fuel [3].

Dual fuel diesel–natural gas engines feature essentially a homogeneous natural gas–air mixture compressed rapidly below its auto-ignition conditions and ignited by the injection of an amount of liquid diesel fuel around top dead center position. Natural gas is fumigated into the intake air and premixed with it during the induction stroke. At constant engine speed, the fumigated gaseous fuel replaces an equal amount of the inducted combustion air (on a volume basis) since the total amount of the inducted mixture has to be kept constant. Furthermore, under fumigated dual fuel operating mode, the desired engine power output (i.e. brake mean effective pressure) is controlled by changing the amounts of the fuels used. Thus, at a given combination of engine speed and load, the change of the liquid fuel ‘‘supplementary ratio” leads to a change of the inhaled combustion air, thus resulting to the alteration of the total relative air–fuel ratio [1-3].In internal combustion engines, exhaust gas recirculation (EGR) is a nitrogen oxide (NOx) emissions reduction technique used in petrol/gasoline and diesel engines. EGR works by re-circulating a portion of an engine's exhaust gas back to the engine cylinders[5]. In a gasoline engine, this inert exhaust displaces the amount of combustible matter in the cylinder. In a diesel engine, the exhaust gas replaces some of the excess oxygen in the pre-combustion mixture, Because NOx forms primarily when a mixture of nitrogen and oxygen is subjected to high temperature, the lower combustion chamber temperatures caused by EGR reduces the amount of NOx the combustion generates. Most modern engines now require exhaust gas recirculation to meet the emission standard [4, 6-9].

II. Experimental Procedure

Series of several experimental cycles have been conducted with varying CNG percentages and iterations were done with varying exhaust gas recirculation and the results were compared. The engine used in the present study is a Kirloskar AV-1, single cylinder direct injection, Water cooled diesel engine with the specifications given in Table N0 1. Diesel injected with a nozzle hole of size 0.15mm.the engine is coupled to a dynamometer. Engine exhaust emission is measured. Load was varied from 0.5 kilo watt to 3 kilo watts. The amount of exhaust gas sent to the inlet of the engine is varied. At each cycle, the engine was operated at varying load and the efficiency of the engine has been calculated simultaneously.

The experiment is carried out by keeping the compression ratio constant i.e., 16.09:1. The exhaust gas analyzer used is MN-05 multi gas analyzer shown in Fig.1. (4 gas version) is based on infrared spectroscopy technology with signal inputs from an electrochemical

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cell. Non-dispersive infrared measurement techniques use for CO, CO2, and HC gases. Each individual gas absorbs infrared radiation absorbed can be used to calculate the concentration of sample gas. Analyzer uses an electrochemical cell to measure oxygen concentration. It consists of two electrodes separated by an electrically conducted liquid or cell. The cell is mounted behind a polytetrafluorethene membrane through which oxygen can diffuse. The Device therefore measures oxygen partial pressure. If a polarizing voltage is applied between the electrodes the resultant current is proportional to the oxygen partial pressure. The important properties of diesel fuel and natural gas are given in Table 1.

Table 1 : Properties of Diesel Fuel and Natural Gas

Fuel	Diesel	Natural gas
Chemical formula	$C_{10.8}H_{18.7}$	-[a]
Density (kg/m^3)	43	0.695[b]
Low heating value (MJ/kg)	830	49
Flammability limits (% vol.)	0.6-5.5	5-15
Laminar flame speed (cm/s)	5	34
Octane number	N/A	120
Cetane number	52	N/A
Autoignition temperature (^{0}C)	220	580
Stoichiometric air-fuel ratio (AFR^{stoic}, kg air/kg fuel)	14.3	16.82

[a]Natural gas consists of various gas species; from which methane (CH4) is the main constituent. The equivalent chemical composition of natural gas may be expressed as C1.16H4.32[10].
[b] At normal temperature and pressure.

Figure 1 : Multi gas analyzer experimental set up

III. Engine Specifications

Table 2 : Engine Specifications

Type	4- Stroke, single cylinder, Compression ignition engine, with variable compression ratio.
Make	Kirloskar AV-1
Rated power	3.7 KW
Speed	1500 RPM
Bore and stroke	80mm×110mm
Compression ratio	16.09:1, variable from 13.51 to 19.69
Cylinder capacity	553cc
Dynamometer	Electrical-AC Alternator
Orifice diameter	20 mm
Fuel	Diesel
Calorimeter	Exhaust gas calorimeter
Cooling	Water cooled engine
Starting	Hand cranking and auto start also provided

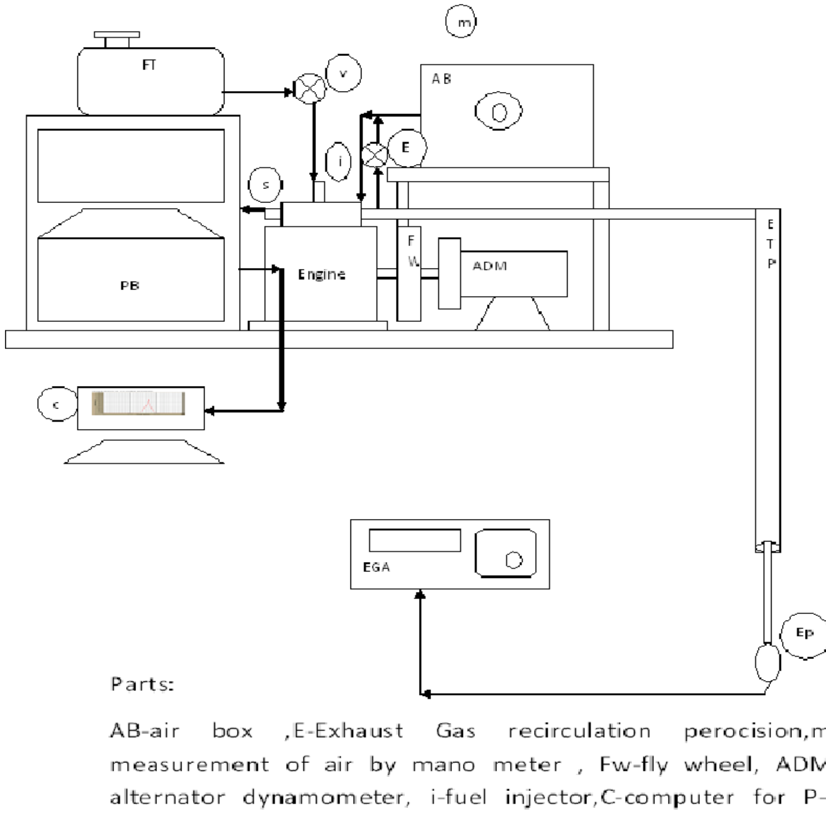

Figure 2 : Block diagram of experimental set up

A. Parts

AB-air box, mmeasurement of air by manometer,FW-fly wheel, ADM-alternator dynamometer, i-fuel injector, C-computer for P-θ interface, V-valve for fuel control, EGA-exhaust gas analyzer, S-piezoelectric sensor for p-θ interfacing, PB- panel board, EP-exhaust gas probe, FT-fuel tank.

B. Nomenclature

NO_X	Oxides of nitrogen
B_{th}	Brake thermal efficiency
Vol. Eff.	Volumetric Efficiency
UHC	Unburnt hydro carbons
PPM	Parts per million
EGR	Exhaust Gas Recirculation
CA	Crank Angle

Table 3 : Engine nomenclature

C. Brake Thermal Efficiency

Chart1 represents the trends of brake the rmal efficiency with the substitution of compressed natural gas (CNG) with corresponds to Brake power

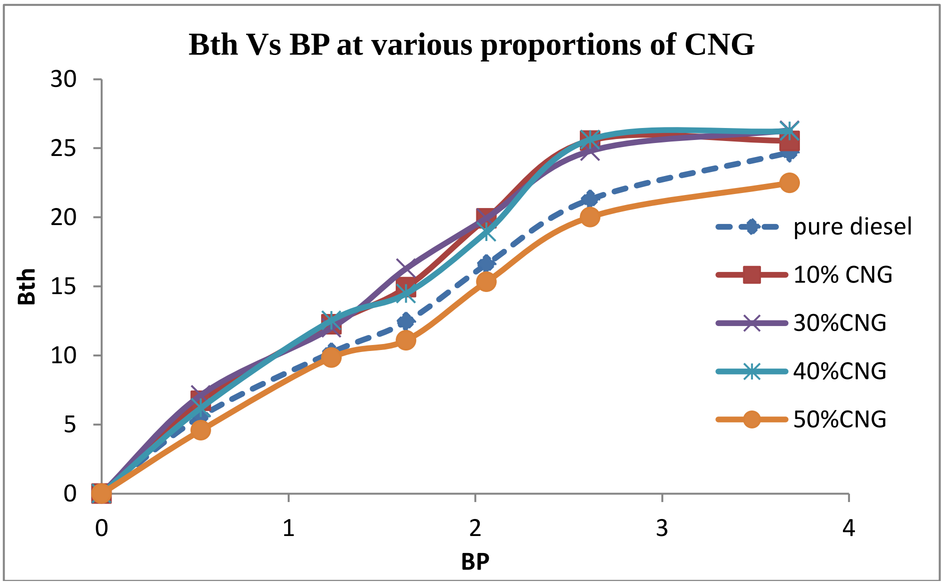

Chart 1 : Bth Vs BP at various proportions of CNG

From the chart1 it can be seen that up to 40% CNG substitution would be observed an increase in brake thermal efficiency of 10% compared to that of pure diesel, but 50% substitution of CNG has shown 5% decrease in brake thermal efficiency when compared to that of pure diesel.

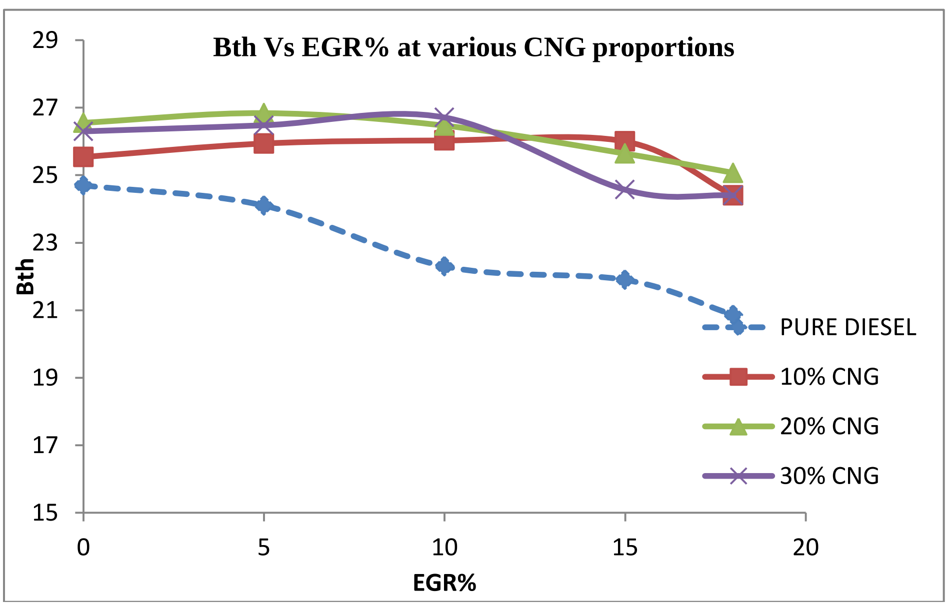

Chart 2 : Bth Vs EGR% at various CNG proportions

The chart 2 represents the relation between brake thermal efficiency and percentage of Exhaust gas recirculation. it shows that with an increase in exhaust gas recirculation proportion the brake thermal efficiency has increased till 10% of substitution but decreased with above 10% substitution .

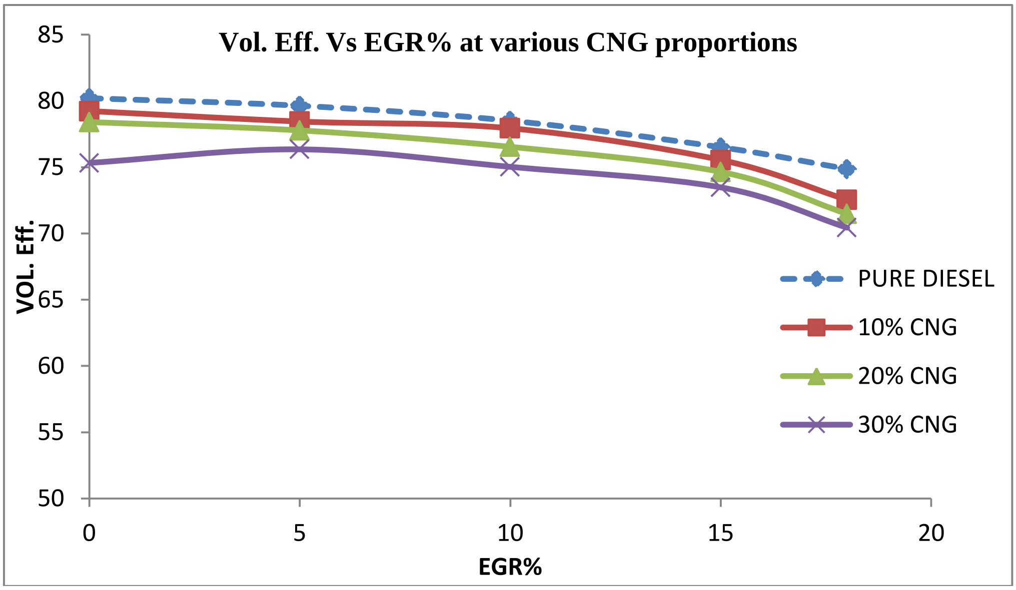

Chart 3 : Vol. Eff. Vs EGR% at various CNG proportions

The relation between volumetric efficiency and exhaust gas recirculation is represented in chart 3. It has been observed that the volumetric efficiency decreases with an increased substitution of compressed natural gas (CNG) and with increased exhaust gas recirculation (EGR).

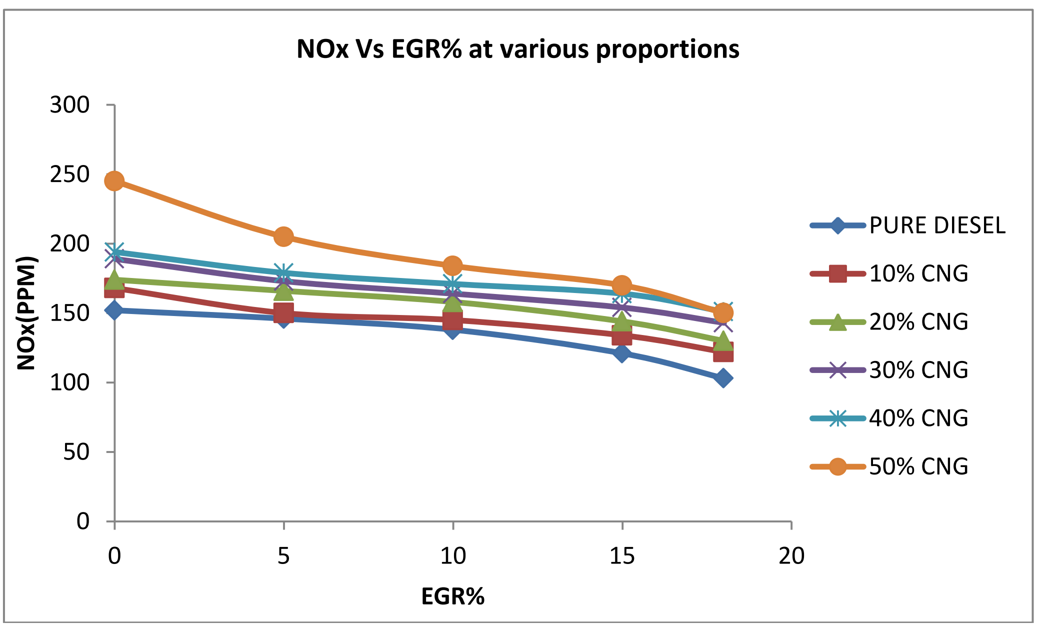

Chart 4 : NOx Vs EGR% at various proportions

The chart 4 represented the trends of NOx with the EGR substitution. it is observed that, with an increase in exhaust gas recirculation NOx emission havedecreased by 28% at all proportions of CNG substitution.

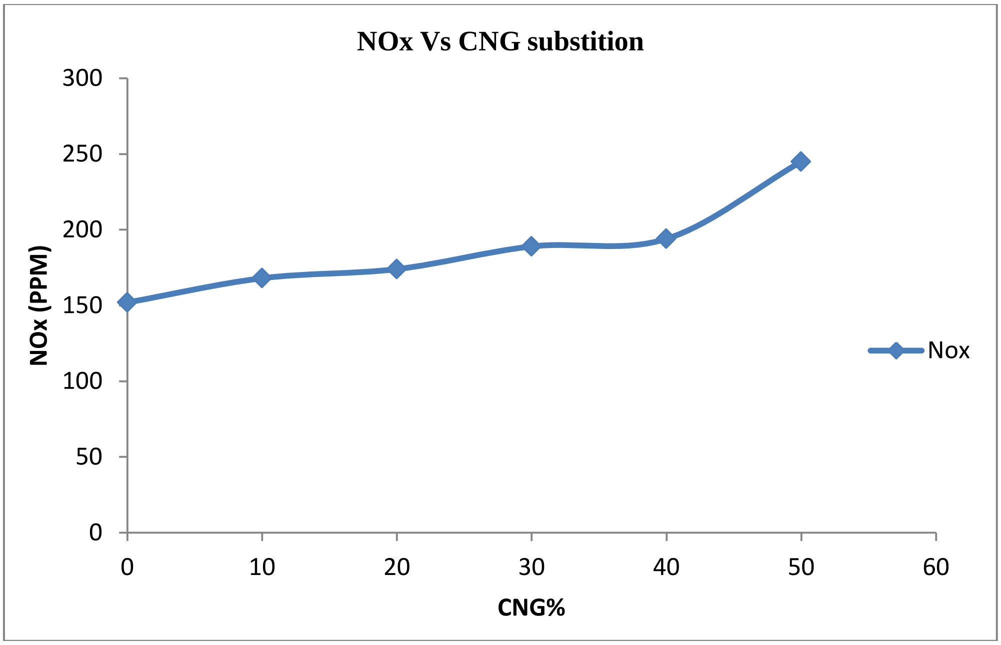

Chart 5 : NOx Vs CNG substitution

It is observed from chart 5 that with increase in CNG substitution Nox emission has increased, there 45% increase in NOx emissions when compared to that of pure diesel.

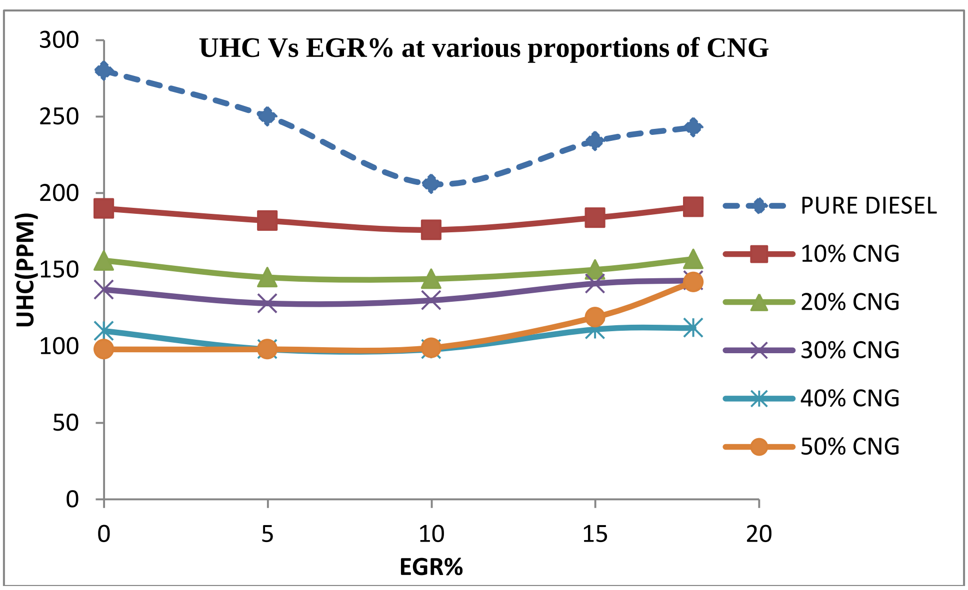

Chart 6 : UHC Vs EGR% at various proportions of CNG

Chart 6 represents the relation between un-burnt hydrocarbons and percentage of EGR for various proportions of CNG. The chart shows that with increase in exhaust gas recirculation up to 10% UHC have slightly decreased and again increased for further substitution.

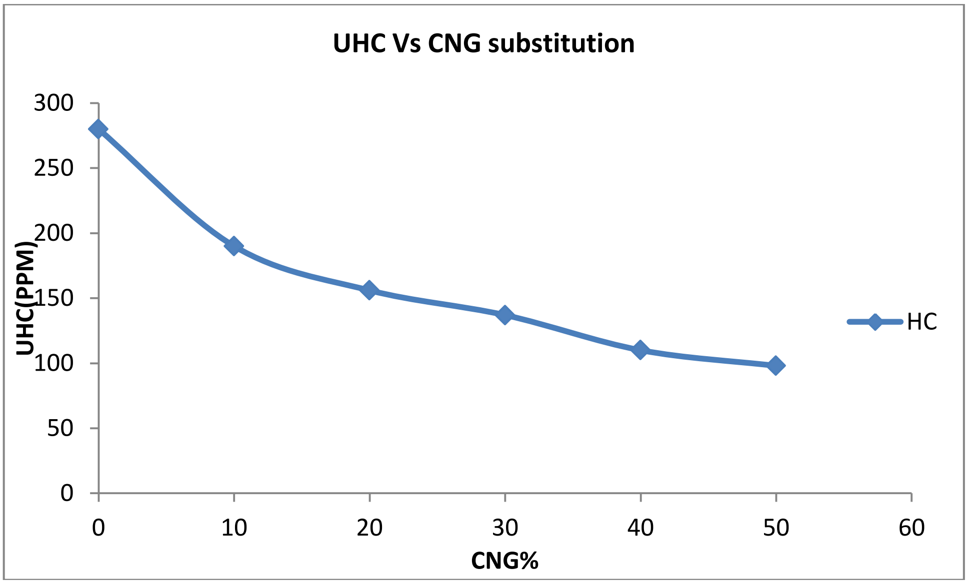

Chart 7 : UHC Vs CNG substitution

The chart7 represents the relation between un-burnt hydrocarbons and percentage of CNG substitutions which shows that with increase in CNG substitution un- burnt hydrocarbons have decreased, 50% of CNG substitution shows 61% decrease in UHC emission rate when compared to that of pure diesel.

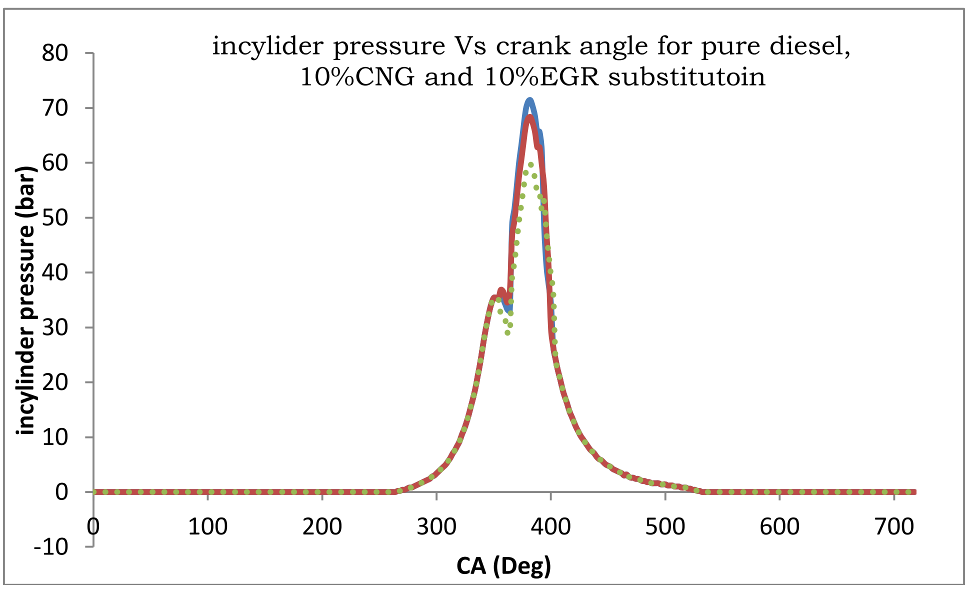

Chart 8 : in-cylinder pressure Vs crank angle for pure diesel, 10%CNG and 10%EGR substitution

Chart 8 shows the pressure inside cylinder at varying crank angles of the cycle for pure diesel, 10% CNG substitution and 10% exhaust gas recirculation at 10% CNG substitution.

IV. Conclusion

From the above obtained results the following conclusions were drawn:

a) Substitution of CNG up to 40% has shown increase on brake thermal efficiency of 20% compared to that of pure diesel, but 50% substitution of CNG has shown 11% decrease in cylinder pressure (bar) CA (Deg) in cylider pressure Vs crank angle for pure diesel, 10%CNG and 10%EGR substitutoin in brake thermal efficiency when compared

b) to that of diesel. The normal injection timing has shown higher volumetric efficiency. Any how the trend of varying volumetric efficiency has stood very general.

c) Substitution of 10% EGR to 10% CNG substitution has shown 15% increase in brake thermal efficiency

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when compared to that of 10% CNG substitution of CNG.

d) With increase in exhaust gas recirculation proportion brake thermal efficiency has increased till 10% of substitution but decreased above 10%.

e) Volumetric efficiency decreases with increased substitution of CNG and with increased exhaust gas recirculation.

f) Increase in exhaust gas recirculation NOx emissions have decreased by 28% at all proportions of CNG substitution.

g) With increase in CNG substitution NOx emission has increased, there 45% increase in NOx emissions when compared to that of pure diesel.

h) With increase in exhaust gas recirculation up to 10% UHC have slightly decreased and again increased for further substitution.

i) With increase in CNG substitution un-burnt hydrocarbons have decreased, 50% of CNG substitution shows 61% decrease in UHC emission rate when compared to that of pure diesel.

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Thermal Characterization of Nanoclay Nanocomposites

By Yousef Haik, Saud Aldajah, Kamal Moustafa, Saleh Hayek & Ammar Alomari
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Abstract- Nanocomposites have attracted the attention of scientists during the past few decades due to their superior mechanical, thermal, chemical and electrical characteristics. This paper studies the potential of using Nanoclay woven Kevlar laminated composites to enhance the impact the mechanical and thermal performance. The variation of Nanoclay percentage usually lead to different thermal characteristics of the resulting composite. Various percentages of Nanoclay added to the woven Kevlar composites were studied ranging from 0% to 9.4%. The results showed that the nanoclay reinforced composites showed a considerable change in the thermal characteristics of the considered samples. Thermal gravitational and differential scanning calorimetry analysis were performed and it was found that the decomposition temperature of the pure vinylester was increased by the addition of the Nanoclay, whereas the glass transition temperature was little affected. The results of the infrared spectrum analysis indicated the presence of both nano materials and polymers at various frequencies.

Keywords: nano composites, nano particles, thermal properties.

GJRE-A Classification : FOR Code: 290501p

Thermal Characterization of Nanoclay Nanocomposites

Yousef Haik [α], Saud Aldajah [σ], Kamal Moustafa [ρ], Saleh Hayek [ω] & Ammar Alomari [¥]

Abstract- Nanocomposites have attracted the attention of scientists during the past few decades due to their superior mechanical, thermal, chemical and electrical characteristics. This paper studies the potential of using Nanoclay woven Kevlar laminated composites to enhance the impact the mechanical and thermal performance. The variation of Nanoclay percentage usually lead to different thermal characteristics of the resulting composite. Various percentages of Nanoclay added to the woven Kevlar composites were studied ranging from 0% to 9.4%. The results showed that the nanoclay reinforced composites showed a considerable change in the thermal characteristics of the considered samples. Thermal gravitational and differential scanning calorimetry analysis were performed and it was found that the decomposition temperature of the pure vinylester was increased by the addition of the Nanoclay, whereas the glass transition temperature was little affected. The results of the infrared spectrum analysis indicated the presence of both nano materials and polymers at various frequencies.

Keywords: nano composites, nano particles, thermal properties.

I. Introduction

The widespread use of new nano composites attracted the attention of scientists in many engineering applications. The development of these new materials enables the circumvention of classic material performance trade-offs by accessing new properties and exploiting unique synergies between materials, that only occur when the length scale of morphology and the fundamental physics associated with a property coincide, i.e., on the nano scale level. Multifunctional features attributable to polymer nano composites consist of improved thermal resistance and/or flame resistance, moisture resistance, decreased permeability, charge dissipation, and chemical resistance. Through control/alteration of the additives at the nano scale level, one is able to maximize property enhancement of selected polymer systems to meet or exceed the requirements of current military, aerospace, and commercial applications. The technical approach involves the incorporation of nano particles into selected polymer matrix systems [1].

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One of the important characteristics of nano composites that lead to their wide use in many industrial applications is their improved impact resistance. Woven roving fabric laminates have proved to have superior impact energy absorbing properties to those of laminates made of unidirectional prepregs [2, 3]. Woven fabrics are used in a number of engineering applications across various industries, including such products as automobile airbags; flexible structures like boat sails and parachutes; reinforcement in composites; architectural expressions in building roof structures; protective vests for military, police, and other security circles; and protective layers around the body in planes. Woven fabrics consist of yarns woven in the fill and the warp directions.

The laminated composites were prepared manually, in this research, of fifteen plies of woven Kevlar49 arranged in symmetrical 0/45 alternation. Painting the matrix mix over each ply using painting brushes, then rolling each ply using a metallic roller to insure saturation of the resin and complete bonding between layers, after that composite hot pressing technique is performed to insure plies perfect bonding and unified thickness and to expedite the curing process.

The aim of this study was to investigate the effect of the addition of the NC on the thermal characteristics of the NC reinforced composite such as the glass transition temperature, the melting temperature, decomposition and crytallinity. Different percentages of NCs were tested and the results were compared to control samples composed from Kevlar plies only. The considered NC reinforced samples were tested by thermal gravitational analysis (TGA) [4], differential scanning calorimetry (DSC) [5] and the infrared (IR) [6] analysis techniques.

Using the TGA technique, one can measure the amount and rate of weight change in a material, either as a function of increasing temperature, or isothermally as a function of time, in a controlled atmosphere. This information helps to identify the percentage weight change and correlate chemical structure, processing, and end-use performance. The TGA measurements were performed under nitrogen atmosphere with balance purge flow of 40 mL/min and sample purge flow of 60 mL/min. About 10 mg of the composites samples were used each time. The measurements were done with a heating rate of 20°C/min in the temperature range of (0-600°C). It is demonstrated that the addition of NC increased the decomposition temperature of the composite which is expected due to the cross linking effect of NC reinforcement.

Differential Scanning Calorimetry (DSC) is a thermo analytical technique in which the difference in the amount of heat required to increase the temperature of a sample and reference is measured as a function of temperature. Both the sample and the reference are maintained at nearly the same temperature throughout the experiment. The DSC results of the tested samples has shown that the composite experienced direct decomposition without melting. No melting temperature was defined for each composite and crystallinity was, thus, difficult to define. Moreover, the results has shown very small variation in the glass transition temperature for all composites. and broadening in the glass transition temperature which could be an indication of a cross linking effect of the NC.

Infrared spectroscopy was used to check for the presence of nano clays. IR spectrum of a chemical substance is a fingerprint for its identification. The IR spectrum results of all samples show that the presence of both nano materials and polymers at various frequencies.

II. Materials used in Preparing Samples

The control samples are composite lamina prepared by adding 56 g of Vinylester to 117 g of Kevlar 49, thus making a resin percentage of 32. The nanoclay composite test samples are prepared by adding nano montmorillonite caly, nanomer 1.34T CN that contains 25-30 wt% to the Vinylester in different percentages. Nanoclay is the most widely investigated nanoparticle in a variety of different polymer matrices for a spectrum of applications [7]. The origin of bentonite (natural clay) is most commonly formed by the in-situ alteration of volcanic ash. Nanoclays have become attractive materials because of their potential use in wide range of applications such as in polymer nanocomposites [8]. Different percentages of Nanoclay Kevlar composites were prepared in this work; namely, 2%, 4.3%, 7%, and 9.4%.

Kevlar is an aramid fiber, a term invented as an abbreviation for aromatic polyamide developed in 1965 by DuPont Company. The chemical composition of Kevlar is poly para-phenyleneterephthalamide, and it is more properly known as a para-aramid. The aramid ring gives Kevlar thermal stability, while the para structure gives it high strength and modulus [9]. Kevlar aramid has a high tensile strength, higher tensile modulus and lower density than fiber glass but it is more expensive than glass fiber [10]. Aramid fibers provide the highest tensile strength-to-weight ratio among reinforcing fibers. They provide good impact strength and, like carbon fibers, provide a negative coefficient of thermal expansion.

III. Thermal Analysis Experimental Results

a) Thermal Gravimetric Analysis (TGA)

Thermal Gravimetric Analysis (TGA) Q50 Device from TA Instruments (New Castle, Delaware) was utilized to study the thermal weight-change of the NC/ Vinylester samples. The Thermo gravimetric analyzer measures the amount and rate of weight change in a material, either as a function of increasing temperature, or isothermally as a function of time, in a controlled atmosphere. It can be used to characterize any material that exhibits a weight change and to detect phase changes due to decomposition, oxidation, or dehydration. This information helps us identify the percentage weight change and correlate chemical structure, processing, and end-use performance [4].

The TGA measurements were performed under nitrogen atmosphere with balance purge flow of 40 mL/min and sample purge flow of 60 mL/min. About 10 mg of the composites samples were used each time. The measurements were done with a heating rate of 20°C/min in the temperature range of (0-600 °C).

Figures 1 and 2 show the TGA results of all samples where the onset slope method was used to evaluate the exact value of decomposition temperature. These figures indicate that almost each addition of NC to the vinylester/NC nanocomposite increased the decomposition temperature. The results are summarized in Table 1. It can be seen that the decomposition temperature of pure vinylester is 437°C. The addition of NC percentage by 2%, 4.3%, 7% and 9.4% to the vinylester resin increased the decomposition temperature, respectively to, 445°C, 460°C, 468°C, and 466°C. This increase in the decomposition temperature is expected due to the cross linking effect of NC. It shows that the 9.4% did showed similar, somewhat less, results as the 7% which could be attributed to the non-uniform dispersion of the added NC. However, it showed higher decomposition temperature when compared to the other samples with lower NC content.

3.2 Differential scanning calorimetry (DSC).

Differential Scanning Calorimetry (DSC) is a thermal analytical technique in which the difference in the amount of heat required to increase the temperature of a sample and reference is measured as a function of temperature. Both the sample and the reference are maintained at nearly the same temperature throughout the experiment. The basic principle underlying this technique is that when the sample undergoes a physical transformation such as phase transitions, more or less heat will be needed to flow to the sample compared to the reference to maintain both at the same temperature [5].

The DSC measurements were performed using a TA instrument (New Castle, Delaware) DSC 200 under nitrogen atmosphere with a sample purge flow of 50 mL/min. 10 mg of the composites samples were used each time in a sealed aluminum pan. The samples were heated to 250°C at a rate of 10°C/min to eliminate the heating history. Then they were cooled below 0°C at a rate of 10°C/min and then heated at the same rate to a temperature of 500°C.

Figure 3 shows the DSC results of the NC/vinylester nanocomposites zoomed at the decomposition region. It is clear that the tested composites experienced direct decomposition without melting, so no melting temperature were defined for each composite. Moreover, no melting temperature is observed for this type of composite, and, therefore, crystallinity is impossible to define. To find the glass transmission temperature (Tg), the results data were zoomed at the expected region of this temperature as seen in Fig. 4. The glass transition temperature for pure vinylester was determined as 56.5ºC. The addition of 2%, 4.3%, 7% and 9.4% of NC, change the glass transition temperature of the corresponding composite to 56.5ºC, 53.8ºC, 55.4ºC and 56.8ºC respectively. The results show very small variation in the glass transition temperature for all composites. Also, we can notice broadening in the glass transition temperature which may be an indication of a cross linking effect of the NC.

3.3 Infrared (IR) Analysis.

Infrared spectroscopy is one of the most powerful analytical techniques, which offers the possibility of chemical identification [6]. This technique when coupled with intensity measurements may be used for quantitative analysis. One of the important advantages of infrared spectroscopy over the other usual methods of structural analysis (X-ray diffraction, electron spin resonance, etc.) is that it provides information about the structure of a molecule quickly without tiresome evaluation methods. This technique is based on the simple fact that a chemical substance shows marked selective absorption in the infrared region giving rise to close-packed absorption bands called an IR absorption spectrum, over a wide wavelength range. Various bands will be present in the IR spectrum, which corresponds to the characteristic functional groups and bonds present in a chemical substance. Thus an IR spectrum of a chemical substance is a fingerprint for its identification. Figure 5 shows the IR spectrum of all samples including the nanoclays. IR spectrum of all samples shows the presence of both nano materials and polymers at various frequencies.

IV. Conclusions

The NC addition to the Vinylester resulted in a considerable change in the thermal characteristics of the NC reinforced composites. Samples with different NC percentage were tested using the thermal gravitational analysis, the differential scanning calorimetry, and infrared analysis techniques. The NC percentage used in preparing the samples were 2, 4.3, 7, and 9.4. The thermal gravitational analysis showed that the decomposition temperature of pure vinylester was increased by the addition of the nanoclay. The results of the differential scanning. calorimetry analysis indicated that vinylester nanocomposites experienced direct decomposition without melting and it was difficult to define crystallinity. The glass transition temperature of the vinylester/Nanoclay composite was little affected by the nanoclay addition. The results of the infrared spectrum analysis indicated the presence of both nano materials and polymers at various frequencies.

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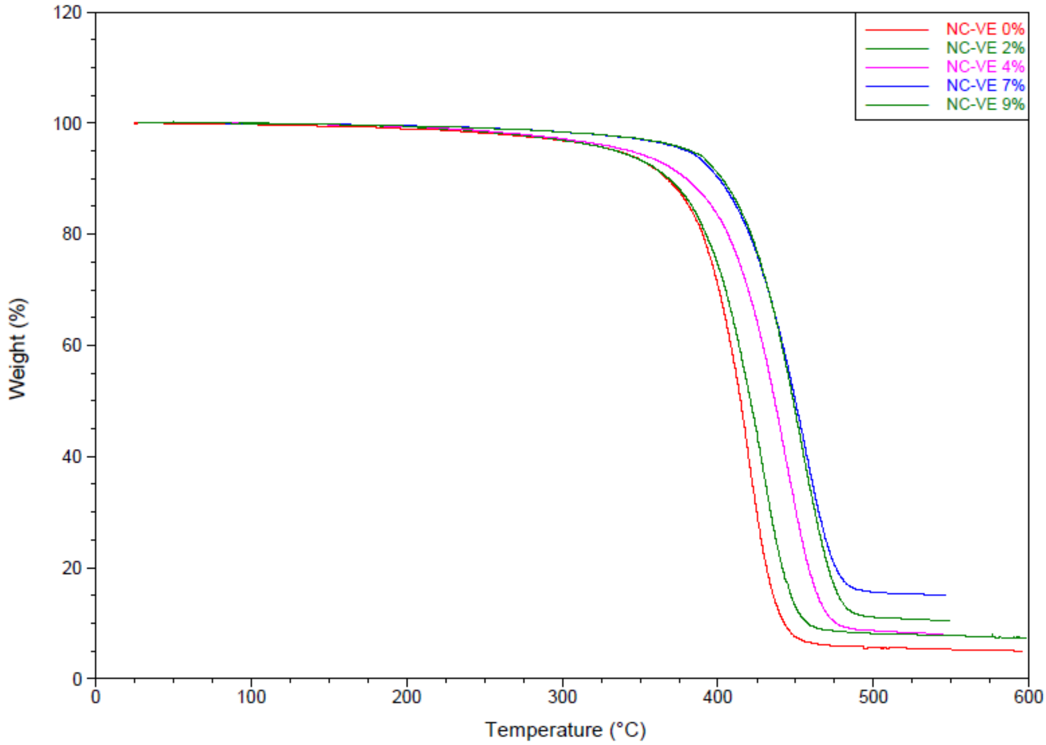

Figure 1 : TGA Results of NC-VE-All Results

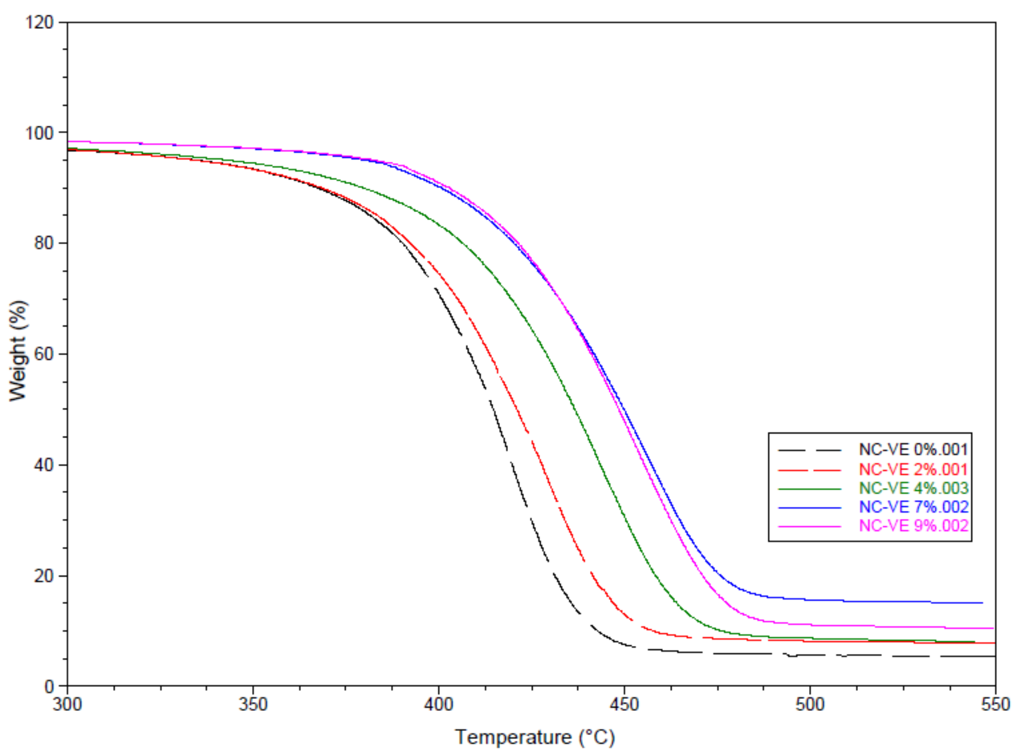

Figure 2 : TGA Results of NC-VE-All Results with Zoom at the Decomposition Region

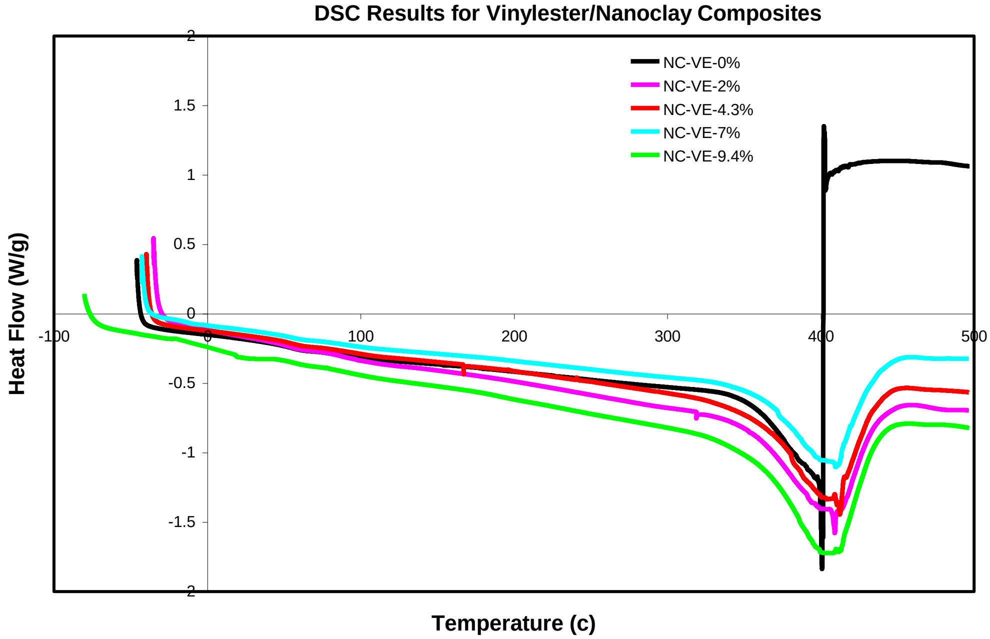

Figure 3 : DSC Results of NC-VE-All with zoom at the decomposition region

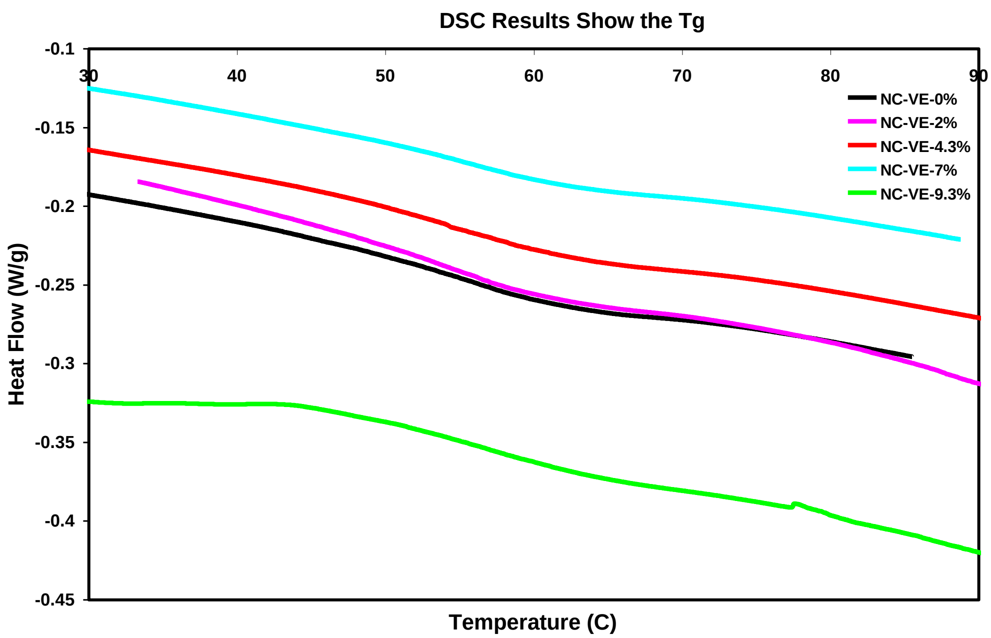

Figure 4 : DSC Results of NC-VE-All with zoom at the glass transition temperature region

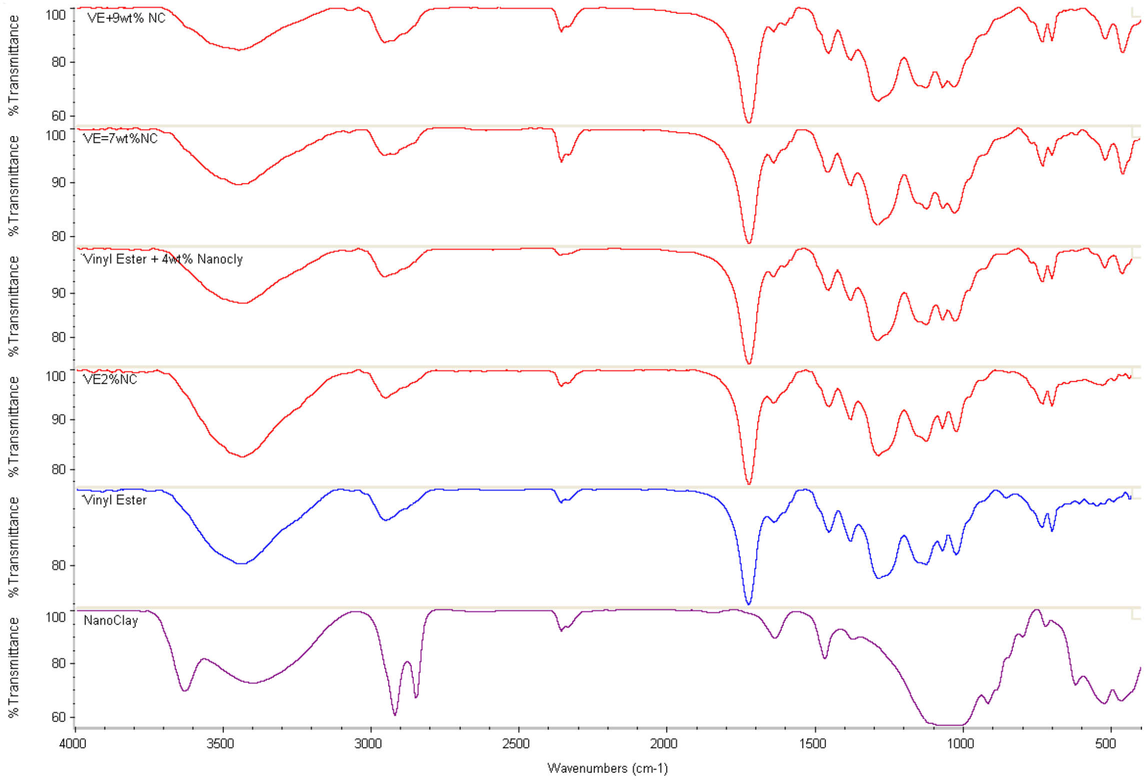

Figure 5 : IR spectrum for all samples

Table 1 : Increase in decomposition temperature as a function of NC %

NC %	0	2	4.3	7	9.4
Decomposition Temperature (°C)	437	445	460	468	466

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Study of Effect of Deformation Temperature on 6061 Aluminium Alloy by Thermo Mechanical Simulation

By Rahul D. Dongre & Swati Salunkhe
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Keywords: forging temperature, stress-strain curve, dynamic recovery, 6061 alloy.

GJRE-A Classification : FOR Code: 091399

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I. Introduction

At the present, the metal forming industrials have high technology competition, not only the modernized machinery but also the manufacturing process which reduced the production cost in various ways. The forging process was the fast work pieces production and had accurate size when compared with the metal molding process. For this reason were necessary to studied for searching several variables such as choosing the kind of materials which were suitable with hot forming process, forging temperature, stain, strain rate which directly affected the end product quality [1-2].Researches of aluminum alloys indicate a great correlation between these parameters and structure quality from which mechanical properties depend. During deformation of aluminium alloys at elevated temperature, the intensive processes of structure restoration are preceded. In the majority of studies it is ascertained that the main process of structure restoration in aluminium alloy is dynamic recovery [3].

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II. Experiments

The experiment were carried out on Al-Si-Mg Alloy (6061 alloy) whose main chemical composition are give in table 1. Cylindrical samples with size of d10 mm x 15 mm were machined from commercially extrusion billet. A computer –controlled, servo –hydraulic Gleeble 3500 Machine was used for compression testing. It can be programmed to simulate both thermal and mechanical industrial process variable for a wide range of hot deformation condition. The specimens were heated to the deformation temperature at heating rate of 5 °c/s and held at the temperature for 120 s by thermo coupled-feedback-controlled AC Current. The isothermal hot compression tests were performed at 350, 400, 450 °c Temperature and strain rates of 0.2, and 20 s^{-1}. The experimental stress-stain curves under various deformation conditions were obtained. The deformed specimens were water quenched after compression to maintain the microstructure for further observation.

Table 1 : Chemical composition of AlSiMg Alloy (wt %)

Mn	Mg	Si	Cu	Fe	Zn	Cr
0.06	0.97	0.64	0.39	0.15	0.08	0.04

Following process cycle were carried for total of 9 samples in order to determine the effect to deformation temperature on material and properties which can be achieved if they are forged for particular strain rate which is being maintained. He figure of complete TMS Experiment cycle are given at fig no.1.

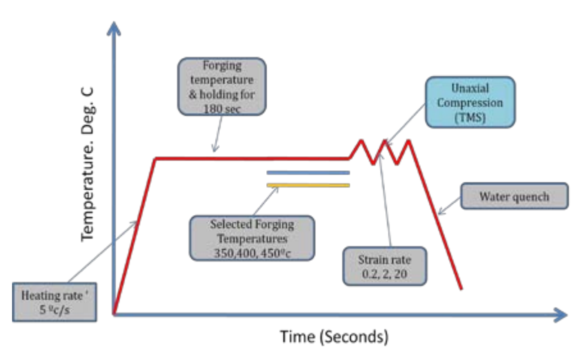


Figure 1 : Gleebel cycle for 6061 Aluminium Alloy

III. Results and Discussion

a) Stress –Strain Curve

A serious typical true stress-strain curves obtained during hot compression of 6061 alloys at strain rate of 0.2,&20 s^{-1} and deformation temperature of 350, 450°c are show in Fig.2&3.It can be seen that the true stress –true strain curve exhibit a peak stress at a certain strain, followed by dynamic flow softening until the end of compression. The flow softening is probably subjected to the dynamic recovery and recrystallization during the hot deformation of precipitation hardening alumimum alloys [4].Comparing the curves with one another, it is found that,for a specific strain rate, the flow stress deceases markedly with temperature deceasing. Further, the temperature changes have a significant effect on the dynamic softening rate. The strain corresponding to the peak stress increases with increasing strain rate [5].

It can be seen clearly from fig.2 that the strain –stress curve of 6061 alloy deformed at 350°c is typically characterized by a rise to a plateau followed by a constant flow stress, which is the feature of curves for DRV. This indicates that the main softening mechanism of 6061 alloy in this condition is DRV. However, the stress –strain curves of 6061 alloy deformed at 450°c exhibits a single and smooth peak, followed by a slow but obvious softening stage, which is quite different from that deformed at 350°c. It is reasonable to presume that the softening mechanism in this condition may be DRX. Table no.2 shows that as the strain rate incenses the flow stress also increases and as a temperature increases flow stress decreases at constant strain rate.

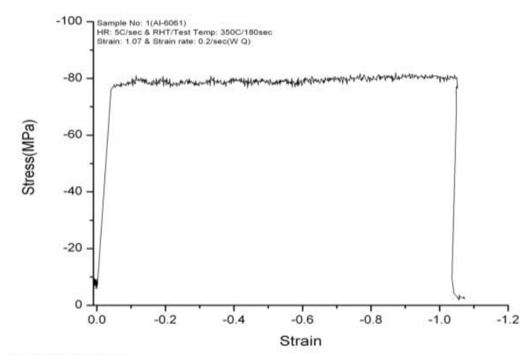


Figure A

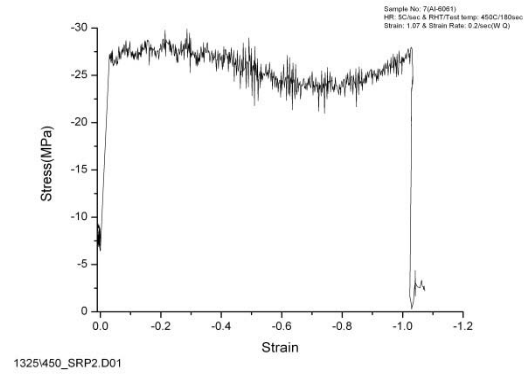


Figure B

Figure 2 : True stress-true strain curves during hot compression of 6061-Al A)350 B)450 °c at 0.2 s^{-1}

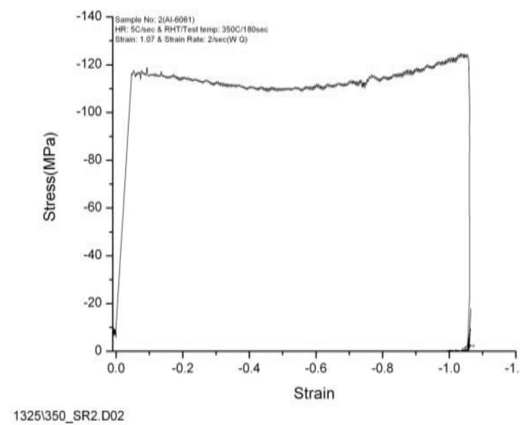


Figure A

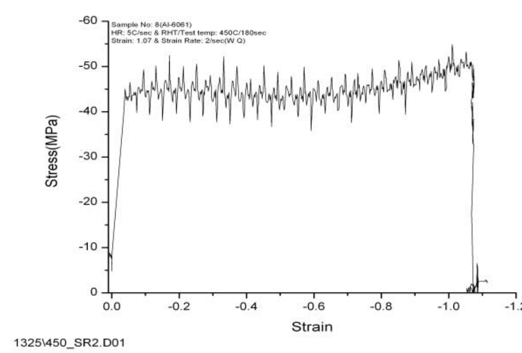


Figure B

Figure 3 : True stress-true strain curves during hot compression of 6061-Al a) 350 b) 450 °c at 2 s^{-1}

Table No. 2

Temp °c	Strain rate s^{-1}	Peak Stress (MPA)
350	0.2	79
450	0.2	27
350	2	114
450	2	44

b) Microstructure Evolution

After preparing stress-stain diagram next thing is microstructure evolution [6].Fig.4 of the microstructure show that at low temperature there is a Precipitation taking place which directly increases the flow stress[7]. The dark region in the microstructure show the Mg2Si Precipitate and light grey colour shows AlFeSi. Due to low temperature the size of the precipitate is Bigger. There is a sub grain formation with a dissolute precipitate inside due to which hardening taking places at 350°c temperature.

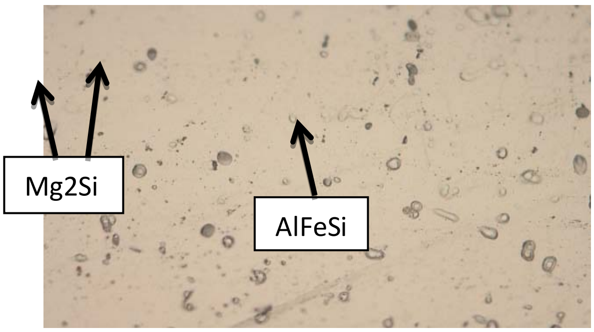


Figure 4 : microstructure at 350 and $0.2s^{-1}$

Fig.5 at 450°c there is a completed solid solution of aluminium due to which precipitates are almost very less and flow stress decreases. Due to the high temperature the hardness decreases & very low Mg2Si will appear. Precipitation thickness will be very low & some amount of water marks are also there in 450°c. Because of the various factor& restriction the microstructure of 350 & 450°c is only check at $0.2s^{-1}$strain rate.

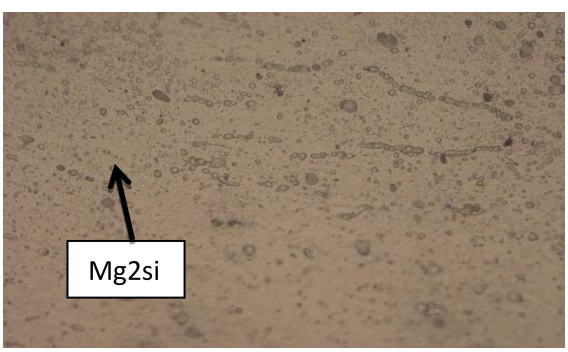


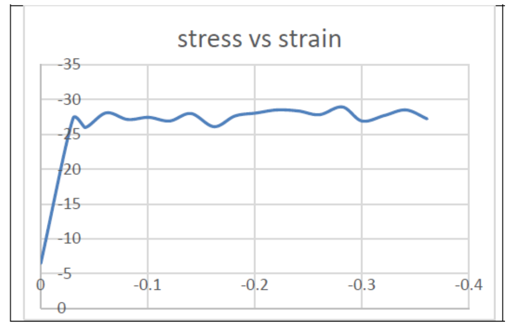
Figure 5 : microstructure at 450°c and $0.2s^{-1}$

IV. Dynamic Recovery

For the conformation of dynamic recovery work hardening exponent is calculated and then double differential of that is take to find out that there is DRX orDRV[9-10].The change of slope $\theta = d\sigma / d\varepsilon$ of stress-strain curve with stress can be a good indication of microstructure change taking place in material.

Fig. 6&7 show that Strain hardening curve is generated i.e $\theta = d\sigma / d\varepsilon$ where the change in slope of the θ-curve with respect to $- d\sigma / d\varepsilon$ if there is occurrence of DRX then slope can be identified by means of inflation point.

The curve is generated for 350°c, 450°c for $0.2s^{-1}$ strain rate.



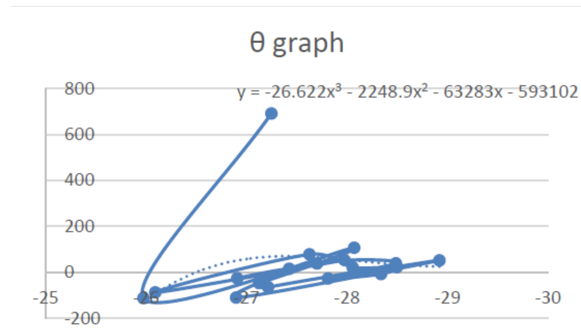


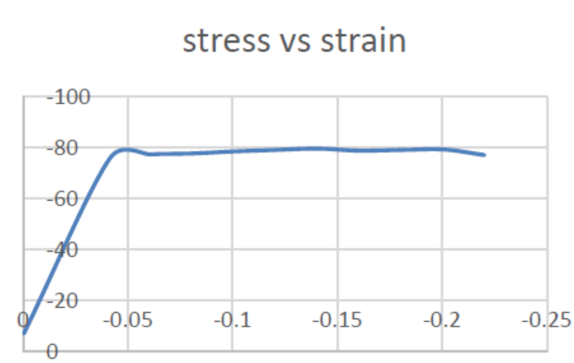
Figure 6 : Strain hardening curve along with stress strain curve at 350°c

For the above sample the strain hardening curve is generated and it was observed that for strain rate of 0.2 s^{-1} there was no DRX taking place but recovery and hardening was initiated with peak stress. The Θ graph showing that there is no such smooth DRX formation is there hence the dark line and dotted line in the graph are just collapse with each other at various point. This is the indication of DRV.

Critical stress =B/3A

$\sigma c = 79.429$

At a temp of 350 c & strain rate of $0.2s^{-1}$the critical stress occur is 79 Mpa which remain almost constant. Which show that a dynamic softening is replaces by work hardening.



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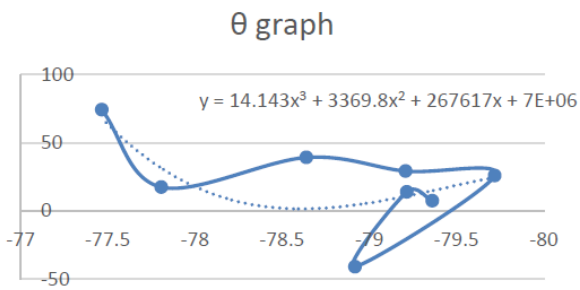

Figure 7 : Strain hardening curve along with stress strain curve at 450°c

At 450°c the ϴ graph showing that there is a point were both dotted & dark line meet at point. Hence we can predict that there is a chance of DRX at high temperature.

a) Hardness value

For knowing the hardness value change according to the temperature the Vickers hardness test is done. The hardness has been taking at core & edge of the specimen and the value are put in Table no.3. The maximum hardness achieve is at 350 c in core 71.1 HV. Hence we can say that as the temperature increases the hardness decreases vice versa.

Table 3

No.	Temp	Hardness (HV)			
	0°c	Core		Edge	
1	350	71.1	70.1	68.1	70.2
3	450	49.9	50.9	49.8	50.1

V. Conclusions

a) The true compressive stress –strain curves of 6061 aluminum alloy deformed at different temperature and strain rates were obtained.

b) The result shows that temperature changes have a significant effect on the dynamic softening rate.

c) At 350° c there is typical rise to a plateau followed by a constant flow stress, which is the feature of curve for DRV.

d) At 450°c exhibit some peak followed by a slow but obvious softening stage. It is reasonable to presume that the softening mechanism in this condition may be DRX.

e) At 350 °c a horizontal line is obtained which show that precipitation is taking places.

f) At 450 °c dynamic softening is balances by work hardening.

g) The true stress & stain graph show that at low temperature and low stain rate flow stress are low. But as the stain rate is increases and temperature is a decrease the flow stress increases.

h) In contrast, for a temperature of 450° c the low stress generally increases with the strain rate due to the increases of dislocation density & dislocation multiplication rate.

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Superlow Interaction in Layered Structures

By Michail V. Nozhenkov
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Abstract- The article investigates the impact of technology of the properties of thin films of anisotropic laminated structures. Performed electron diffraction and electron microscopy studies of the structure. Testing of the tribological properties. The positive effect of applying wear-resistant underlayer and alloying of the coating material, which led to a significant increase in the durability and appearance of superlow friction. The generalized model of non-dissipative transport of mass (energy) in the absence of resistance forces during the move. Found that the superlow friction, superconductivity and superfluidity are related phenomena defined phase transition particle energy distribution across the critical value (energy potential barrier).

Energetically favorable arrangement of the particles in the crystal lattice for the non-dissipative movement in the lack of forces of resistance are the spaces of Van der Waals in layered systems where possible prediction of the investigated phenomena.

Keywords: vacuum ion-plasma coating methods, particle, atom, cluster, electron diffraction and electron microscopy studies, superconductivity, superfluidity, superlow friction.

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SUPERLOWINTERACTIONINLAYEREDSTRUCTURES

Strictly as per the compliance and regulations of:

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I. Introduction

To improve the physical and mechanical characteristics of the surface layers of parts in order to increase the durability and reliability of used durable and anti-friction coatings applied by various methods. Surface properties used in modern engineering austenitic stainless steels and titanium alloys can be improved by application of multilayer wear-resistant and anti-friction coatings. As such coatings have been used transition metal compounds IY-YI of the periodic system (dichalcogenides, nitrides, carbides, oxides), applied vacuum ion-plasma methods. Having a range of features of the crystal structure and properties of high anisotropy in various crystallographic directions resulted in widespread use for these purposes dichalcogenides of transition metals. Very promising and has several advantages are vacuum ion-plasma methods of applying such coatings based on ion (cathode) sputtering. Development of the theory of managing the growth of coatings based on transition-metal dihalcogenides and their relationship with the technology application, explain the process of the formation of coatings with high tribological properties and mechanism of anti-friction properties, as well as comprehensive investigations of the crystal structure and physical properties of coatings are important scientific and technical challenge.

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II. Subjects and Methods

Coatings based on dichalcogenides of transition metals from Groups IV–VI of the periodic table, inparticular, molybdenum and tungsten disulfides and diselenides (MoS_2, $MoSe_2$, WS_2, and WSe_2), were deposited via the HF cathode sputtering technique described in [1–6]. In disk-on-sphere friction tests, the specific load and the constant sliding rate were ~105 N/cm2 and 0.019 m/s, respectively [1-6]. The coatings were formed on polished samples fabricated from compact Al_2O_3 ceramics and SH-15 and 12H18N10T steels. The crystalline structure of the coatings was investigated by means of reflection electron diffraction using an EMR-102 electronograph, and the surface morphology was examined using JXA-841 and JSM-35C electron microscopes. The elemental composition of the prepared coatings was analyzed via characteristic X-ray spectroscopy(a JEM-100C instrument equipped with a CEVEX attachment) and X-ray photoemission spectroscopy (an ESCALAB-5 device).

III. Experimental Results

To protect work surfaces from wear of friction pairs technology for production of wear-resistant antifriction coatings of variable thickness with high tribological properties [2], is an effective means of protecting the parts, especially made of corrosion-resistant austenitic steels or titanium alloys from wear. Used in modern engineering austenitic stainless steels and titanium alloys have a number of advantages, but these materials are due to the peculiarities of physical and mechanical properties tend to grasp, followed by catastrophic wear, especially under high vacuum. From the coating process parameters to be considered the most important temperature substrate further bias potential applied to the charge of the sample holder, as well as alloying of the applied coating by applying to the working chamber of reactive gas (or gas mixture) and a complex manufacturing replaceable target structure.

Studies have found that when the temperature of the substrate were formed quasi-amorphous, polycrystalline or textured coatings. Crystallite orientation axis textures [$10\bar{1}0$], perpendicular to the substrate surface was observed for MoS_2, $MoSe_2$, WS_2, WSe_2 in the temperature range 473-973K, and the axis [$11\bar{2}0$] - to MoS_2 at T = 673-773K [1-4] . Texture growth with the axis [$10\bar{1}0$] formed in all dichalcogenides, whereas the texture with the [$11\bar{2}0$]

was detected in the coatings of molybdenum disulfide in the temperature range 673-773K.

Dependence of the structure from the location of the samples on the plate of holder of substrates. Research was conducted at the location of coating growth patterns in different places (in the center and the periphery) of the plate of substrate holder. It was found that the location of the sample in the center of the plate oa holder crystallites grow with a preferred orientation in the form of texture with the axes [10$\bar{1}$0] and [11$\bar{2}$0], with appropriate substrate temperatures (Fig.1). The axis [0001] was completely disoriented in a plane parallel to the substrate surface. At a distance from the center to the periphery of the board was observed smooth tilting axes [10$\bar{1}$0] and [11$\bar{2}$0] direction crystallite orientation with simultaneous central axis [0001] at the center of the radius of the sample holder, wherein the angle of inclination of the axes reached up to 30^0. Coincidence direction of the electron beam in the column c electronograph radius vector of the center of the plate leads to a symmetric diffraction pattern, and when the sample is moved parallel to the beam view of the diffraction pattern remains unchanged.

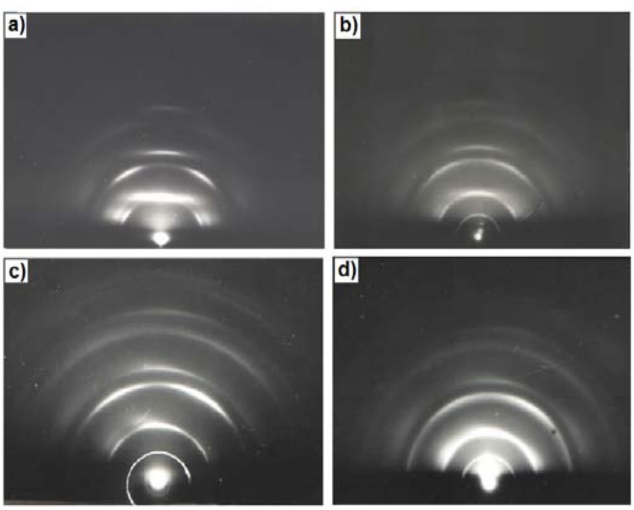

Figure 1 : The electron diffraction patterns of coatings MoS_2 (a, c) and WSe_2 (b, d) a thickness of 0.5 microns, applied at a temperature 523 K (MoS_2) and 623 K (WSe_2), and the location of samples in the center of the plate (a, b) and at its periphery (c, d)

The results obtained are confirmed by studies of surface morphology of the coating (Fig. 2). Micrograph shows that the crystallites are oriented with a small angular spread. With increasing distance from the center of the board, they form closed concentric circles. This morphology of the films stored at different coating dichalcogenides ($MoSe_2$, WS_2, WSe_2) (Fig.1,2). Range of crystallization under the same deposition conditions (substrate temperature varied only) shifted into a zone of higher temperatures. The highest transition temperature of the amorphous structure to a crystalline textured observed for tungsten diselenide WSe_2 (Fig. 3). Studies shows, that the texture with the axes [10$\bar{1}$0] and [11$\bar{2}$0] in the coatings on the basis of textures are dichalcogenides growth, since they do not occur in its infancy, and in the later stages. For example, if a molybdenum disulfide coating on polished samples of steel or Al_2O_3 at a temperature of 523K is different along coating thickness.

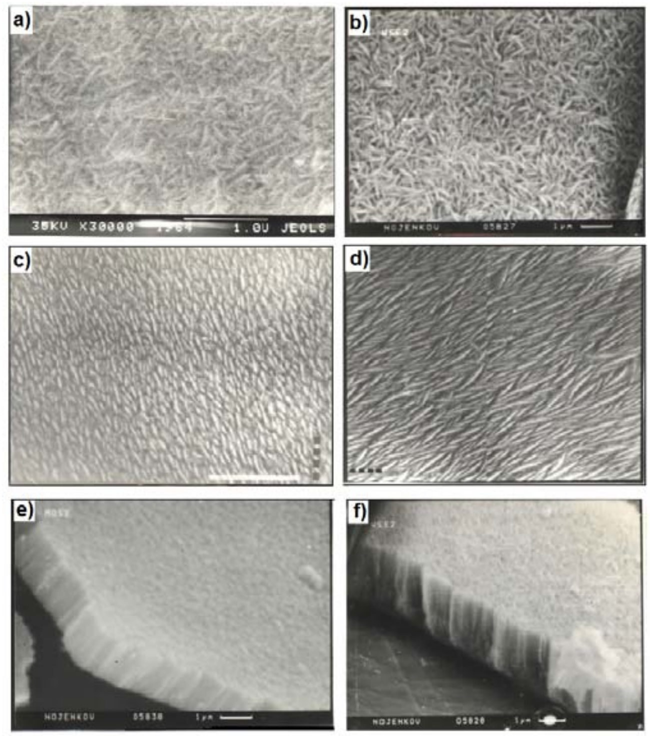

Figure 2 : Micrgfotoraphs of the surface of (a-d) and cleavages (e, f) coating MoS_2 (a, c, e) and WSe_2 (b, d, f), applied at a temperature of 523 K (MoS_2) to 653 K (WSe_2) at location samples in the center of the plate (a, b, e, f) and on its periphery (c, d)

Coating thickness of less than 0.08 m have an amorphous structure and have a smooth surface. When such friction tests showed no anti-friction coating acts as in the case of coating deposition at low substrate temperatures . A similar mechanism of crystallite growth was observed in the coating of aluminum nitride AlN (having a hexagonal crystal structure with a lattice Wurtzite) by magnetron sputtering. As the distance from the center axis of the formed coating [10$\bar{1}$0] in the presence of simultaneous orientation of the second axis texture [0001] along the radii from the center of the plate (Fig. 4) . As follows from the diffraction pattern, the second axis [0001] at an angle of crystallites to a surface of the substrate up to 15^0 and the principal axis is tilted textures [10$\bar{1}$0], respectively, towards the center. When applying vacuum ion-plasma methods and by electron-beam evaporation (REP) coatings of pure molybdenum and chromium and their compounds such as nitrides and oxides with body-centered cubic lattice, in the center of the plate to form a coating samples with texture axis [110]. As the distance to the periphery was a gradual slope texture axis [110] to the center (up to the transition to the texture of a [111] axis) while being oriented to the [100] direction along radii from the center of the plate. I.e. also in this case maintained a similar growth mechanism.

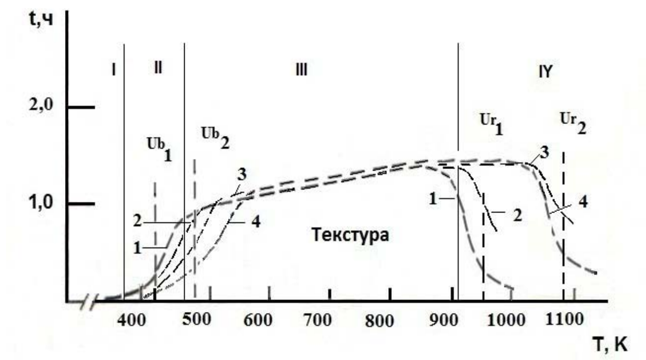

Figure 3 : Dependence durability of coatings based on samples of dichalcogenides Al_2O_3 substrate temperature Scheme disc-sphere. 1-MoS_2; 2-$MoSe_2$; 3 - WS_2; 4 - WSe_2; I - The amorphous structure; II - Polycrystal; III - Texture; IY - Area expansion dichalcogenide MX_2 on metal and halcogen; $Ub_{1,2}$ - surface potential barrier and MoS_2 and WSe_2 ; $Ur_{1,2}$ - energy decomposition dichalcogenides MoS_2 and WSe_2

Microphotographs (Fig.4) is not visible almost two-dimensional elongation of the crystals, as in the case of transition-metal dichalcogenides, due to the lack of such a large anisotropy of the surface energy of crystal faces. Cr_2O_3 coating had a hexagonal structure, space group D^6_{3d}-3RS. Crystal growth Cr_2O_3 obey the same law - in the center of the plate texture is formed with the axis $[10\bar{1}0]$ perpendicular to the substrate surface.

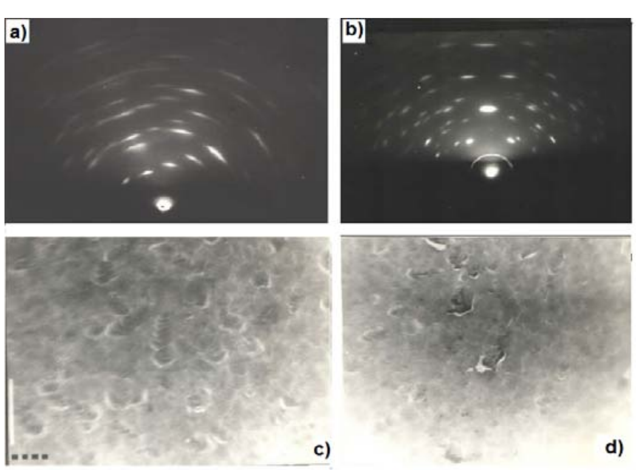

Figure 4 : Electron diffraction (a, b) and micrographs (x5000) (c, d) coating AlN (a) and Cr_2O_3 (b, c, d)

When removing the periphery occurs smoothly tilt axes $[10\bar{1}0]$ towards the center with simultaneous orientation [0001] axis along the radii from the center of the sample holder. As the distance from the center of the coating formed with the $[10\bar{1}0]$ in the presence of simultaneous orientation of the second axis texture [0001] along the radii from the center of the plate (Fig. 4). As follows from the diffraction pattern, the second axis [0001] at an angle of crystallites to a surface of the substrate up to 15^0 and the principal axis is tilted texture $[10\bar{1}0]$ toward the center respectively. Improving tribological properties of the coatings is possible with the changes in technology application. For example, increasing the hardness of the substrate reduces the coefficient of friction and increased durability of coatings based dichalcogenides. Improved tribological characteristics occurs when doping atoms of molybdenum disulfide additional element. The combination of applying a wear-resistant outer sublayer with doping atoms antifriction layers additional element can significantly improve the tribological characteristics.

Doped coating. Were obtained from the doped molybdenum disulfide coating composition MoS2Dx that appearance is not much different from conventional coatings MoS2. As dopant D can be selected elements or compounds that do not form strong (chemical) bonds with the host lattice MoS_2. When friction testing scheme disk sphere coatings with a hexagonal crystal structure of molybdenum disulfide 2H-MoS_2 were obtained sufficiently low coefficient of friction, but in general the corresponding friction natural molybdenum disulfide. However, friction tests in the same conditions coating composition MoS_2D_x led to getting unusually low values of the coefficient of friction (effect of superlow friction) (Fig.5).

Electron diffraction studies of coatings MoS_2D_x showed that there was a significant increase them ¬ crease the lattice period along the axis c (up to 1.38-1.43 nm against 1.2295 nm for compounds with a stoichiometric composition (hexagonal 2H-MoS_2) in practically constant period along the a axis . Increasing the distance between the layers when placing the D atoms in the inter-packet spaces due to the fact that the energy of the van der Waals interaction varies in proportion to $\sim r^{-6}$, should lead to a decrease in this interaction practically an order of magnitude [1-6].

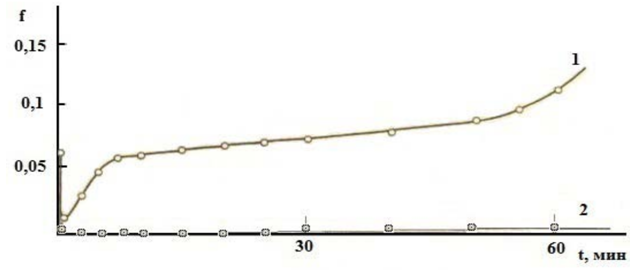

Figure 5 : Coefficient of friction on the duration of the test coatings doped MoS_2 (*1* - MoS_2; *2* - MoS_2D_x)

Anti-friction coating with wear resistant underlayer. In magnetron sputtering a target of pure molybdenum in an atmosphere of nitrogen was obtained from the compound coating type molybdenum nitride (solid solution) with high microhardness (Vickers hardness scale (HV) 1,400 kgf/mm^2). Molybdenum nitride forms cubic crystals with lattice period a = 0,4163 nm. With the application of the technology [1-6] have been applied to the coating composition variable along thickness of the wear layer composition to the antifriction (M_kN - $M_kN_mX_n$ - MX_2D_X), in which the outer sliding layer of MoS_2 stoichiometric composition was replaced with an additional layer MX_2D_X alloying element D. Coating MoS_2D_X led to ultralow values of the coefficient of friction on the air under normal conditions (Fig.5,6).

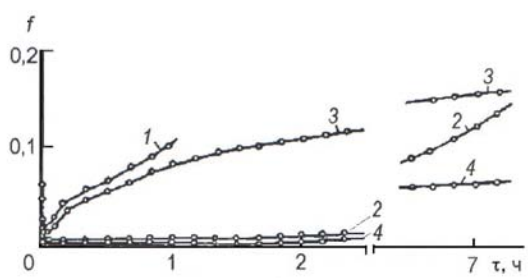

Figure 6 : Dependence of the friction coefficient on the duration of the test coatings: 1 - MoS_2; 2 - $MoS_2Д_x$,; 3 - (Mo_2N- $M_kN_mX_n$ - MoS_2); 4 - (Mo_2N- $M_kN_mX_n$- $MoS_2Д_x$)

Studies were carried out properties of the composite anti-friction wear-resistant coating based on tungsten diselenide and disulfide WS2 and WSe2, deposited on a substrate made of structural strength titanium alloy VT23, and gallium alloyed coating WS2Gax and WSe2Gax (Fig. 7), deposited on a substrate by reactive electron-beam plasma spraying (RAP) as wear Cr_2O_3 sublayer thickness of 2.0-2.5 microns.

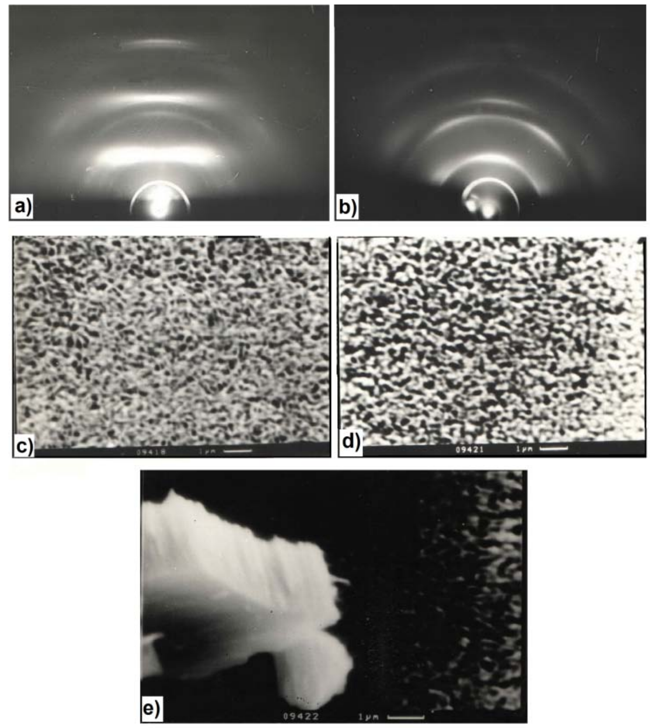

Figure 7 : Electron diffraction (a, b) and micrographs (x5000) (c, d, e) coating WS_2Ga_x

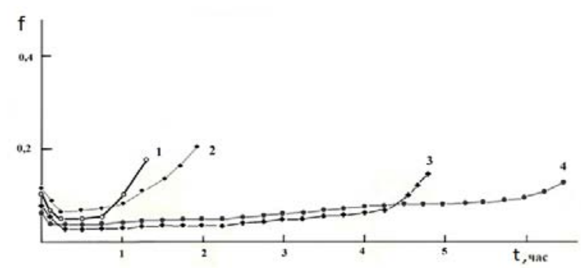

Figure 8 : Dependence of the friction coefficient on the duration of the test doped coatings WS_2 and WSe_2 with wear sublayer Cr_2O_3, deposited on titanium alloys: (*1* - WS_2; *2* - WSe_2; *3* - WSe_2Ga_x; *4* - WS_2Ga_x)

Coatings based on dichalcogenides WS_2 and WSe_2 had a hexagonal structure, crystal growth corresponded to the above atomic cluster model of crystallization on the formation of smooth periphery texture with two axes type mosaic crystal. Doping gallium of WS_2 and WSe_2 coatings led to a significant increase in their tribo-technical properties (Fig. 8).

IV. Disscussion of Results

Based on the concepts of migration processes of atoms on the surfaces of solids, along with a rough structure of atomically smooth areas, created a generalized mathematical model of the application and obtained the properties of ion-plasma coatings, determining their structure during application and physico-mechanical properties of the coatings when applying such coatings[1-6].

On the basis of established generalized theoretical model:

- Application developed atomic cluster model of crystal growth in the coating vapor deposition or the flow of sputtered particles in vacuum, caused by the presence of two phases on the surface of the atoms (condensed and migratory) and phase transitions occurring in a temperature range on the substrate;
- Proposed and experimentally substantiated mechanism of action of anti-friction coatings doped dichalcogenides explaining the effect of superlow friction solid laminates and defining opportunities for ultralow friction. The essence of atomic cluster model of crystal growth is as follows: Atoms in the adsorption sites in the "sedentary state" on a solid surface are condensed phase. Migratory phase can be represented as two-dimensional gas on the surface that follows an exponential distribution of particle energies (Maxwell distribution). The ratio of the two phases determines the structural state of the growing coating. Then the crystal size L in a growing number of the coating is determined by the ratio of the condensed phase (defined by B) and the migratory phase (defined by C).

$$L = A\,[(1-\varepsilon)B + \varepsilon C]^{1\backslash 2} \qquad /\ 1\ /$$

where A - value depending on the structure and properties of deposited material.

Flux of sputtered material in vacuum ion-plasma deposition methods, along with the atomic phase contains a certain number of cluster phase consisting of N atoms (for N = 1,2,3 and more). Such polarized clusters in the coating on the surface can be oriented properly and around the center of the board and play a role in the crystallization step coverage, identifying the growing structure. Decisive influence should provide flow distribution of the deposited particles on the cosine law. Thus facets with the highest surface energy should rise with a slope in the direction of maximum density of flux, which particles with the cosinusoidal distribution of the target is in the center. Under the influence of these factors together formed texture with two axes preferred orientation of crystallites, with properties approaching the single crystal (Fig.1, 2).

With increasing temperature observed broadening of the distribution curve of the particle energy, the displacement magnitude of the potential barrier at higher temperatures should be an increase in the width of the crystallization. As indicated above, this occurs, for example, in the case of transition metal dichalcogenides, wherein the smallest width of the crystallization for MoS_2 (373 ... 413 K, and, most - for WSe_2 (493 ... 563 K). Therefore, when the displacement magnitude of potential barrier to absolute zero can be achieved practically hopping phase transition type crystallization (Fig. 9), which may occurs, for example, in the time of the transition from the normal state to the superconducting.

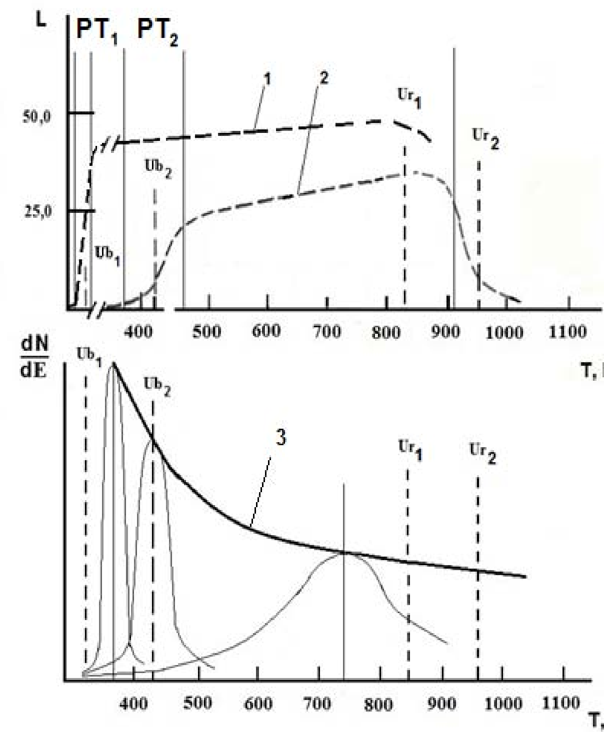

Figure 9 : Dependence characteristics L (a) and the particle energy distribution (b) of temperature

Curve 1, 2 - L value specifications for compounds MX_2 (1 or 2);

Curve 3 - envelope of the inflection points of the energy distribution of particles MX_2 (1 or 2);

$Ub_{1,2}$ - MX_2 surface potential barrier (1 or 2);

$Ur_{1,2}$ - MX_2 binding energy (1 or 2);

PT_1 and PT_2 - phase transitions.

Antifriction mechanism of action, explaining the occurrence of the effect of superlow friction solid laminates based dichalcogenides and defining high tribological properties of the coatings during friction, cracking easily justified crystals on planes (0001) dichalcogenide packages where there are weak van der Waals interactions of the type, not related to the exchange or socialization electrons, and allow ease of sliding such packets to each other. Terms of superlow friction coefficients are presented in [1-6]. Determining factor in this process is to not break the binding energies of Ur in the contact zone, and the shift of the atomic planes overcoming potential barriers sliding over each other surfaces Ub. In the study of changes in the surface layers during friction dichalcogenides found that the structure of crystals with preferred orientation (texture) with the axis $[10\bar{1}0]$ turns into a texture with the [0001] direction perpendicular to the substrate.

The emergence of superlow friction due to the presence of migratory phase on friction surfaces (0001), in a state of two-dimensional gas. In [1-6] the occurrence of this phenomenon is determined by the coefficient of slip K_s ratio of condensed B_s and migratory C_s phases through the dependence

$$K_s = A_a [(1- \varepsilon)B_s + \varepsilon C_s]^{1\backslash 2} \qquad /\ 2\ /$$

where A_a - value depending on the structure and properties of applied substance.

The particles of this phase (atoms , molecules, clusters) can be adsorbed from the environment or introduced into the lattice of solid as it is formed . For superlow friction coefficients in normal air must shift the phase transition in the temperature range of less than 300 K , i.e. the binding energy of atoms adsorbed on the (0001) plane dihalcogenide to ensure free movement on the surface to be less than the kinetic energy of the atom under normal conditions. Mass transfer without heat loss and energy costs possible along the equipotential surface. Having alloy monolayers of particles on the surfaces of friction increases the distance between the planes (0001) and reduces the interaction energy between the layers U_r. Such particles when opportunities for migration of the diffusion surface (0001) provide ease of sliding the opposed planes (0001) relative to each other and thus by moving the particles along the field lines of the surface (0001) arises the possibility of movement without energy dissipation.

In the absence of a condensed phase is preserved only migratory phase

$$K_s = A_a (\varepsilon C_s)^{1\backslash 2} \qquad /\ 3\ /,$$

provides the effect of superlow friction.

V. Superlow Interaction between Particles

Discovered physical phenomenon of mass transport along the lines of equipotential surface fields without energy dissipation in the absence of resistance forces is a process of moving the motion of matter, manifested in the form of ultra-low friction, superconductivity and superfluidity. This movement is possible under normal conditions in the form of particles moving between the solid surface along the lines of equipotential fields determined the shape and structure of the Fermi surface.

An unusual feature of the motion of particles (atoms, molecules, clusters) of homogeneous singular planes (0001) dichalcogenides is uniform motion without energy dissipation. Similar phenomena have been observed to create the conditions for the movement of particles in the absence of frictional forces (superfluidity) and resistance to movement of particles (superconductivity). Intercalation dichalcogenides which are semiconductors, led to the emergence of their superconducting properties, which was a consequence of placement of dopant atoms in the interlayer spaces. Superlow friction phenomena and superconductivity observed in layered crystal structures of type dichalcogenides (MX_2) and diboride (MB_2) metals [1-6]. In magnesium diboride MgB_2 was discovered high-temperature superconductivity for a simple chemical compound critical temperature of 39 K, due to the presence in MgB_2 energy gap is not one but two . In the superconducting magnesium diboride present two kinds of Cooper pairs. Their interaction provides a sufficiently high temperature Superconductivity. It is important to note that each class has its electron pairs size, or its coherence length. Wherein magnesium diboride is only one value of the London penetration depth.

In [5,6] studied the movement of negatively charged electron around the positive proton in the hydrogen system with the absence of dissipation in the uniform motion. To preserve the symmetry of Riemann and Lobachevsky fields opposite curvature in such systems, there exists the possibility of geometrical rectilinear motion of a particle in the absence of centripetal forces, the conservation movement at a constant speed . In this case, there is no change in the energy of the moving particles, i.e. the absence of dissipation. Anisotropic properties dihalcogenides and diboride preserves mass transfer phenomena dissipationless along equipotential surfaces fields determined the shape and structure of the Fermi surface at a sufficiently high temperature. Placement of dopant particles in the interlayer spaces along the plane (0001) causes the mass to move at a constant speed without dissipation of energy, i.e. there is the possibility of zero change of the interaction energy with the solid surface during the movement (a phenomenon superlow friction).

High-temperature transport mass without dissipation is possible along the lines of equipotential surfaces (0001) layered anisotropic compounds in the presence of a layered structure of the solid body spaces van der Waals forces. Owing to the special status of the layered solid body - the availability of space Van der Waals forces - which are long-range forces of the dispersion and no free valence electrons capable of forming strong exchange interactions, there is the possibility of moving particles without dissipation (scattering) energy.

Interaction between packages of dichalcogenide X-M-X (X – chalcogen; M - metal) have dispersion nature, which are based on the dipoles formed by the action of collective phonon vibrations of the atoms inside the package X -M - X . These vibrations cause additive phonon vibrations associated with the polarization of opposite sign in the nearby package. Additivity of the dispersion interaction (unlike pair interactions of exchange type) causes its long-range nature of this interaction and potential decreases with increasing size of the gap by doping dichalcogenide by law r^{-2}, up to n = 2.

Dissipative processes are the result of the forces of resistance arising from the exchange interaction processes.

VI. Conclusions

- Drawing doped multilayer coatings enables obtaining ultralow friction under normal environmental conditions and increases the durability of the coating several times.
- The phenomenon of non-dissipative mass transfer along the equipotential surfaces of fields that define the shape and structure of the Fermi surface.
- Established that ultra low friction, superconductivity and superfluidity are related phenomena defined phase transition through the critical value of the characteristic parameter (energy potential barrier) Fermi surfaces. Creation of the composite coatings of variable thickness of the wear layer doped to antifriction of high anti-friction and wear-resistant properties.

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Investigation on the Effect of EGR with Diesel and Grooved Piston with Diamond Mesh Cut in an Internal Combustion Engine

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Abstract- In this present work a study about influence of the Exhaust gas recirculation (EGR) in the cylinder upon the performance and emission of a single cylinder diesel direct injection engine is presented. In order to achieve good swirl intensity in the cylinder, a grooved brass piston with 9 grooves with Diamond mesh cut configuration on the piston crown is selected. With this modification turbulence in the combustion chamber is enhanced. Also in the present work, performance of the engine is done with diesel along with 10%, 15% and 20% EGR, with 9 grooved piston (GP) with Diamond mesh cut configuration.

Keywords: EGR, diesel, grooved piston, air swirl.

GJRE-A Classification : FOR Code: 850402, 091399

INVESTIGATIONONTHEEFFECTOFEGRWITHDIESELANDGROOVEDPISTONWITHDIAMONDMESHCUTINANINTERNALCOMBUSTIONENGINE

Strictly as per the compliance and regulations of:

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Abstract- In this present work a study about influence of the Exhaust gas recirculation (EGR) in the cylinder upon the performance and emission of a single cylinder diesel direct injection engine is presented. In order to achieve good swirl intensity in the cylinder, a grooved brass piston with 9 grooves with Diamond mesh cut configuration on the piston crown is selected. With this modification turbulence in the combustion chamber is enhanced. Also in the present work, performance of the engine is done with diesel along with 10%, 15% and 20% EGR, with 9 grooved piston (GP) with Diamond mesh cut configuration

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I. Introduction

Regulations to reduce NOx emissions continue to become more and more stringent year after year. Since high cylinder temperatures cause NOx, it can be reduced by lowering the cylinder temperatures. Reduced cylinder temperatures can be achieved by reducing the amount of oxygen by re-circulating a part of exhaust gases back in to the cylinder, which inhibits the combustion process. In the present work, engine tests are conducted with 10%, 15% and 20% EGR along with Grooved piston with 9 grooves with Diamond mesh cut configuration *(Appendix-A)*, and their effect on performance and emissions are studied.

- EGR10 :10% of exhaust gas circulation.
- EGR15 :15% of exhaust gas circulation.
- EGR20 : 20% of exhaust gas circulation.

a) *Test Engine*

A single cylinder air-cooled four stroke, direct injection (DI) compression ignition diesel engine is chosen for the present investigation. The detailed engine specifications are provided in *Appendix-B.* The recommended injection timing by the manufacturer is 28^0bTDC (static) and the nozzle opening pressure of 190 bar.

II. Performance Parameters

The performance parameters like brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature are discussed below.

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Author σ: Professor, Department of Mechanical Engineering, JNTUACE, Anantapur, India.

a) *Brake Thermal Efficiency*

The variations of brake thermal efficiency with power output for the piston with different configurations are shown in Figure 1. The brake thermal efficiency for normal engine at 3/4 of rated load is 26%. It can be observed that the engine with EGR10, EGR15 and EGR20 give thermal efficiencies of 28.1%, 27.9 and 27.6%, respectively, at 3/4 of rated load. From Figure, it is inferred that the brake thermal efficiencies are increasing with an increase in brake power for configurations that are under consideration. It is also observed that there is a gain of 7.4% with EGR20 for normal engine.

b) *Brake Specific Fuel Consumption*

The variations of brake specific fuel consumption with brake power for different configurations are shown in Figure 2. The brake specific fuel consumption for normal engine at 3/4 of rated load is 0.34 kg/kW-hr. It can be observed that the engine with EGR10, EGR15 and EGR20 give brake specific fuel consumption of 0.31 kg/kW-hr, 0.32 kg/kW-hr and 0.33 kg/kW-hr respectively, at 3/4 of rated load. From Figure 4.20, it is inferred that the brake specific fuel consumption are increasing with an increase in brake power for configurations that were under consideration. It is also observed that the EGR20 has a reduction of 2.94% of fuel consumption for normal engine.

c) *Exhaust Gas Temperature*

The comparison of exhaust gas temperature with brake power is shown in Figure 3. The exhaust gas temperatures are higher for EGR10 compared to that of EGR20. The exhaust gas temperature for EGR20 varies from 145°C at no load to 328°C at 3/4 of rated load. For EGR 10, the exhaust gas temperature varies from 149°C at no load to 330°C at 3/4 of rated load whereas for normal engine it varies from 151°C at no load to 341°C at 3/4 of rated load. It is observed that there is a decrease of 3.8% for EGR20 at normal engine.

III. Combustion Parameters

The combustion parameters like ignition delay and peak pressure are discussed below.

a) Ignition Delay

The variation of ignition delay with brake power for different configurations is shown in Figure 4. It is inferred that ignition delay, decreases with an increase in brake power for almost all configurations. With an increase in brake power, the amount of fuel being burnt inside the cylinder is increased and subsequently the temperature of in-cylinder gases is increased. This may lead to reduced ignition delay in all configurations. However, the ignition delay for diesel fuel was lower under EGR10, EGR15 and EGR20 configurations than the normal engine. It is observed that the ignition delay of EGR10, EGR15 and EGR20 are 10.3o CA, 10.5o CA and 10.8o CA at 3/4 of rated load respectively. The reduction in the ignition delay of EGR20 is about 1.8% at 3/4 of rated load for normal engine.

b) Cylinder Peak Pressure

The variations of peak cylinder gas pressure with brake power for different configurations are given in Figure 5. It is observed that the peak pressure is increased with an increase in brake power. The peak pressures for EGR10, EGR15 and EGR20 are 57.4 bar, 57.8 bar and 58.4 bar at 3/4 of rated load respectively. There is a decrease of 2.7 % in peak pressure for normal engine.

IV. Emission Parameters

The emission parameters like smoke density, NOx emission hydrocarbon and carbon monoxide emission are discussed below.

a) Smoke Density

Smoke is solid soot particles suspended in exhaust gas. The comparison of smoke level with brake power is shown in Figure 6. It can be observed that smoke increases with increase in brake power. The smoke number for EGR10, EGR15 and EGR20 are 2.35 BSU, 2.38 BSU and 2.4 BSU respectively, whereas for normal engine it is 2.46 BSU. Due to the complete combustion of diesel with excess air, the smoke emissions are marginal. At 3/4 of the rated load, the smoke emissions for EGR20 are reduced by about 2.4 % for normal engine.

b) Nitrogen Oxide Emissions

The comparison of NOx emission with brake power for different configurations is shown in Figure 7. It can be observed from the figure that NOx emission increases with increase in turbulence in the cylinder because of high temperature. The NOx emissions for EGR10, EGR15 and EGR20 are 540 ppm, 520 ppm and 490 ppm respectively, whereas for normal engine it is 562 ppm. The NOx emissions are lower of 13 % for EGR20 for normal at 3/4 of rated load.

c) Hydrocarbon Emissions

The comparison of Hydrocarbon emission with brake power is shown in Figure 8. The HC emissions for EGR10, EGR15 and EGR20 are 71 ppm, 72 ppm and 74 ppm respectively, whereas for normal engine it is 78.2 ppm. The HC emissions are lower of 5.4% for EGR20 for normal at 3/4 of rated load.

d) Carbon Monoxide Emissions

The comparison of Carbon monoxide emission with brake power is shown in Figure 9. The CO emissions for EGR10, EGR15 and EGR20 are 0.155, 0.162 and 0.165 % volume respectively, whereas for normal engine it is 0.17 % volume. The CO emissions are lower of 2.9% for EGR20 for normal engine at 3/4 of rated load.

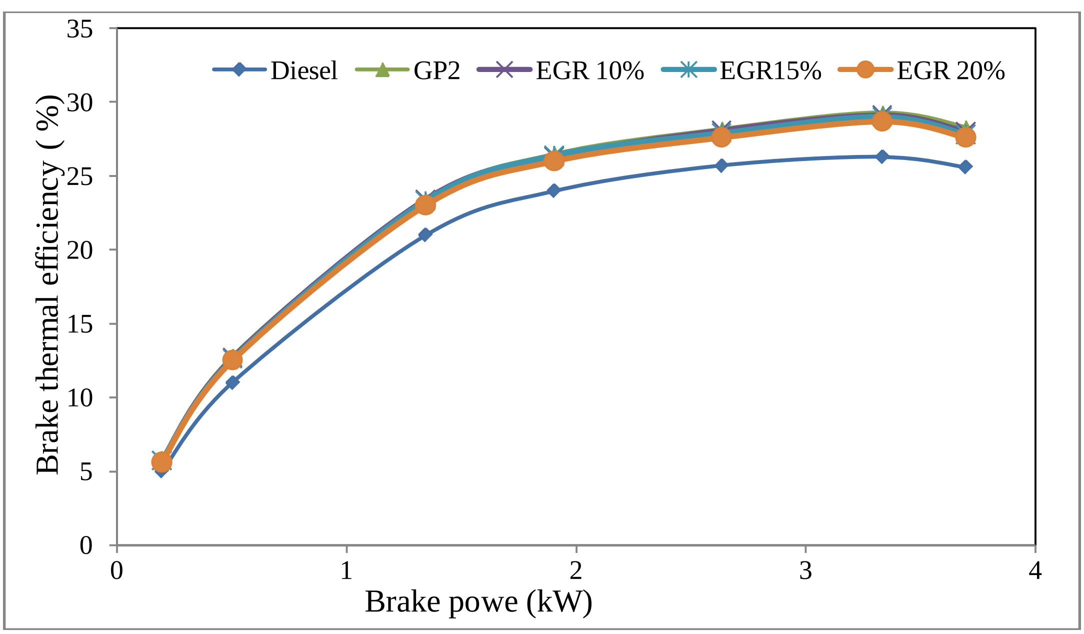

Figure 1 : Comparison of Brake thermal Efficiency with different percentages of EGR

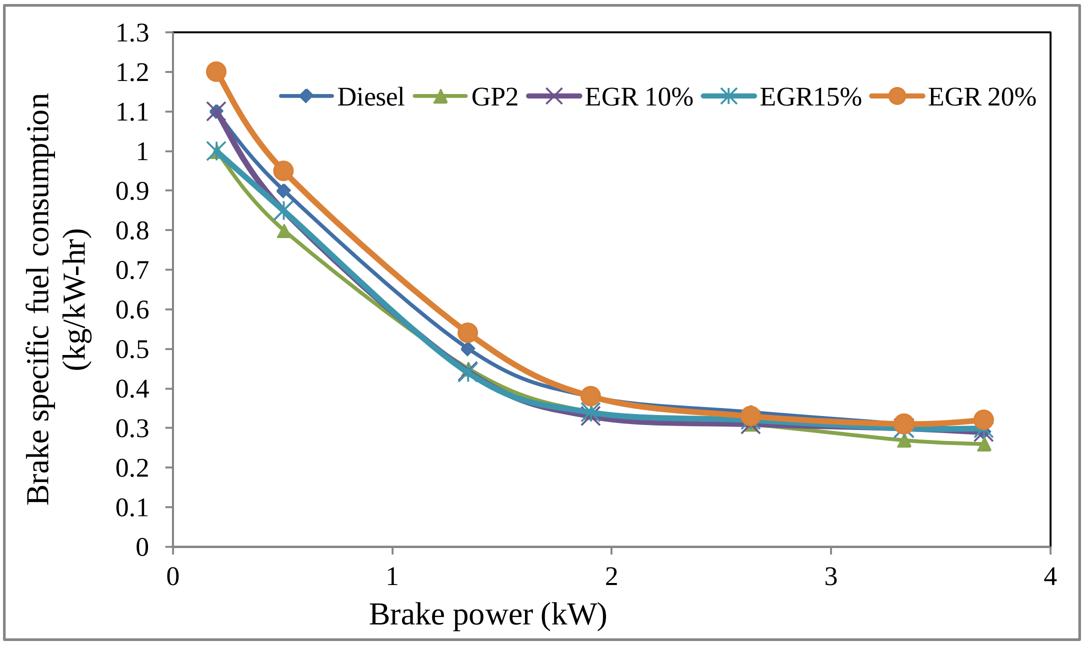

Figure 2 : Comparison of Brake specific fuel consumption with different percentages of EGR

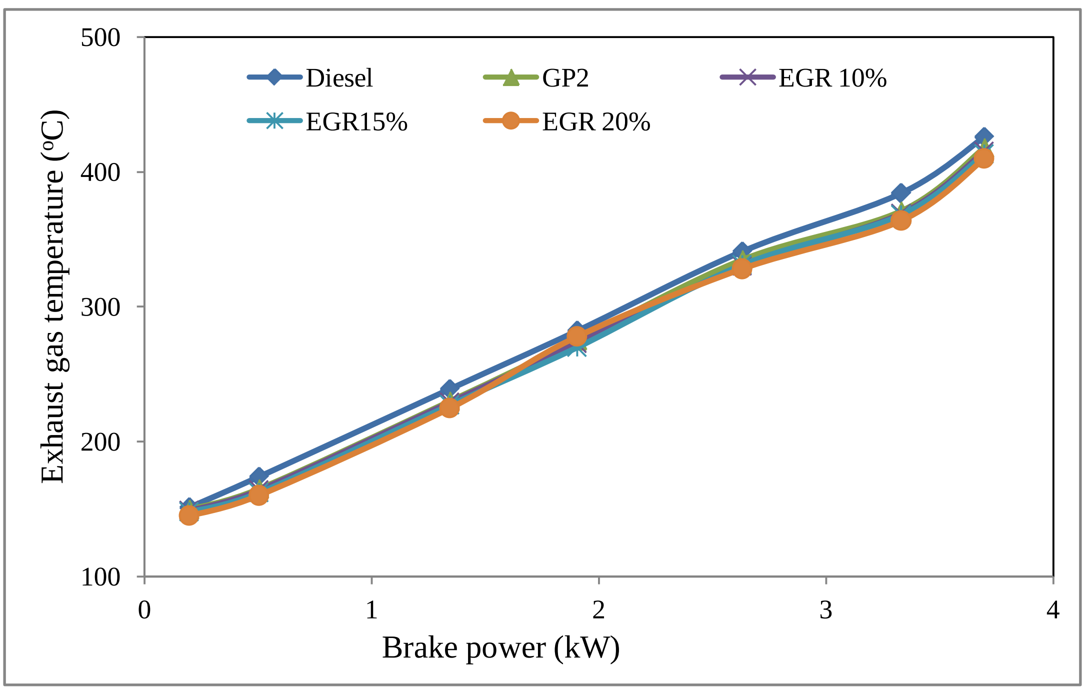

Figure 3 : Comparison of Exhaust gas temperatures with different percentages of EGR

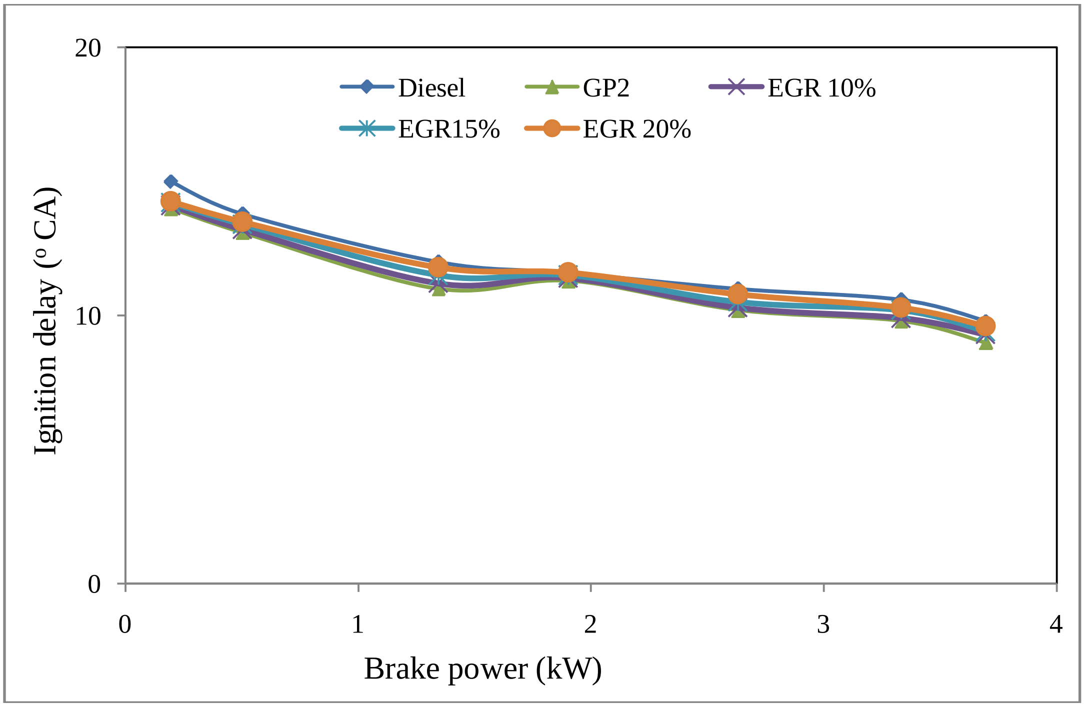

Figure 4 : Comparison of Ignition delay with different percentages of EGR

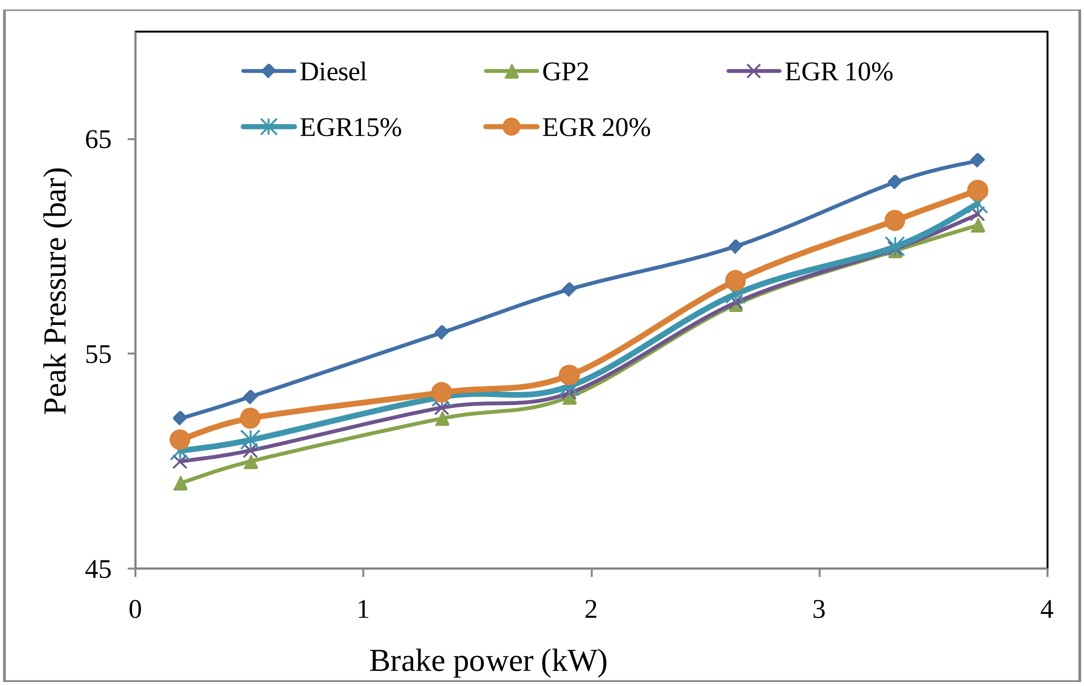

Figure 5 : Comparison of Peak pressure with different percentages of EGR

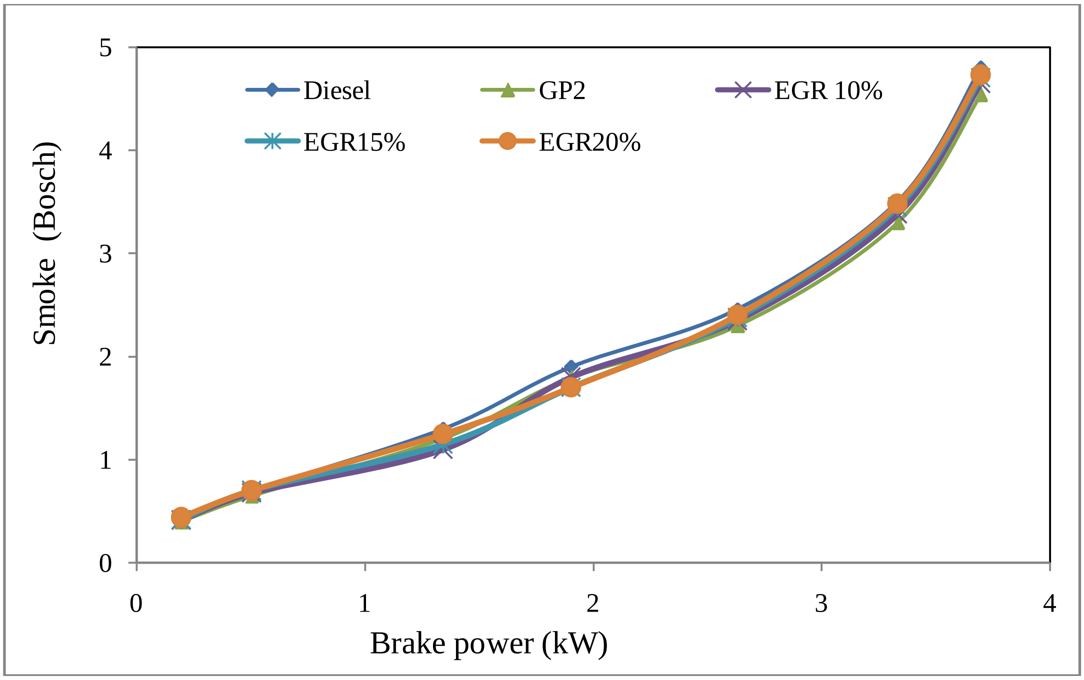

Figure 6 : Comparison of Smoke Density with different percentages of EGR

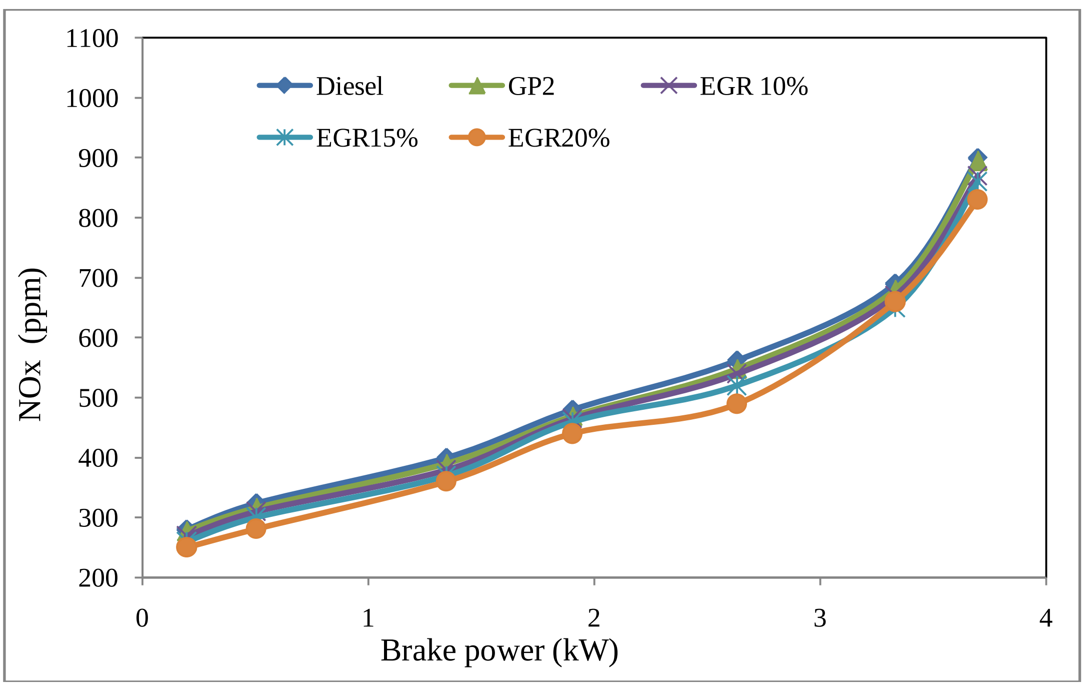

Figure 7 : Comparison of NO_x with different percentages of EGR

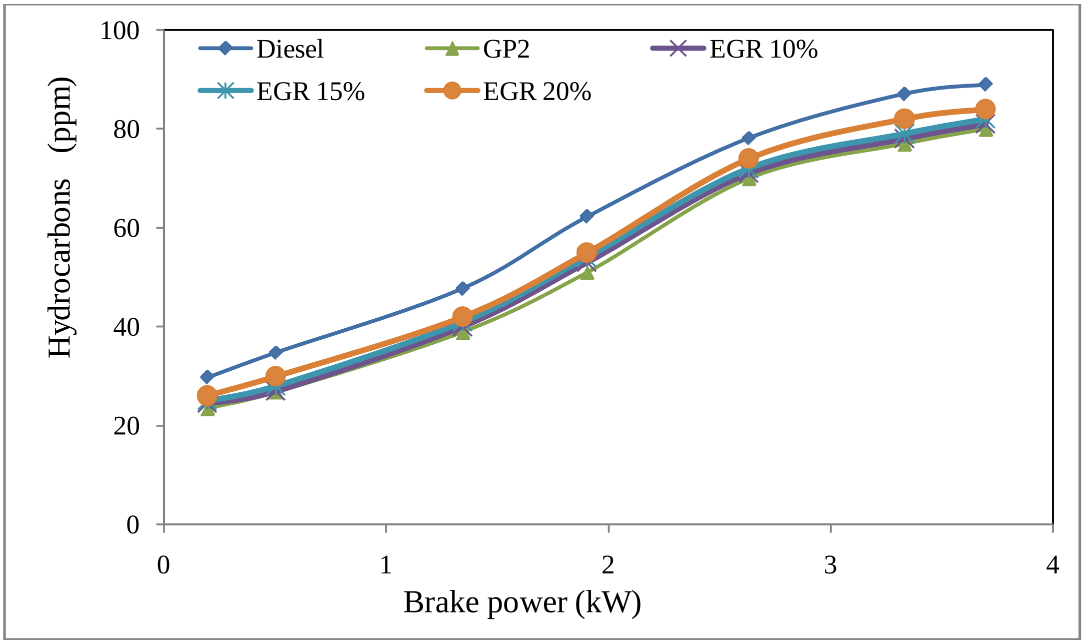

Figure 8 : Comparison of HC with different percentages of EGR

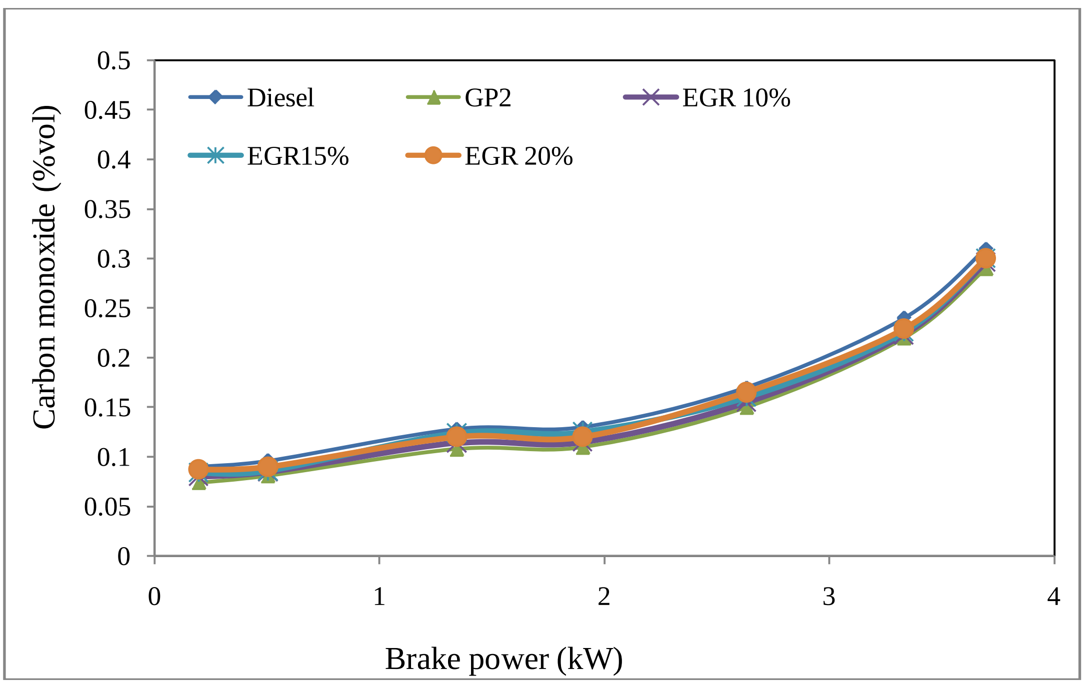

Figure 9 : Comparison of CO with different percentages of EGR

Appendix-A

Specifications of Diesel Engine

Appendix-B

Engine Parameters	Specifications
Make	Kirloskar
Type	Single Cylinder, DI Vertical
Type of Cooling	Water
Rated Horse Power(kW)	3.68
Rated Speed (R.P.M)	1500
Compression Ratio	16.5:1
Bore (mm)	80
Stroke (mm)	110
Swept Volume (cm^3)	553
Injection Timing	28° b TDC

V. Conclusions

The following conclusions are drawn based on the effect of EGR in the cylinder and the results are compared to normal engine at 3/4 of the rated load.

- The brake thermal efficiency is increased by about 7.4%.
- The improvement in brake specific fuel consumption is about 2.9%.
- The exhaust gas temperature is lower and it is 3.8% less than normal engine.
- The reduction in the ignition delay is about 1.82%.
- The peak cylinder pressure is decreased by about 2.7%.
- The smoke emission in the engine is reduced by about 2.4%
- The maximum reduction in NOx emissions are about 13%.
- The maximum reduction in HC emissions are about 5.4%.
- The carbon monoxide emissions are found to be reduced by about 2.9%.

From the investigation, it is evident that in the single cylinder D.I diesel engine, the combination of karanja bio-diesel with EGR20 and piston with nine grooves give better performance and reduced emissions.

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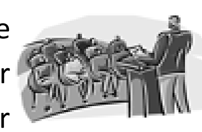

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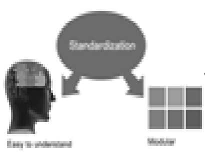

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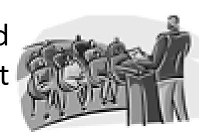

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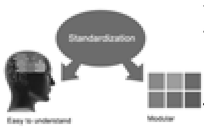

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26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

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Key points to remember:

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- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

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- Separating a table/chart or figure - impound each figure/table to a single page
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· Present your points in sound order

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- Fundamental goal
- To the point depiction of the research
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- Significant conclusions or questions that track from the research(es)

Approach:

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- Center on shortening results - bound background information to a verdict or two, if completely necessary
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- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

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- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

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- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

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- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
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- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
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Approach:

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- Resources and methods are not a set of information.
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- Leave out information that is immaterial to a third party.

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The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

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- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
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- Present a background, such as by describing the question that was addressed by creation an exacting study.
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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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