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Keywords- Flying Capacitor Multi-Level Inverter, STATCOM , VSI , SMIV

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SYNCHRONOUS VOLTAGE SOURCE INVERTER USING FCMLI

Strictly as per the compliance and regulations of:

Synchronous Voltage Source Inverter Using FCMLI

Vikas Kumar Rai[1], Mohit Gaharwar[2], Rajesh Kumar[3], Shobhit Saraswat[4]

Abstract : The structure and control schemes of a STATic synchronous COMpensator (STATCOM) using Flying Capacitor Multi-Level Inverter (FCMLI) have been discussed in this paper. The STATCOM is realized by a synchronous Voltage Source Inverter (VSI), which generates three-phase ac voltages in phase with the transmission system voltage. Multilevel inverter structure of the VSI is used for the realization of the STATCOM. Three multilevel inverter structures (Diode clamped, cascade and flying voltage source) have been described in this work. The operation of these structures for the general inverter operation and compensation purposes has been studied. FCMLI is a special structure of the flying voltage source topology. A method for controlling the FCMLI is used which ensures that the flying capacitor voltages remain constant. The above inverter structures and control schemes of the STATCOM have been verified through digital computer simulation studies using PSCAD/EMTDC software package.

Indexterms : Flying Capacitor Multi-Level Inverter, STATCOM , VSI , SMIV

I. Introduction

In this paper, the FCMLIs are used to implement an STATCOM. Three-level and Five-level structures have been used separately to simulate the STATCOM. Two control approaches i.e., Direct Control and Indirect Control are used and comparisons are made based on the results.

For an STATCOM to operate, several important requirements listed below, have to be made.

1. The transformers, interconnecting the inverter and the transmission line, should provide galvanic isolation of the inverter from the line so that the three legs of the multilevel inverter can be connected to a common dc link.
2. To allow the zero sequence currents to flow during faults, it is necessary to connect the secondary windings of the three phase transformers in delta, so that the zero sequence secondary currents flow as the circulating current of the delta.
3. The transformer primary to secondary turns ratio should be such that, it insures that the voltage and currents across the power semiconductor devices do not exceed their ratings.

Keeping in consideration these requirements, an STATCOM can be designed using a voltage source converter. It is seen that FCMLI is able to operate in high voltage and high power conditions, while maintaining constant its flying capacitor voltages. From this paper we proved that FCMLI is a well-suited inverter for the compensation purposes. In the system under consideration, ideally there is no real power transfer between the converter and the lines. For only reactive compensation, the battery of the inverter can be replaced by capacitor of suitable size. The simulation study has been done using PSCAD/EMTDC

II. Transmission System under Consideration

A three-phase, Single Machine Infinite Bus (SMIB) transmission system is being considered for the simulation studies. A coupled pi-section model of the transmission line is being considered. The transmission line data is given in Table 1. The phase of the sending end voltage is fixed at 0° while the phase of the receiving end voltage is varied. Initially, receiving end voltage has 30° lag with respect to the sending end voltage phase. At 1.0 second, the phase angle of the receiving end is changed to 0° such that the power transferred over the transmission line is reduced to zero. The phase angle is again changed to – 60° at 1.5 second.

The simulation results for an uncompensated transmission are shown in Fig. 1. The real power transferred from the sending end and the power received at the receiving end is shown in Fig. 1 (a) and the reactive power is shown in Fig. 1 (b). Note that in this figure and the following figures in this paper, the receiving end real power shown with multiplying it by – 1 as this power is entering at the receiving end terminals. Fig. 2 (a and b) shows line current of phase *a* at the

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sending end and the receiving end respectively. Fig. 3 (a and b) shows the line current of phase *a* from 1.49 second to 1.8 second. It shows that the transients die out within 5 cycle. Fig. 4 shows per unit mid point terminal voltage. Table 2 lists the steady state values of the system without compensation.

Table 1: Transmission Line Parameter.

System Parameter	Values
Base MVA	1000 MVA
Base voltage	230 kV (Line-line)
Operating Source Voltage	1.0 per unit
Source Impedance type	R= 0.01 Ω (resistive)
System frequency	50 Hz
Line length	2 × 200 km
Positive sequence resistance	0.17816×10^{-4} [Ω/m]
Positive sequence inductive reactance	0.31388×10^{-3} [Ω/m]
Positive sequence capacitive reactance	273.545 [M Ω*m]

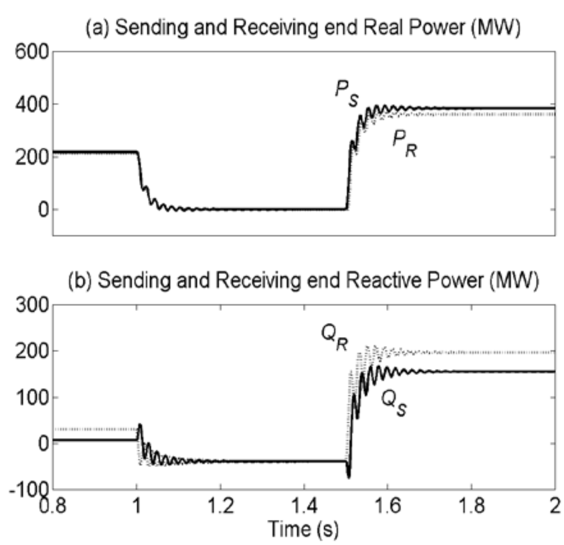

Fig. 1: Simulation Results of Uncompensated Transmission System.

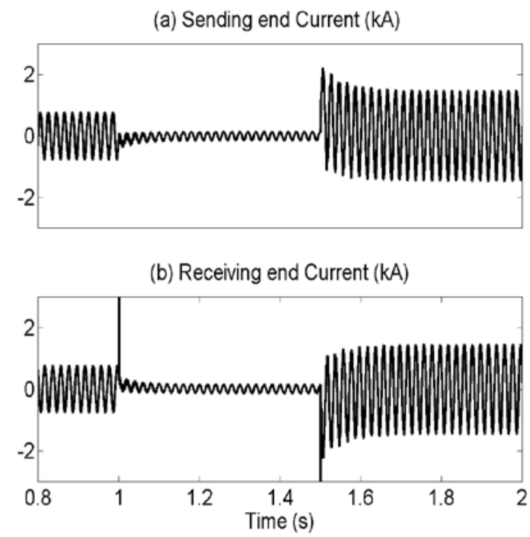

Fig. 2: Line current of phase '*a*'.

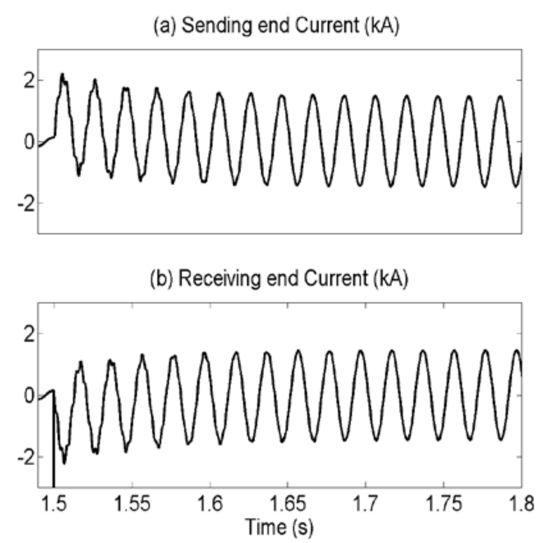

Fig. 3: Magnified portion of Line current of phase '*a*' from 1.5 s to 1.8 s.

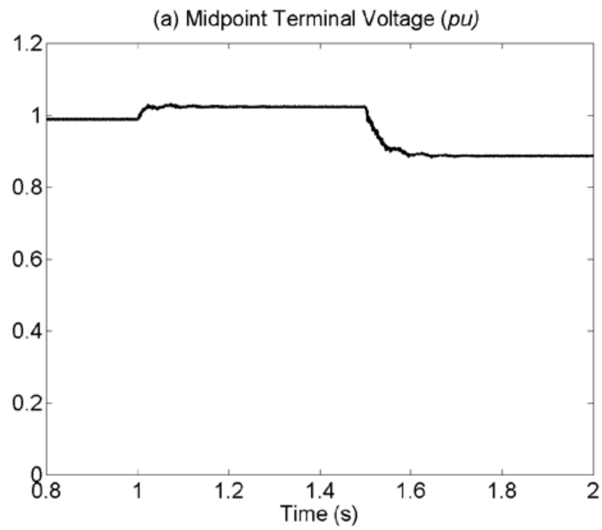

Fig.4: mid-point terminal Voltage .

III. CONTROL STRATEGY OF STATCOM

In STATCOM control, the main objective is to control the output of the VSI through varying the modulation index and the dc capacitor voltage. The control of the STATCOM can be broadly categorized in two categories.

- Indirect control
- Direct control.

Table 2 : System parameters of the Transmission line.

Parameters	Values before 1.0 sec.	Values after 1.0 sec. and before 1.5 sec	Values after 1.5 sec.
P_s (MVA)	218.17	0.048	384.28
P_r (MVA)	211.68	–0.032	360.27
Q_s (MVA)	6.45	–39.13	155.01
Q_r (MVA)	30.46	–39.13	196.58
V_m (pu)	0.989	1.024	0.888

The output voltage of the VSI depends on the magnitude of the dc side voltage and the modulation index m_a. In the indirect control, the dc side voltage of the VSI is varied by keeping m_a constant while in the direct control, the m_a is varied keeping the dc side voltage constant. The parameters of the switches, which are being used for the realization of VSI is listed in Table 3. The same ratings of anti parallel diodes are used. The simulation results for both these controls are discussed below.

Table 3: Switching device parameters.

Main device type	IGBT
IGBT *ON* resistance	0.01 Ω
IGBT *OFF* resistance	1.0×10^6 Ω
Forward voltage drop	0.0 kV
Forward breakover Voltage	1.0×10^5 kV
Reverse withstand Voltage	1.0×10^5 kV
Snubber Resistance	5000 Ω
Snubber Capacitance	0.05 μF

1) *Indirect Control*

A STATCOM is connected at the midpoint of the transmission line. The transmission line discussed in the previous section has been again taken in this case. The PSCAD/EMTDC simulation diagram of a STATCOM connected to transmission line at the midpoint line through a coupling transformer and a smoothing reactor is shown in Fig. 5. The data of the coupling transformer is given in Table4. The VSI is connected to the transformer through a coupling inductor whose inductance is 1 mH. Main capacitor and capacitors of clamping leg are 20000 μF each. Only one capacitor in each clamping leg is taken for simulation but it is of different voltage rating. The instantaneous value of the main capacitor voltage is passed through a moving average (MA) filter [5]. The output of the MA filter is compared with the actual value of the other clamping capacitor to get the error. This error is used to get the proper switching combination for different voltage levels.

Now the midpoint voltage is measured and compared to its reference value. This error is passed through a proportional plus integral (PI) controller and then subtracted from the synchronizing signal. It gives the reference signal for switching of the power electronic devices used in VSI, the output of the PI controller provides the required phase shift between the midpoint bus voltage and the VSI output voltage. This phase shift controls the real power exchange between the midpoint bus and the VSI. This leads to charging or discharging of the dc capacitor. There is an additional phase shift of 30° to compensate the phase shift due to star delta connection of the transformer.

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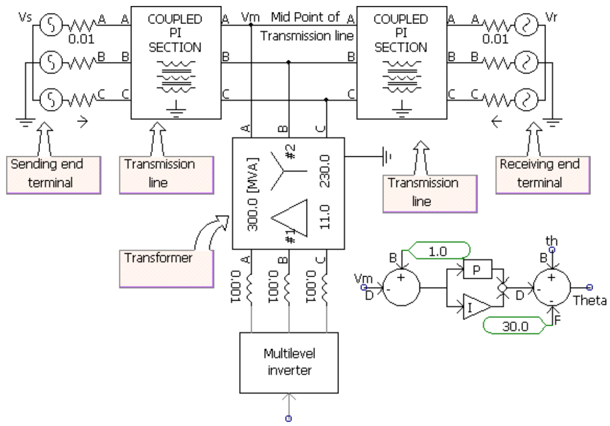

Fig. 5: Indirect controlled STATCOM.

Table 4: Transformer Parameters.

Parameter	Values
System frequency	50 Hz
Base MVA	300 MVA
Connection	Delta-star with neutral ground
Delta winding voltage	11 kV (line-line)
Star winding voltage	230 kV (line-line)
No load losses	0.01 per unit
Positive sequence leakage reactance	0.1 per unit

Let us consider that V_m is less then its reference value. Then the error will be positive and hence the phase shift provided by the PI controller is increased. This leads to increase in the real power flow from the midpoint bus to the VSI, which increases the dc capacitor voltage, and hence the VSI output voltage. Therefore reactive power supplied by the inverter also increases, which increases the midpoint terminal voltage to its reference value. The proportional gain and the integral time constant of the PI control are chosen as 500 and 0.0009 second respectively. The simulation results for the indirect controlled STATCOM are given in Figures.6 to 11. From Fig.7 (a), it can be seen that the midpoint voltage approaches to its reference value. When the receiving end phase angle changes from –30° to 0° at 1.0 second, the midpoint terminal voltage increases. When the phase angle of the receiving end changes, the reactive power demand by the line also changes. But the dc capacitor voltage can not be changed suddenly and hence the reactive power supplied by the STATCOM does not change fast. In the meanwhile the midpoint terminal voltage deviates from its reference value. Now once the dc capacitor regulates its voltage to supply the required reactive power, the midpoint terminal voltage returns to its specified value. It can be seen that the midpoint terminal voltage does not change much for a small disturbance occurred at 1.0 second but it has a large fluctuation for very large transient at 1.5 second. However the voltage approaches its reference value within 15 cycles. Now consider the case when power transfer from sending end to receiving end increases suddenly. For this, more reactive power is required by the line. It needs to increase the dc capacitor voltage. Therefore the real power flow from the system to STATCOM which also increases the line drop and reduces the midpoint voltage. As the dc capacitor charges to the required value, the midpoint terminal voltage reaches to its reference value. The real power and the reactive power at the sending end and receiving end are shown in Figures 6 (a and b) respectively. It shows that the power at both ends vary at the time of transient. Fig. 6 (c) shows the real and reactive power supplied by the STATCOM. It can be seen that a large amount of real power exchange occurs at the time of transients while a very small amount of power flows from the line to the STATCOM. This power accounts for the compensation of the losses in the STATCOM and transformer under steady state. Fig. 7 shows the dc capacitor voltage magnitude maintaining the mid point terminal voltage. The dc capacitor voltage is high for large real power transfer while its value is low under light load condition. Note that for the above, the capacitor voltage varies between 16 kV to 35 kV.

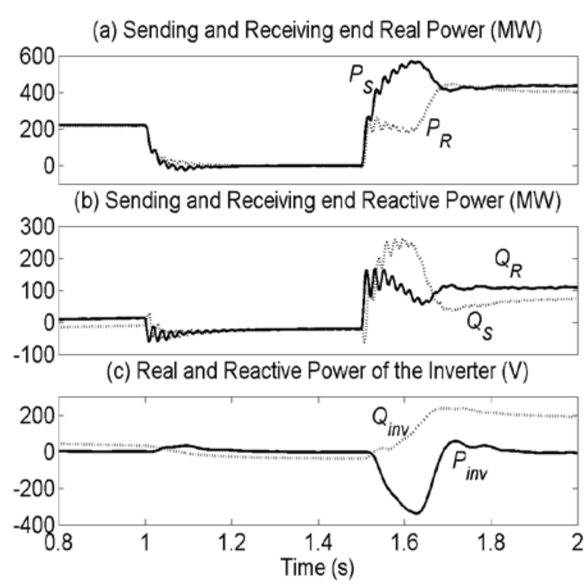

Fig. 6: Real and reactive powers.

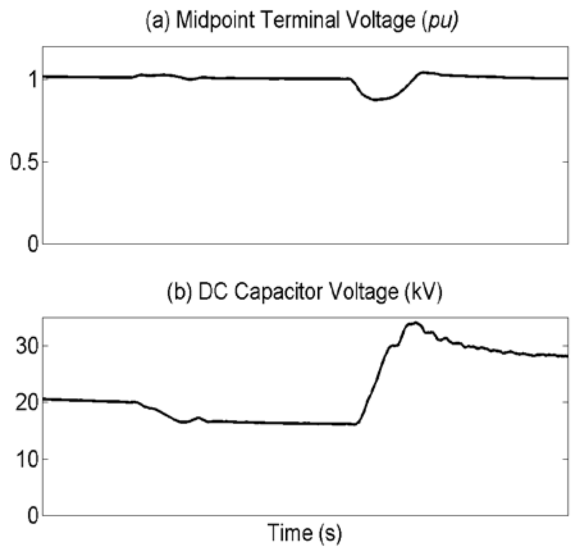

Fig.7: Midpoint terminal voltage and dc capacitor voltage.

Figs. 8 and 9 shows the current of phase *a* at sending end, receiving end and the current supplied by the STATCOM. It can be seen that all currents are sinusoidal and balanced under steady state condition. In comparison of sending end currents, the receiving end currents have a large variation at the time of transients. This is due to the transients at the receiving end. Note that the transients in the currents die out within 15 cycles for large system variation at the time of 1.5 second.

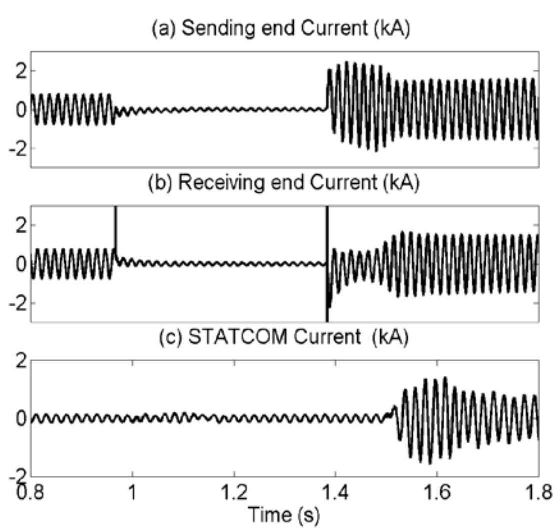

Fig.8: Phase *a* line current at various terminals.

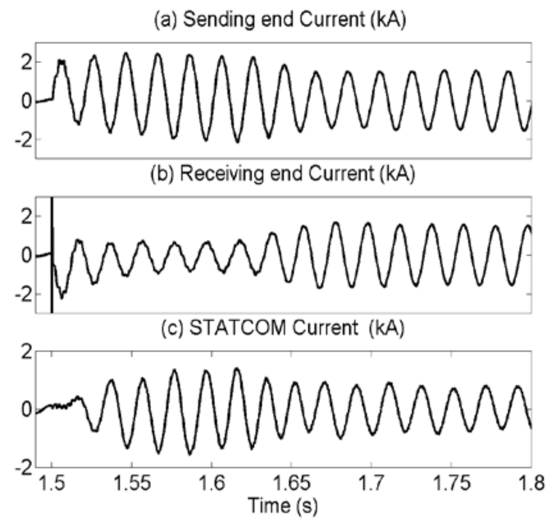

Fig.9 : Magnified portion of Phase *a* line current at various terminals from 1.5 s to 1.8 s .

Fig. 10 shows the line voltage in the inverter side. It is measured between the smoothing reactor and the coupling transformer. It can be seen that the line voltage is approximately sinusoidal. Third and multiples of third harmonics are removed due to delta-star connection of the transformer. With higher value of smothing reactor and higher switching frequency, the other harmonics can also be removed.

Fig. 11 shows the clamping capacitor voltages of various leg and main capacitor voltage. The main capacitor voltage shown is obtained after passing it through a MA filter while other voltages shown indicate instantaneous values. Table 5 lists the steady state system quantities for different phase angles of the receiving end. Note that, there are large variations in the reactive power supplied by the STATCOM for various system conditions.

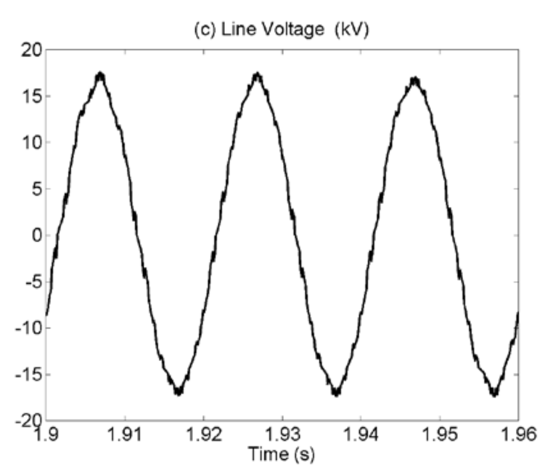

Fig.10: Line voltage before the transformer.

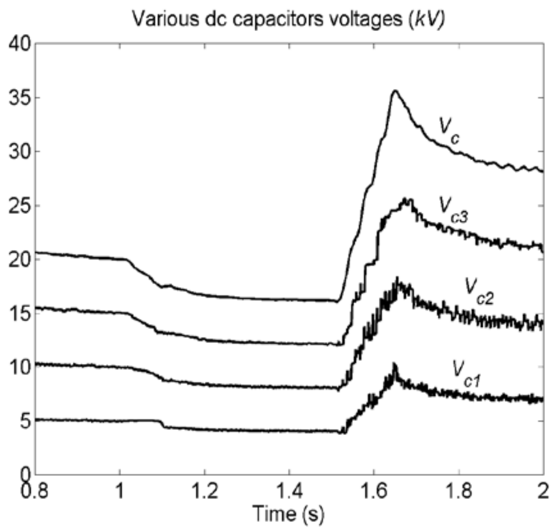

Fig. 11: Various capacitor voltages.

2) Direct control

In this case, the control strategy of the STATCOM is different than indirect control. The system parameters are assumed to be same as in the case of indirect control. The modulation index (m_a) is varied for controlling the output of the VSI while keeping the dc capacitor voltage constant. The error between midpoint terminal voltage and its reference value is passed through a PI controller. The output of the PI controller gives the m_a for the switching of the VSI that decides the output voltage of the VSI.

Table 5: System parameters of the Transmission lin with STATCOM

Parameters	Values before 1.0 sec.	Values after 1.0 sec. and before 1.5 sec	Values after 1.5 sec.
P_s (MVA)	222.37	1.06	438.31
P_r (MVA)	221.37	–1.06	405.27
Q_s (MVA)	–10.04	–19.94	79.11
Q_r (MVA)	14.01	–19.94	112.28
P_{inv} (MVA)	0.72	-2.35	13.31
Q_{inv} (MVA)	34.33	-37.05	181.04
V_m (pu)	1.011	1.003	1.002

It influences the midpoint terminal voltage. The dc capacitor voltage is compared to its reference value and the error is passed through a PI controller. The output of the PI controller gives the necessary phase shift for the VSI, which controls the real power flow between the STATCOM and the transmission line. The output of the phase shift PI controller is subtracted from the synchronizing signal. A small amount of real power is required for the losses in the STATCOM and coupling transformer. The PSCAD/EMTDC simulation diagram of a STATCOM connected to transmission line at the midpoint is shown in Fig. 12. The proportional gain and integral time constant of the PI controller (for m_a) are chosen as 4.0 and 0.002 second respectively while that for the phase shift controller are 8.0 and 0.005 second respectively.

Figures 13 to18 show the simulation results of the direct control of STATCOM. Figs. 4.13 (a and b) show the midpoint terminal voltage and dc capacitor voltage respectively. The midpoint terminal voltage and the dc capacitor voltage are nearly constant under all transients. However, a small fluctuation occurs in the midpoint terminal voltage under heavy transients but it is much smaller as compared to the case of indirect control.

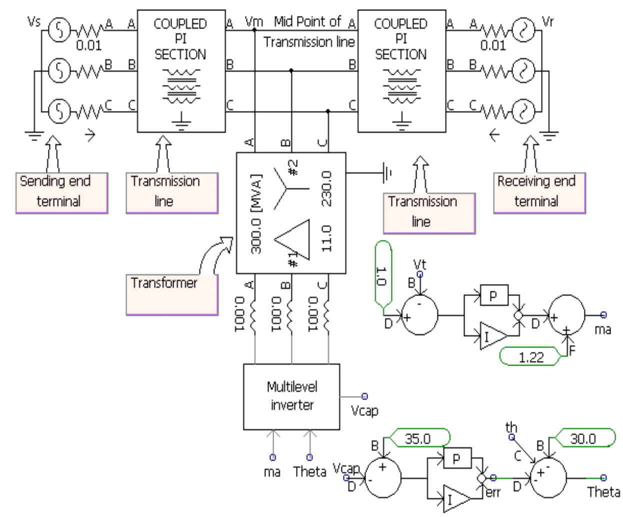

Fig. 12: Circuit diagram of Direct control STATCOM.

Fig.14 (a) shows the real powers at the sending end (P_s) and the receiving end (P_r). Fig. 14 (b) shows the respective reactive powers and Fig. 14 (c) shows the real power (P_{inv}) and reactive power (Q_{inv}) flowing from the VSI to the line. It can be seen that the reactive power demand of the line increases with real power transfer and a large amount of reactive power is supplied by the STATCOM to maintain the midpoint terminal voltage. The negative value of P_{inv} under steady state shows that there is a small amount of real power flow from the line to the STATCOM. Q_{inv} has positive value for the inductive compensation and negative value for the capacitive compensation.

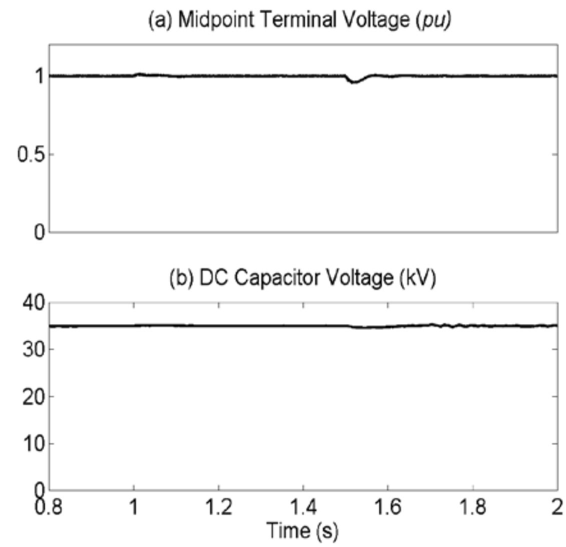

Fig. 13: Midpoint voltage and dc capacitor voltage.

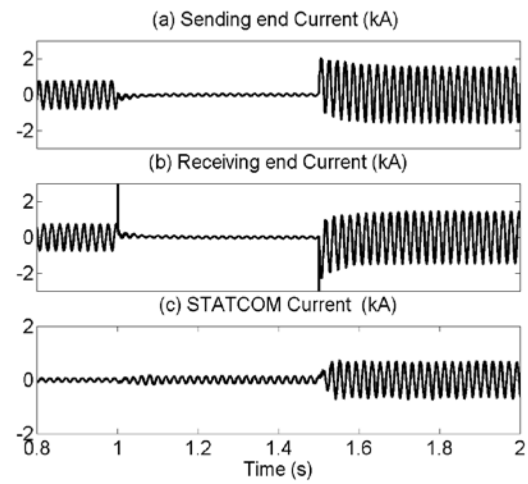

Fig. 15: Phase *a* line current at various terminals.

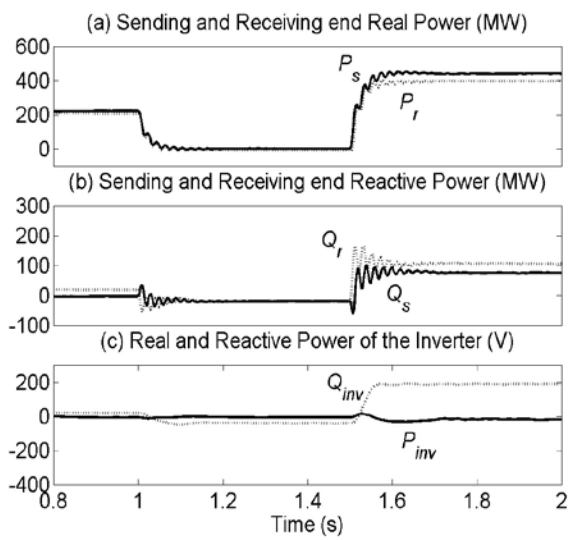

Fig. 14: Real and Reactive Powers at various end.

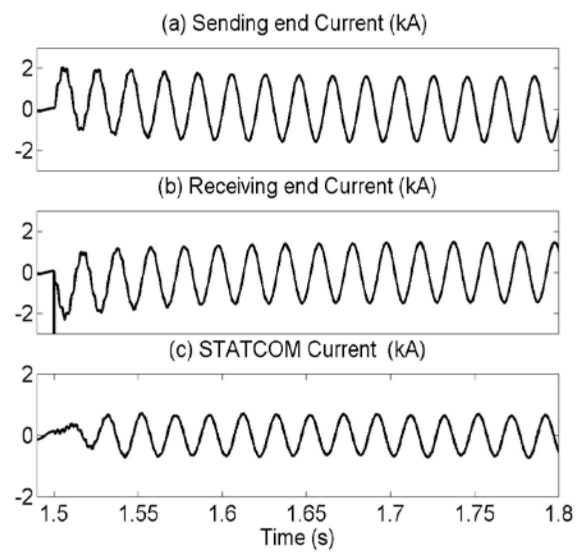

Fig. 16: Magnified portion of phase *a* line current from 1.49 s to 1.8 s.

Figs. 15 shows the sending end, the receiving end and the STATCOM currents respectively. It can be seen that there are large transients in all the three curents at the time of receiving end phase angle (δ) change. Fig. 16 shows that these transients die out with time. The magnitude of the STATCOM currents show the amount of reactive power exchange between the line and the STATCOM. The STATCOM currents are sinusoidal except at the time of transient as of sending end and receiving end currents.

Fig. 17 shows the main capacitor voltage and various clamping capacitor voltages. It can be seen that all the capacitor voltages are nearly constant at their reference value.

Table 6 lists the steady state system quantities for different phase angle of the receiving end. Note that, there are large variations in the reactive power supplied by the STATCOM for various system conditions without high transient as in the case of indirect control.

Table 6: System parameters of the Transmission line with STATCOM.

Parameters	Values before 1.0 sec.	Values after 1.0 sec. and before 1.5 sec	Values after 1.5 sec.
P_s (MVA)	223.9	2.54	442.37
P_r (MVA)	211.15	– 2.53	398.27
Q_s (MVA)	– 2.68	– 18.09	76.0
Q_r (MVA)	19.78	– 18.09	106.93
P_{inv} (MVA)	– 6.02	– 4.8	– 20.15
Q_{inv} (MVA)	19.79	– 39.94	190.56
V_m (pu)	1.002	1.00	1.00

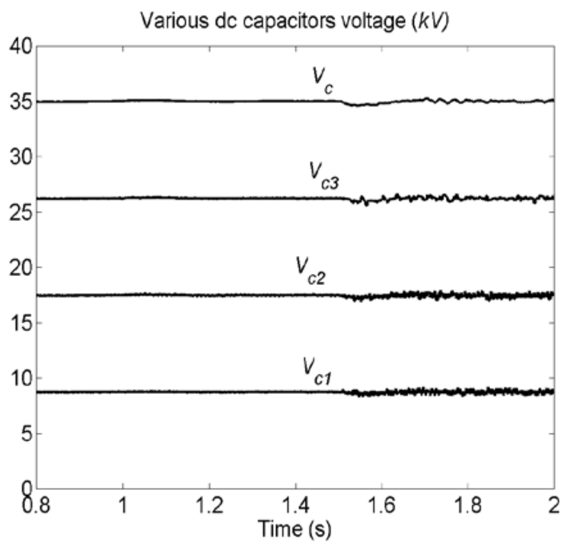

Fig..17 : Various capacitor voltages.

Fig. 18 shows the line voltage at the inverter side. It can be seen that line voltage is nearly sinusoidal. Third harmonic and its multiple harmonics are reduced by delte-star transformer connection. If the switching frequency of the inverter is increased, the amplitude of harmonics in the output line voltage can be further reduced. As said earlier the harmonic amplitude can also be reduced by increasing the value of smothing reactor.

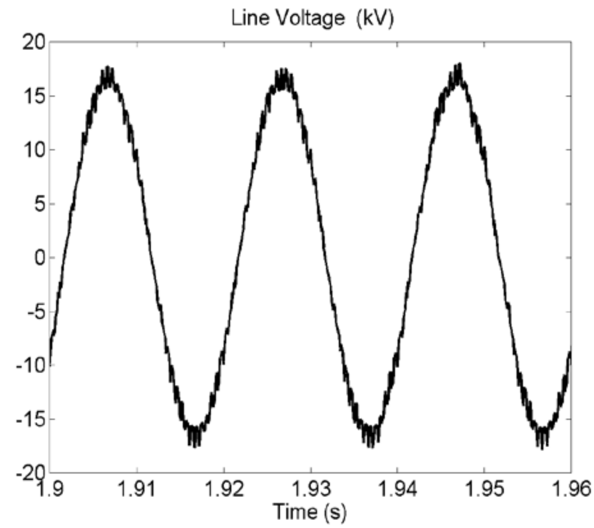

Fig.18: Line Voltage before the transformer.

IV. CONCLUSION

The simulation results of a STATCOM are discussed. It has been observed that the real power transfer is increased with the shunt compensation while the reactive power supplied by the sending end and the receiving end is decreased. The midpoint terminal voltage remains near to its specified value under low as well as high transients. The response of the direct control is faster than indirect control. It can therefore be concluded that the direct control of the STATCOM is much more superior to indirect control.

REFERENCES RÉFÉRENCES REFERENCIAS

1) N. G. Hingorani and L. Gyugyi, "Understanding FACTS: Concepts and technology of Flexible AC Transmission Systems," *IEEE Press*, New York, 2000.
2) A.Edris, “FACTS Technology Development: An Update”, *IEEE Power Engineering Review*, 2000.
3) N. G. Hingorani, “High Power Electronics and flexible AC Transmission System”, *IEEE Power Engineering Review*, 1988.
4) L.Gyugyi, “Dynamic compensation of AC transmission lines by solid-state synchronous voltage sources,” *IEEE/PES Summer Meeting*, paper No. 93SM431-1 PWRD, 1993.
5) N.H Yukseler, “The line-length effects on voltage stability of series compensated power transmission lines”, *AFRICON '92 Proceedings., 3rd AFRICON Conference*, 22-24 Sep 1992 pp. 479 –482

6) D.N.Kosterev, W.A Mittelstadt, R.R. Mohler, and W.J Kolodziej, "An application study for sizing and rating controlled and conventional series compensation" *IEEE Technical Applications Conference and Workshops Northcon95*, Northcon 95, pp. 280 –286, 1995.
7) Y.Besanger, S. Maginier, N. Hadjsaid, and R. Feuillet, "Thyristor controlled series compensation: some aspects of different circuit parameters and voltage stability margin" *International Conference on Energy Management and Power Delivery*, Volume: 2 , 21-23, pp. 753 –758, 1995
8) L.Gyugyi, C.D.Schauder and K.K Sen, "Static synchronous series compensator: a solid-state approach to the series compensation of transmission lines", *IEEE Transactions on Power Delivery*, Vol. 12, pp. 406 –417, No. 1, 1997
9) B.Han, S. Moon, J. Park and G. Karady, G "Dynamic characteristic analysis of SSSC based on multibridge inverter", *IEEE Transactions on Power Delivery*, Vol. 17 Issue 2, pp. 623 –629, 2002
10) H.F Wang, "Modelling STATCOM into power systems", .*International Conference on Electric Power Engineering, PowerTech Budapest 99*, pp 302, 1999
11) M.R. Iravani and D Maratukulam, "Review of semiconductor-controlled (static) phase shifters for power systems applications" *IEEE Transactions on Power Systems*, Vol. 9 No. 4, pp. 1833 –1839, 1994.
12) S. L. Kumar and A. Ghosh, " Modelling and control design of a static synchronous series compensator ", *IEEE Transactions on Power delivery*, Vol. 14, No. 4, , pp. 1448-1453, 1999
13) A.Ghosh and G. Ledwich, "Power Quality Enhancement Using Custom Power Devices", *Kluwer's Power Electronics and Power System Series*, 2002.
14) M.H. Rashid, "Power Electronics Handbook", Academic Press, 2001.
15) A.Nabae, I. Takahashi and H. Akagi, "A New Neutral-Point-Clamped PWM Inverter", *IEEE Transactions on Industry Applications*, Vol. IA-17, No. 5, pp. 518-523, 1981.
16) N. S. Choi, J. G. Cho and G. H. Cho, "A general circuit topology of multilevel inverter", Power Electronics specialist conference, *PESC 1991 Record, 22nd annual IEEE*, pp. 96-103, 1991.
17) J. S. Lai and F. Z. Peng, "Multilevel Converters-A new breed of Power converters", *IEEE Transactions of Industry Applications,* Vol. 32, No. 3, pp. 509-517, 1996.
18) X. Yuan and I. Barbi, "Fundamentals of a New Diode Clamping Multilevel Inverter", *IEEE Transactions on Power Electronics*, Vol. 15, No.-4, 2000.
19) C. Ying and M.L Crow, "A diode-clamped multi-level inverter for the StatCom/BESS", *IEEE Power Engineering Society Winter Meeting,* pp. 470 -475 Vol.1, 2002
20) B. R. Lin, Y. P. Chien and H. H. Lu, "Multilevel Inverter with Series Connection of H-bridge Cells", *IEEE International Conference on Power Electronics and Drive Systems*, pp. 859-864, 1999.
21) F. Z. Peng, "A Generalized Multilevel Inverter Topology with Self Voltage Balancing", *IEEE Transactions on Industry Applications*, Vol. 37, No. 2, pp. 611-618, 2007.

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Reduction of Pollutants in CI Engine Using Emulsion Fuels To Reduce Overall Traffic-Induced Emissions

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Abstract- Diesel passenger vehicles will require over a 90 percent reduction in NOx and a 75 percent reduction in Particulate Matter to meets the new emission standards over the next few years. Such a large technical challenge will require a systems-based approach combining water emulsion and additives. The emissions improvement achieved by properly designed fuel-water emulsification is universal regardless of engine. The primary benefit of water-fuel emulsions in diesel engines is a notable reduction in NOx emissions. The added water acts as a diluent, which lowers the combustion temperature and suppresses NOx formation. The water emulsification decrease overall particulate emissions. Diesel water emulsification may require additional cetane enhancing additives. NOx can roughly be lowered on one- percent reduction of for every percent of water added to the fuel, depending on engine design and service profile. This reduction is achieved by lowering the peak combustion temperature in the engine cylinders. Better fuel atomization and more complete combustion serve to offset any reduced thermal efficiency from the quenching effect of water during the combustion process. The net impact on engine power development and fuel economy is minimal. This paper describes the fundamental approaches, water-diesel emulsion preparation, monitoring emulsion stability, retention period and corrosion testing to utilizing water-fuel emulsions. This paper also describes the analysis of particle size and its effect.

Keywords- Water Emulsions, Additives, Emission control

Classification: GJRE-A Classification: FOR Code: 889802, 919901

REDUCTION OF POLLUTANTS IN CI ENGINE USING EMULSION FUELS TO REDUCE OVERALL TRAFFIC-INDUCED EMISSIONS

Strictly as per the compliance and regulations of:

Reduction of Pollutants in CI Engine Using Emulsion Fuels To Reduce Overall Traffic-Induced Emissions

R.Venkatesh Babu [1], Dr.S.Sendilvelan[2]

Abstract : Diesel passenger vehicles will require over a 90 percent reduction in NOx and a 75 percent reduction in Particulate Matter to meets the new emission standards over the next few years. Such a large technical challenge will require a systems-based approach combining water emulsion and additives. The emissions improvement achieved by properly designed fuel-water emulsification is universal regardless of engine. The primary benefit of water-fuel emulsions in diesel engines is a notable reduction in NOx emissions. The added water acts as a diluent, which lowers the combustion temperature and suppresses NOx formation. The water emulsification decrease overall particulate emissions. Diesel water emulsification may require additional cetane enhancing additives. NOx can roughly be lowered on one- percent reduction of for every percent of water added to the fuel, depending on engine design and service profile. This reduction is achieved by lowering the peak combustion temperature in the engine cylinders. Better fuel atomization and more complete combustion serve to offset any reduced thermal efficiency from the quenching effect of water during the combustion process. The net impact on engine power development and fuel economy is minimal. This paper describes the fundamental approaches, water-diesel emulsion preparation, monitoring emulsion stability, retention period and corrosion testing to utilizing water-fuel emulsions. This paper also describes the analysis of particle size and its effect.

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I. Introduction

The emulsions are engineered to provide reduced carbon particulate, lower capacity and lower nitrogen oxide levels, with increased thermal efficiency. Typically, the larger fuel droplets do not completely burn, leaving unburned carbon to collect on heat transfer surfaces and escape as particulate matter in the exhaust gases. The emulsion is maintained by recirculating the emulsion and adding a ratio of fuel and water to the system to achieve a desired fuel/water ratio in the recirculation loop. The paper relates to an internal combustion engine fueled by relatively heavy petroleum products, such as diesel fuel. The engine incorporates a fuel supply system, which generates a controlled emulsion of fuel oil, and water, which is fed into a cylinder of substantially conventional design. Some of the advantages of water addition to fuel results from a decrease in the combustion temperatures. These temperature reductions result in the suppression of spark-knock and pre-ignition in the engine as well as the reduction of exhaust NOx concentrations and smoke, and lower fuel consumption. In emulsified fuels for use in diesel engines was renewed because of the possibility of reducing the pollutants emitted by automobiles.Diesel engines are gaining much importance nowadays due to its better thermal efficiency and high fuel economy. Reduction of exhaust gas emissions from diesel engines is desirable due to environmental concerns. Especially, NO_x emission has become a serious problem in urban environments where traffic congestion is common and stricter regulations are being enforced in worldwide.At present intense research is being carried in various parts of the world to minimize NO_x emission from diesel engines through improvements in engine design, fuel injection timings, optimization of fuel injection rate, increasing fuel injection system modification is highly difficult. Hence addition of aqueous metal salt solution in the combustion region is most effective way to reduce the oxides of nitrogen compare to other methods.

In this investigation, the effect of several aqueous metal – salt solutions on NO_x lowering in Direct Injection diesel engine exhaust was examined. These salt solutions lower the peak cycle temperature due to its endothermic reaction and thereby lower the NO_x formation. In this experimental investigation on NO_x emission control using variation metal salt solutions such as Sodium Formate, Potassium Carbonate, Calcium Acetate and Potassium Acetate at different brake power have been carried out. I that been experimentally investigated that Sodium Formate metal solution gives maximum reduction in NO_x emission than other metal salt solution – diesel emulsions.

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II. Water-fuel emulsions

A combination of retardation of fuels injection timings, optimization of fuel injection rates, increased in fuel injection pressures with smaller diameter, and exhaust gas recirculation (EGR) is effective and practical for lowering of NO_x, but further lowering seems to be impossible without a deterioration of engine output performance and other exhaust gas emissions.The addition of water in the combustion region is also an effective way to achieve NO_x lowering. NO_x can be significantly reduced with a urea solution injection directly into the cylinder. The results suggest that NO_x could be reduced without deterioration in the thermal efficiency or other exhaust gas emissions if a substance, which suppresses NO_x formation or promotes reduction of NO_x could be put into the burning zone.In this research, the effect of several aqueous metal-salt solution on NO_x in DI diesel engine was examines. The salt solution – diesel emulsion was directly injected into the combustion chamber. The results shows significant lowering in NO_x over a wide operation range could be achieved with alkali metal slat solutions. The degree of NO_x lowering with the solution injection was much larger than with a water injection alone, and the solution also reduced smoke emissions, which was not much affected by water injection.

Essential requirements of aqueous metal salt solution

- It should not cause secondary pollution
- The solution should be non – toxic, less hazardous and should be easy to handle
- It should have a high life time.
- Easy availability in the market
- Cost must be cheap for automotive pollution
- It should reduce more NO_x
- It must have minimum effect on engine performance.

III. Present investigation

With the ever–increasing number of diesel vehicles day by day, all the countries in the world have legislated stringent NO_x emission standards so as to save the environment and the human beings from its evil effects NO_x can be reduced by five different techniques such as charge dilution, in cylinder charge condition, fuel injection system parameter, fuel formation and exhaust gas after treatment. The present investigation aims at NO_x control using aqueous metal salt – diesel emulsion in DI diesel engine. The degree of NO_x lowering with the solution injection was much larger than with a water injection alone, and the solution also reduced smoke emissions, which was not much affected by water injection.

IV. Emulation theory and preparation

The process according to the present invention allows to produce emulsions of liquid fuels and water in which the water is dispersed in the liquid fuel with predetermined dispersion characteristics, particularly as regards the average size of the dispersed water particles. It is believed that this characteristic is decisive in achieving a combustion of high quality in terms of both energy efficiency and polluting emission reduction. In particular, it is believed that high-quality combustion can be achieved with an average size of the water particles dispersed in the liquid fuel of generally less than 1.5 microns, preferably between 0.05 and 1 microns. Moreover, the dispersion characteristics of the water in the liquid fuel directly affect the stability of said emulsion, which is a particularly critical property in the case of low-density liquid fuels (for example Diesel fuels), for which storage in tanks, also for long periods, is usually required. The stability of the resulting emulsions can be evaluated on the basis of any phase separations found after centrifuging a sample of the emulsion at a predetermined speed and for a predetermined time. It is believed that the emulsions of liquid fuels and water have a stability which is sufficient to allow to store them for long periods (more than 1 month) if they show substantially no phase separation after centrifuging at 1000 g (g=acceleration of gravity) for 15 minutes (at room temperature).

An emulsion is a two– phase liquid system consisting of fairly coarse dispersions of one liquid in another in the form of droplets, whose diameter exceeds 0.1 microns. Of the two phase, dispersed phase is present in the form the matrix in which those droplets are suspended. Generally there exist two distinct emulsion types, Oil-in-water type and Water-in-oil type. Water–in–oil type is suited best type of fuel for internal combustion engines rather than oil–in–water type. While using emulsion as fuel the care must be taken so that there mat be on side effects and we should also succeed economically in producing them. The reason behind the use of water– in–oil emulsion (WOE) as engine fuel is mainly due to the micro – explosion phenomenon of droplet of water, which caused large fragmentation of the oil and less change in viscosity with water content.

1) Emulsifying Agents

Emulsifying agents are chemicals, which are added during the process of emulsion preparation. The main aim of adding emulsifying agents in to reduce the interfacial tension between the two liquid phases to form a homogenized stable solution.

2) Types of Emulsifier

- Anionic
- Cationic
- Nonionic

Only nonionic emulsifying agents are suggested for preparation emulsifying fuel for engine application owing to its non – reactive and non – corrosive nature without any source for secondary pollutants formation in engines. In particular, in order to increase the stability of the produced emulsions it is possible to use surfactants or mixtures of surfactants known in the art. Said surfactants are preferably chosen among those which have low environmental impact, do not generate toxic byproducts during combustion and are not corrosive for the metals with which they make contact. Said surfactants can be preferably chosen among: sorbitol esters with fatty acids, optionally containing at least one polyoxyalkylene chain, preferably a polyoxyethylene chain; polyalkylene glycols, preferably polyethylene glycol; polyalkylene glycol esters with fatty acids; or mixtures thereof. The fatty acids can be chosen in particular among stearic acid, lauric acid, oleic acid or palmitic acid. The following are particularly preferred surfactants: sorbitan monoleate, sorbitan sesquioleate, sorbitan monolaurate, polyoxyethylene sorbitan monostearate, polyethyleneglycol hydroxystearate.The use of surfactants is particularly advantageous in the case of emulsions of low-density, low-viscosity liquid fuels, for example Diesel fuels, which typically have a density between 0.83 and 0.87 kg/m^3 and a viscosity between 1 and 3.C^o., which in the absence of surfactants generally form emulsions that show stability problems after prolonged storage in a tank, particularly due to the separation of the lighter petroleum fractions. For Diesel fuels it has been observed that it is particularly advantageous to use a mixture of surfactants comprising 60 to 95% sorbitan monoleate by weight and 5 to 40% polyethyleneglycol hydroxystearate by weight. This mixture, in addition to stabilizing the emulsions that are produced, also acts as a lubricant and antifreeze.

The total amount of surfactants added is selected according to the type of fuel and the effectiveness of said surfactants in stabilizing the emulsion and can generally vary between 0.1 and 8% by weight, preferably between 0.5 and 5% by weight, with respect to the weight of the total emulsion. In the case of liquid fuels having a higher density, the Applicant has instead observed that it is possible to obtain highly stable emulsions even without adding surfactants. This result can be ascribed both to the density and viscosity characteristics of the liquid fuel and to the possible presence, in said fuel, of small amounts of hydrocarbon oxidation products, which can act as surfactants. Additives suitable to reduce sulfur oxide emissions, such as for example sodium or potassium hydroxide, soluble barium or magnesium salts (for example chlorides), or mixtures thereof, can be introduced by means of the water phase. The presence of said products is particularly advantageous if fuels with a high sulfur content are used. The amount of additive to be added is determined according to the stoichiometric ratios required to eliminate a predetermined amount of sulfur, which is in turn calculated as the difference between the amount of sulfur present in the fuel and the maximum allowable amount of sulfur in the exhaust gases. The apparatus according to the present invention allows producing liquid fuel emulsions in which the amount of water can vary over a wide range and is predetermined according to the specific use for which the emulsion is intended. For combustion processes in general, the amount of water can vary between 5 and 45% by weight, preferably between 10 and 35% by weight, with respect to the total weight of the emulsion.

3) Modes of Adding Emulsifier

Having chosen the appropriate emulsifier, there are four recognized ways of incorporation the emulsifier into the system.

- Agents in Oil method
- Agent in Water method
- Nascent soap method.
- Alternative addition method

In the all above four method is generally used to produce Water– in–oil emulsion type. In this method, the emulsifier of dissolved in the oil phase and water is added to it.

4) Fuel Preparation

In order to avoid any side effects in running the engine only nonionic type emulsifying agents were tried to produce emulsion. The stability of the emulsion was tested with different salt solution.

5) Emulsifier Fuel Mixing Procedure

The aqueous metal salt solution – diesel emulsion were prepared by mixing neat diesel fuel and a 1% emulsifier and 10% salt solution with concentration of 0.4 mol/dm3 (Solution = mixture of salt and distilled water). The neat fuel, emulsifier (between 80) was first mixed together for 15 minutes using a mechanical mixer as shown in Fig. 1. The salt solution was then added with neat fuel emulsifier mixtures and the blend was stirred mechanically for another period of 30 minutes to obtain a macro– emulsion with larger fuel droplets. All emulsion was prepared just before each engine test.

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Emulsions having the composition listed in Table 1, were prepared by using the above-described apparatus

Table 1 : Composition (% by weight)

Emulsion	Hydrocarbon	Water	Additive
A	88.0	10.0	2.0
B	86.0	11.5	2.5
C	88.0	10.0	2.0
D	66.0	34.0	--

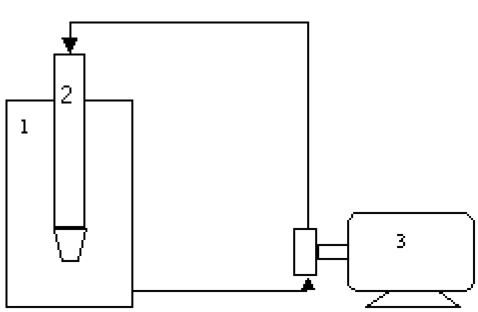
For emulsions A, B and C, the hydrocarbon used was automotive Diesel fuel with a density of 0.836 kg/m^3 while emulsion D was prepared by using fuel oil with a density of 0.95 kg/m^3. Emulsions A, B and C contained, as stabilizing additive, a mixture constituted by 90% sorbitan monoleate by weight and 10% polyethyleneglycol hydroxystearate by weight, while no surfactants were added to emulsion D.

IV. Experimental Procedure

The engine was started on neat fuel and warmed up. The test fuel was selected. If the emulsion were used, the emulsified fuel was introduced into the fuel line and another period of time was allowed for the engine to stabilize. The experimental procedure involves the investigation of the following parameters namely.

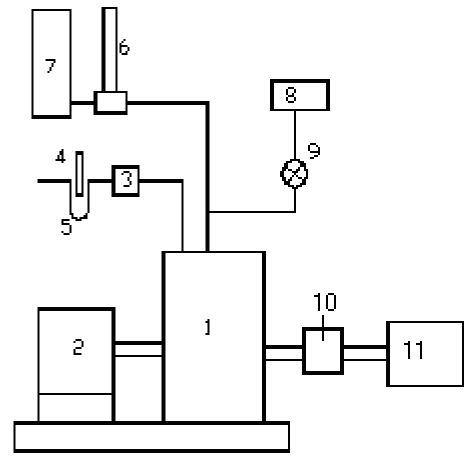
- Brake power
- Brake specific fuel consumption
- Measurement of NOX
- Smoke intensity
- Exhaust gas temperature

Fig. 1: Mechanical Mixer



1. Emulsion Tank 2. Nozzle 3. Motor and Pump

Fig. 2: Experimental Set-up



1.	Engine
2.	D.C Generator
3– 5.	Air Intake
6, 7.	Fuel Reservoir
8, 9.	Emulsion Reservoir
10.	Thermocouple
11.	Nitrogen Oxides Analyzer

1) Measurement of NOx

Oxides of nitrogen were measured with NOX analyzer. The NOX analyzer gives the values NO and NO2 present in the exhaust gas in ppm. Smoke intensity & exhaust gas temperature measurement. Smoke intensities are taken by using HP smoke number and smoke number is evaluated using Bosch Smoke Meter in Bosch Smoke Units (BSU). Exhaust gas temperature is measured by using Iron – constant thermocouple with dial indicating unit.

2) Particulate Emission Measurement

Particulate mass calculation is measured by weighing the filters on an electronic microbalance before and after collection. The filter paper is exposed to the exhaust for a period of 5 minutes and hence particulate emission is measured in Grams Hr. similar procedure was adopted for all the other engine loads. The same sequence was repeated for the emulsified fuel containing salts.

V. Conclusion

It has been found that combusting water and diesel fuel emulsion in a diesel engine as a way to reduce nitrogen oxide emissions but it can lead to mechanical problems. These problems are usually caused by the fact that the components of the engine are designed to operate within the lubricity characteristics of diesel fuel. Since a water and diesel fuel emulsion has lubricity far less than that of diesel fuel, a great deal of damage to the diesel engine components can be caused by combusting a water and fuel oil emulsion in the engine. Although this problem is apparent in virtually all diesel engines, it is especially significant for engines having aluminum parts, which are more sensitive to damage in this way than steel, especially stainless steel, parts. What is desired, therefore, is a method and composition which can achieve significant reductions in the NOx emissions from diesel engines without requiring substantial retrofitting of the engines, nor an increase in emission of other pollutants. The method and composition selected should be capable of being instituted on a commercial level without significant infrastructure changes.

References Références Referencias

1) Andrews, G.E., K.D. Bartle, S.W. Pang, A.M. Nurein, and P.T. Williams, "The Reduction in Diesel Particulate Emissions Using Emulsified Fuels", SAE Paper No. 880348.
2) Barnes, A., D. Duncan, J Marshall, A. Psaila, J. Chadderton, A. Eastlake, "Evaluation of Ester-Blended Fuels in a City Bus and an Assessment of Performance with Emission Control Devices", SAE Paper No. 2000-01-1915.
3) Brown, K.F., J. Chadderton, D.T. Daly, D.A. Langer, D. Duncan, "Opportunity for Diesel Emission Reductions Using Advanced Catalysts and Water Blended Fuel", SAE Paper No. 2000-01-0182.
4) Mario Rapone, Livia Della Ragione and Fulvio D' Aniello (1995), "Experimental Evaluation of Fuel Consumption and Emissions in Congested Urban Trafic", SAF Paper No: 952401
5) Joachim Staab and Dieter Schurmann (1987), "Measurement of Automobile Exhaust Emissions under Realistic Road Conditions", SAF paper No: 871986
6) John Heywood (1989), "Internal Combustion Engine Fundamentals" Tata MegrawHill Company.

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Low Power On-Chip Amplifier For CCD Array

By Er. Amit Kumar, Dr. Himani

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Classification: GJRE-F Classification: 090605

Low Power On-Chip Amplifier For CCD Array

Er. Amit Kumar[1], Dr. Himani[2]

Abstract : The field of Analog VLSI design is an essential part of any electronics system because of our real world is analog, In this paper low power amplifier is presented for CCD array[1] .CCD are used to capture the images modern digital cameras and high resolution cameras consists of CCD array but all the performance of the CCD array is depends on the performance of On-Chip amplifier which is placed at the end of the array in this paper single and two stage amplifier are simulated and the result is presented for the power and bandwidth by varying the sizes of the different transistors all the results are verified by using the Tanner tool (version 7.1) [11]there are number of analysis presented by the researchers in the literature to improve the power dissipation but most of the structure are compromise sometimes with the area or sometimes with the bandwidth here we have achieve the lesser power dissipation but with the handsome value of bandwidth is also maintained to support this claim the detailed results are presented in the result section.

I. Introduction

Charge Coupled Devices (CCDs) were invented in the 1970s and originally found application as memory devices Charge Coupled Devices (CCD) have many applications, but the most important is in imaging [3]. The basic operation of the sensor is to convert light into electrons. When light is Incident on the active area of the image sensor it interacts with the atoms that make up the silicon crystal. The energy transmitted by the light (photons) is used to enable an electron to escape from the tight control of one atom to roam more freely about the device as a "conduction"electron, leaving behind an atom shy of one electron. Modern CCD has two types of architecture:

1. Full-Frame (FF)
2. Frame-Transfer (FT)

FF CCDs have the simplest architecture and are the easiest to fabricate and operate. They consist of a parallel CCD shift register, a serial CCD shift register and a signal sensing output amplifier. Images are optically projected onto the parallel array which acts as the image plane the architecture is shown in the fig. 1

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FT CCDs are very much like FF architectures. The difference is that a separate and identical parallel register, called a storage array, is added which is not light sensitive. The idea is to shift a captured scene from the photosensitive, or image array, very quickly to the storage array [5]. Readout off chip from the storage register is then performed as described in the FF device previously while the storage array is integrating the next frame. The architecture is shown in the fig. 2

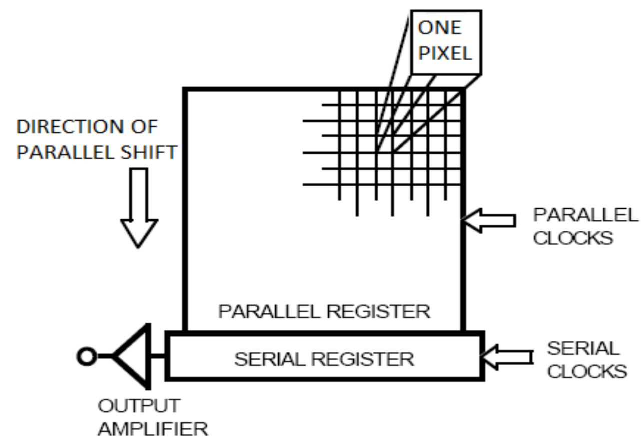

Fig. 1: Full Frame architecture

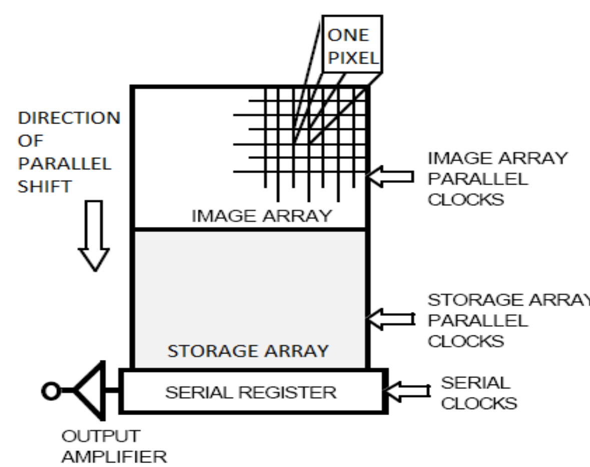

Fig. 2: Frame transfer architecture

Both of the above architecture are widely used but the performance of both the architecture are depends on the type and the quality of the On-chip (output) amplifier which is fabricated at the last stage of the structure as shown in the fig above.

II. Architecture of On-Chip Amplifier

Output amplifier has also two type of the architecture

1. Single stage amplifier
2. Two stage amplifier

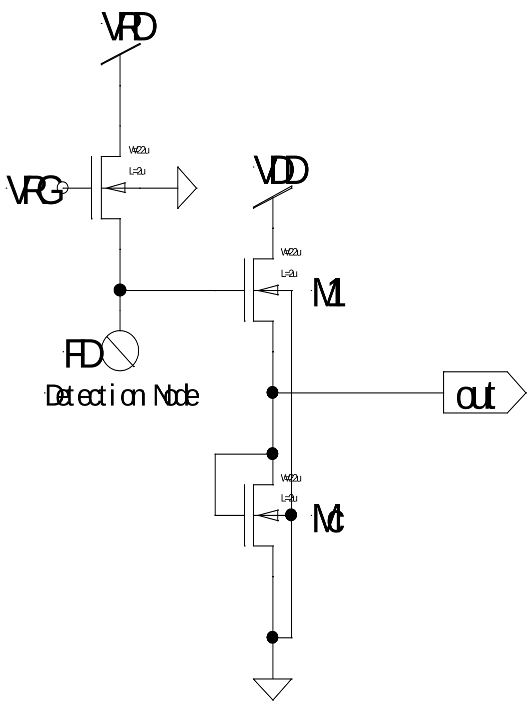

Fig. 3: Single Stage CCD On-Chip amplifier

The single stage amplifier consists of source follower M1 and load transistor Mc for biasing. The reset FET is connected to the detection node and consists of floating diffusion [6, 7] and the gate of M1. In the ON state it resets the detection node to a reference voltage (VRD) and in the OFF state the floating can receives the next charge packet. The voltage source between the gate and source of the current sink Transistor Mc determines the bias current of the first stage and can be used as a signal injection point to measure the ratio between total capacitance and the effective sense capacitance and the bandwidth in the off state. The Two stage amplifier further improves the character tics of the amplifier and gives the better result which is shown in the result section of the paper and the architecture of two stages is shown two stage amplifier also improves the sensitivity of the amplifier and this also reduces the noise level of the overall CCD.

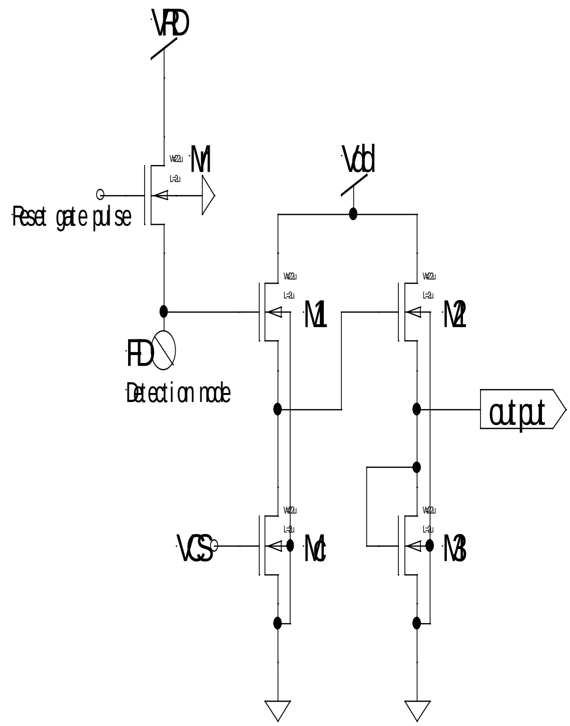

Fig. 4: Two Stage CCD On-Chip amplifier

III. Optimization

For optimization of the on-chip amplifier Length and Width of the individual transistor are varied and the various optimization results are obtained. The effect of increase and decrease of Length and Width of the transistor is given as

To achieve maximum gain:

Transistor 'M1': -The gain can be maximized by increasing the width of this transistor as this increases the difference in the output voltage amplitude.

Transistor 'MC': -The gain can be maximized by decreasing the width of this transistor as this increases the difference in the output voltage amplitude.

Transistor 'M2': -The gain can be maximized by increasing the width of this transistor as this increases the difference in the output voltage amplitude.

Transistor 'M3': -The gain can be maximized by decreasing the width of this transistor as this increases the difference in the output voltage amplitude.

To achieve maximum bandwidth:

Transistor 'M1': - The bandwidth of the circuit can be increased by increasing the width of this transistor as the increase in width increases the transconductance which helps in increasing the bandwidth as the impedance decreases.
Transistor 'MC': - The bandwidth of the circuit can be increased by increasing the width of this transistor as the increase in width increases the transconductance which helps in increasing the bandwidth as the impedance decreases.
Transistor 'M2': - The bandwidth of the circuit can be increased by increasing the width parameter of this transistor. So bandwidth can be increased by changing this parameter.
Transistor 'M3': - The bandwidth of the circuit can be increased by increasing the width of this transistor as the increase in width increases the Tran conductance which helps in increasing the bandwidth as the impedance decreases, although the change desired is not that large.

To achieve minimum power dissipation:

Transistor 'M1': - The power dissipation of the circuit can be reduced by reducing the width of this transistor as the current flowing into this transistor reduces with the reduction in the width while power dissipation can be reduced by increasing the length because increase in length reduces transconductance which in turn reduces the amount of current flowing into the transistor.
Transistor 'MC': - The power dissipation of the circuit can be reduced by reducing the width of this transistor as the current flowing into this transistor reduces with the reduction in the width while power dissipation can be reduced by increasing the length because increase in length reduces transconductance which in turn reduces the amount of current flowing into the transistor.
Transistor 'M2': - The power dissipation of the circuit can be reduced by reducing the width of this transistor as the current flowing into this transistor reduces with the reduction in the width.
Transistor 'M3': - The power dissipation of the circuit can be reduced by reducing the width of this transistor as the current flowing into this transistor reduces with the reduction in the width.

IV. Results

Transistor Dimensions (W× L) µm M1	Mc	M2 (W× L) µm	M3 (W× L) µm	Power Dissipation (mW)	Bandwidth BM (MHz)
15×25	12×10	20x10	10x25	5.9	302
15×25	12×10	20x10	12x25	5.95	320
15×25	12×10	20x10	15x25	6.0	242
15×25	12×10	20x10	18x25	6.1	207

Table 1: When the width of the transistor M3 varied

Transistor Dimensions (W× L) µm M1	Mc	M2 (W× L) µm	M3 (W× L) µm	Power Dissipation (mW)	Bandwidth BM (MHz)
15×25	12×10	20x10	10x25	5.15	69
15×25	12×10	18x10	10x25	5.25	62
15×25	12×10	16x10	10x25	5.2	78
15×25	12×10	14x10	10x25	5.3	70
15×25	12×10	12x10	10x25	5.4	87
15×25	12×10	10x10	10x25	5.7	122
15×25	12×10	8x10	10x25	5.8	148

Table 2 : When the width of the transistor M2 varied

Transistor Dimensions (W× L) µm M1	Mc	M2 (W× L) µm	M3 (W× L) µm	Power Dissipation (mW)	Bandwidth in (MHz)
15×25	12×10	20x10	10x5	7.0	580
15×25	12×10	20x10	10x10	6.4	594
15×25	12×10	20x10	10x15	6.1	596
15×25	12×10	20x10	10x18	6.0	365
15×25	12×10	20x10	10x20	5.9	270
15×25	12×10	20x10	10x25	5.7	122
15×25	12×10	20x10	10x30	5.8	109

Table 3: When the Length of the transistor M3 varied

Transistor Dimensions (W× L) µm M1	Mc	M2 (W× L) µm	M3 (W× L) µm	Power Dissipation (mW)	Bandwidth in (MHz)
15×25	12×10	20x5	10x15	6.4	150
15×25	12×10	20x10	10x15	6.1	490
15×25	12×10	20x15	10x15	5.9	550
15×25	12×10	20x18	10x15	5.8	570
15×25	12×10	20x20	10x15	5.8	326
15×25	12×10	20x25	10x15	5.75	380

Table 4: When the Length of the transistor M2 varied

The results of the above table are taken from the Tanner T-spice tool by using the 2.0 Mosis model file for the enhancement MOSFET transistor. The power dissipation and the bandwidth are directly, measures from the waveform editor in the Tanner EDA tool.

V. Conclusion and Future Scope

It is observed from the result that in case of single stage On-Chip amplifier minimum power dissipation and maximum bandwidth is achieved when the Width of the M1 transistor is 18µm and the Length of the M1 transistor is 25µm meter and the Width of the Mc transistor is 10µmr and the Length of the Mc transistor is 16µm. In this case power dissipation is 4.3 milli-watts and the gain of the amplifier is 0.82 and bandwidth is 617MHz. In case of two stage amplifier maximum bandwidth is achieved when dimension of transistor is as M1(15µmx25µm), M2(20µmx10µm), M3(10µmx15µm) & Mc(12µmx10µm) and for minimum power dissipation the dimension of all the transistor should be M1(15µmx25µm), M2(20µmx10µm), M3(10µmx25µm) & Mc(12µmx10µm). The whole design simulated using MOSIS/Orbit 2.0µm process by using Tanner tool. In this thesis Analog simulation is done by using the Tanner tool and using the enhancement type MOSFET transistor is used, this thesis can be further extended for the depletion type MOSFET because in depletion type MOSFET noise level will get further reduce and the other thing which can be improved in future is, semiconductor and environmental noise effect which is not consider in this current thesis.

References Références Referencias

1) Gruner, Sol M. Tate, Mark W. Eikenberry and Eric F "Charge - coupled device area x-ray detectors". Review of Scientific Instruments, page No. 2815 - 2842 Volume:73 Issue: 8
2) M.J.Howess & D.V.Morgan, "Charge-Coupled Devices and Systems", John Wiley & Sons.
3) James R. Janesick, "Scientific Charge-Coupled Devices", Spie Press Monograph Vol.85.
4) M.s Tyagi, "Introduction To Semiconductor Materials And Devices", by John Wiley & Sons, Inc © 1991.
5) Dalsa web site; CCD Technology Primer; http://www.dalsa.com/corp/markets/ccd_vs_cmos.aspx
6) Kodak CCD Primer, #KCP-001,"Charge coupled device (CCD) Image Sensors", Eastman Kodak Company - Microelectronics Technology Division.
7) D.Barbe, "Imaging Devices Using the Charge-Coupled Concept". Proceedings of the IEEE, pp. 38-67, Jan. 1975.
8) Stuart A. Taylor, "CCD and CMOS Imaging Array Technologies: Technology Review", Technical Report EPC106, Xerox Research Centre Europe, 1998.
9) Beynon J.D.E, "The Basic Principles Of Charge Coupled Devices", MICROELECTRONICS, vol.7 No.2c 1975 Mackintosh Publications Ltd. Luton.
10) P.Centen, E. Roks. "Characterization of Surface-and Buried-Channel Detection Transistors for On-Chip Amplifiers". Technical Digest IEDM97, pp.193-196, San Francisco, Dec 7-10, 1997.
11) http://www.mosis.com/products/fab/vendors/tsmc/tsmc-kits.html

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Design and Analysis of Rectangular Microstrip Antenna with PBG Structure for Enhancement of Bandwidth

By Kapil Goswami, Ashutosh Dubey , Girish Chandra Tripathi, And Birbal Singh

Abstract- Modern wireless systems are placing greater emphasis on antenna designs for future development in communication technology because of antenna being the key element in the whole communication system. The microstrip antenna in a system serves as the transducer between the controlled energy residing within the system and the radiated energy existing in free space. This antenna is very good for wireless communication due to it's light weight, low volume and low profile planer configuration which can be easily made conformal to host surface. Additionally, some of it's characteristics like low fabrication cost, supportive nature for both linear and circular polarization, and low sensitivity to manufacturing tolerance make this antenna very important for next generation. However, a major disadvantage of this type of antenna is that it has very narrow band width. In this paper, we remove such type of disadvantage of rectangular microstrip antenna by adding a PBG structure. We first describe briefly the properties of the microstrip antenna & photonic band gap structure and after this we design a rectangular microstrip antenna with PBG structure using cavity model method. Then the results are simulated with IE3D based on MOM method. At the end, we compare the simulated and measured results. We find that the bandwidth of microstrip antenna is enhanced by adding a PBG structure .

Keywords: Bandwidth, Directivity, Microstrip Antenna, Method of Moment (MOM), Photonic Band Gap Structure.

Classification: GJRE-F Classification: FOR Code: 291701

DESIGN AND ANALYSIS OF RECTANGULAR MICROSTRIP ANTENNA WITH PBG STRUCTURE FOR ENHANCEMENT OF BANDWIDTH

Strictly as per the compliance and regulations of:

Design and Analysis of Rectangular Microstrip Antenna with PBG Structure for Enhancement of Bandwidth

Kapil Goswami[1], Ashutosh Dubey[2], Girish Chandra Tripathi[3], Birbal Singh[4]

Abstract : Modern wireless systems are placing greater emphasis on antenna designs for future development in communication technology because of antenna being the key element in the whole communication system. The microstrip antenna in a system serves as the transducer between the controlled energy residing within the system and the radiated energy existing in free space. This antenna is very good for wireless communication due to it's light weight, low volume and low profile planer configuration which can be easily made conformal to host surface. Additionally, some of it's characteristics like low fabrication cost, supportive nature for both linear and circular polarization, and low sensitivity to manufacturing tolerance make this antenna very important for next generation. However, a major disadvantage of this type of antenna is that it has very narrow band width. In this paper, we remove such type of disadvantage of rectangular microstrip antenna by adding a PBG structure. We first describe briefly the properties of the microstrip antenna & photonic band gap structure and after this we design a rectangular microstrip antenna with PBG structure using cavity model method. Then the results are simulated with IE3D based on MOM method. At the end, we compare the simulated and measured results. We find that the bandwidth of microstrip antenna is enhanced by adding a PBG structure .

Indexterms : *Bandwidth, Directivity, Microstrip Antenna, Method of Moment (MOM), Photonic Band Gap Structure.*

I. Introduction

Antenna is one of the important elements in the RF system for receiving or transmitting the radio wave signals from and into the air as the medium. Without proper design of the antenna, the signal generated by the RF system will not be transmitted and no signal can be detected at the receiver. The development of MIC and HF semiconductor devices and printed circuits has drawn the maximum attention of the antenna community in recent years. In spite of its various attractive features like light weight, low cost, easy fabrication, conformability on curved surface etc, the microstrip element suffers from an inherent disadvantage of narrow impedance bandwidth and low gain. In principle, bandwidth enhancement can be achieved by several approaches [1]. In this paper, we remove such type of disadvantage of rectangular microstrip antenna by adding a structure, that is made by a PBG material [2], in this type of antenna. The coaxial feed technique is used for the analysis of this antenna because it occupies less space and has low spurious radiations by using Teflon connector. The Method of Moment (MOM) [3] is used to discuss the electromagnetic radiation characteristics of the microstrip antenna.

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II. Analysis of Microstrip Patch Antenna

Microstrip patch antenna with PBG structure (Fig-1) can be designed by using a cavity model [4] suitable for moderate bandwidth antennas. The lowest order mode, TM_{10}, resonates when effective length across a patch is half of wavelength. Radiations occur due to fringing field. A brief description of resonant frequency, cavity model and PBG structure is given as follows;

a) Resonance Frequency:

The resonance frequency f_{mn} depends on the patch size, cavity dimensions, and the filling material dielectric constant.

It is expressed as follows;

$$f_{mn}=\frac{K_{mn}c}{2\pi\sqrt{\varepsilon_r}} \quad (1)$$

Where m, n = 0, 1, 2… K_{mn} = wave number at m, n mode, c is the velocity of light, ε_r is the dielectric constant of the substrate, and

$$K_{mn}=\sqrt{\left(\frac{m\pi}{W}\right)^2+\left(\frac{n\pi}{L}\right)^2} \quad (2)$$

For TM_{01} mode, length and width of non radiating rectangular patch's edge at a certain resonance frequency and dielectric constant is given by:

$$L = \frac{c}{2f_r\sqrt{\varepsilon_r}} \qquad (3)$$

$$W = \frac{c}{f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (4)$$

Where f_r is the resonance frequency at which the rectangular microstrip antenna is to be designed. The radiating edge W, patch width is usually kept such that it lies within the range $L < W > 2L$ for efficient radiation. The ratio $W/L = 1.5$ gives good performance according to the side lobe appearances. The actual value of resonant frequency is slightly less than f_r because fringing effect causes the effective distance between the radiating edges of the patch to be slightly greater than L. By using the above equations we can find the values of actual length of the patch as:

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} - 2\Delta l \qquad (5)$$

Whereε_{eff} is the effective dielectric constant and Δl is the line extension which is given as:

$$\varepsilon_{eff} = \left(\frac{\varepsilon_r+1}{2}\right) + \left(\frac{\varepsilon_r+1}{2}\right) \cdot \frac{1}{\sqrt{1+12\frac{h}{W}}} \qquad (6)$$

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \qquad (7)$$

b) Cavity Model:

Transmission line model ignores field variations along the radiating edges. This disadvantage can be overcome by using cavity model in which interior region of dielectric substrate is modeled as cavity bounded by electric walls on the top and bottom. The basis for the assumption is the following observations for thin substrate ($h \ll \lambda$). Since the substrate is thin; the field in interior region does not vary much in Z direction that is normal to the path.

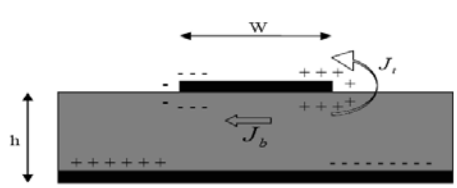

Figure1 .Charge distribution and current density creation on the patch.

Consider Fig 1, when the microstrip patch is provided power, a charge distribution is seen on the upper and lower surfaces of the patch and at the bottom of the ground plane. This charge distribution is controlled by two mechanisms-an attractive mechanism and a repulsive mechanism. The attractive mechanism is between the opposite charges on the bottom side of the patch and the ground plane, which helps in keeping the charge concentration intact at the bottom of the patch. The repulsive mechanism is between the like charges on the bottom surface of the patch, which causes pushing of some charges from the bottom, to the top of the patch. As a result of this charge movement, currents flow at the top and bottom surface of the patch. The cavity model assumes that the height to width ratio (i.e. height of substrate and width of the patch) is very small and as a result of this the attractive mechanism dominates and causes most of the charge concentration and the current to be below the patch surface. Much less current would flow on the top surface of the patch and as the height to width ratio further decreases, the current on the top surface of the patch would be almost equal to zero, which would not allow the creation of any tangential magnetic field components to the patch edges. Hence, the four sidewalls could be modeled as perfectly magnetic conducting surfaces.

c) Principle Of Photonic Band Gap (Pbg) Structure:

Photonic band gap (PBG) structures are periodic structures in which propagation of certain bands of frequencies is prohibited. Original PBG research was done in the optical region, but PBG properties are scalable and applicable to a wide range of frequencies. PBG structure can be achieved by using metallic, dielectric, ferromagnetic, or ferroelectric implants. Dielectric PBG structures have been used for microstrip circuits. Photonic band gap depends on the diffraction, reflection, and refraction.

Photonic band gap structures (PBG) are very promising building blocks of novel photonic components and devices representing the highest level of innovation in light generation, routing, and switching. As the fully three-dimensional (3D) PCs working in the optical domain are still difficult to fabricate, two-dimensional (2D) PCs formed in a dielectric slab ('membrane') or in a slab waveguide represent an attractive alternative. In these structures, light propagation is governed by diffractive effects in the two dimensions of the 2D photonic crystal, and by the classical 'refractive guiding' in the third (usually vertical) dimension.

III. Design parameters for proposed antenna

The various design parameters of antenna which are calculated using the standard equations (1-7) are as follows:-

Substrate material used is glass epoxy.

a) Designed Parameter Of Rectangular Microstrip Antenna With Pbg Structure:

Length of Patch (L) = 29 mm
Width of Patch (W) = 37 mm
Length of ground plate (L_0) = 42 mm
Width of ground plate (W_0) = 55 mm
Regular square shape length and width (a) = 10 mm
Gap of regular square shape (b) = 03 mm
Dielectric Constant of the Substrate (ε_r) = 4.2

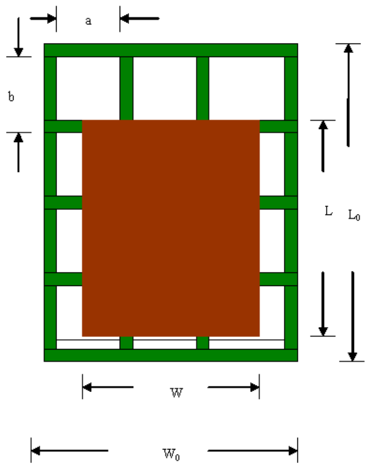

Figure 2 : Geometry of proposed antenna with PBG structure

IV. Result analysis by simulation and discussion:

By using MATLAB [5], we find the values of return loss and VSWR of Rectangular microstrip patch antenna (RMSPA) with 3 by 4 regular square shape PBG structure on ground plane and also simulate the proposed antenna with IE3D [6]. Finally we compare output of simulated and measured results with the support of various graphs and charts given below.

a) Rectangular Microstrip Patch Antenna (RMSPA) with 3 by 4 regular square shape PBG structure on ground plane:

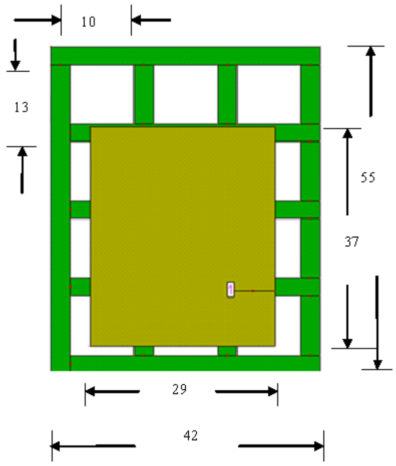

Figure 3: Antenna shape with feed point

b) Simulated result by IE3D based on MOM Method:

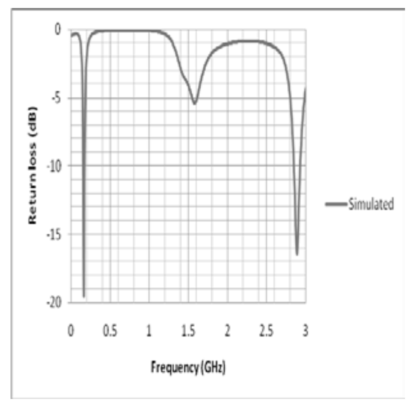

Figure 4: Return loss verses frequency plot

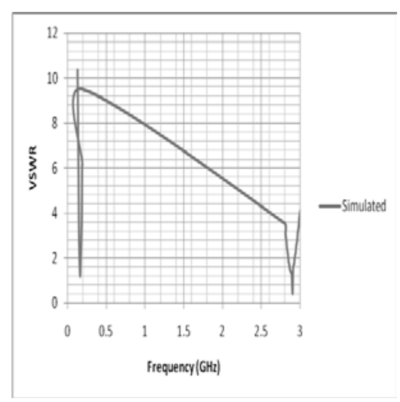

Figure 5: VSWR verses frequency plot

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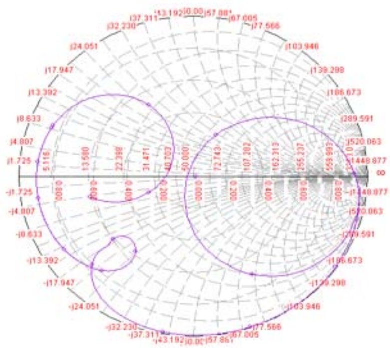

Figure 6 : Impedance verses frequency plot on smith chart

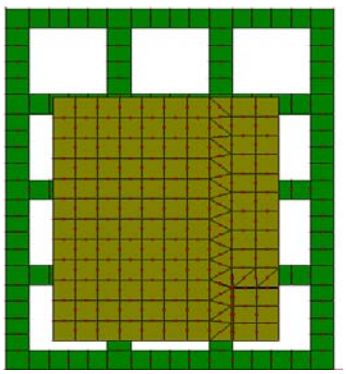

Figure 7 : Current distribution on positive plate

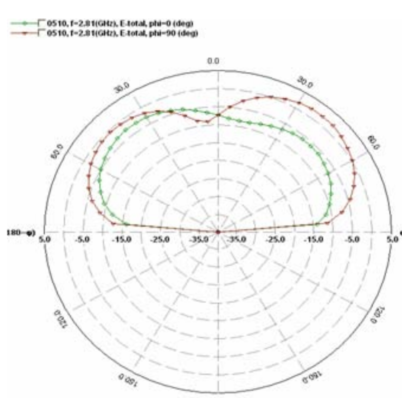

Figure 8 : Radiation pattern of E and H plane plot

c) Discussion:

The results of microstrip antenna designs such as the return loss, VSWR and the radiation pattern can be obtained by using the IE3D are shown in Fig 4, 5 and Fig 8 respectively. The results for the antenna simulation does not accurately give similar result as measured. Based on the simulations and measurements that have been done, the operating frequency of the antenna fabricated is shifting to the lower frequency because of PBG structure. Fig. 9 shows a graph which compares the simulation and measurement return loss results of rectangular microstrip patch antenna with PBG structure. For the simulation results the resonant frequency is exactly at 2.89 GHz with a return loss -15.95 dB. The operational frequency of the antenna is 2.85 GHz to 2.93 GHz measured at a return loss value below -10 dB. The bandwidth is about 2.78%. From the measurement result, the resonant frequency shifts to the lower frequency at 2.26 GHz. The return loss value at the resonant frequency is -18.4 dB. The operational frequency of the antenna shifts from 2.21 GHz to 2.30 GHz. The bandwidth is 3.99%.

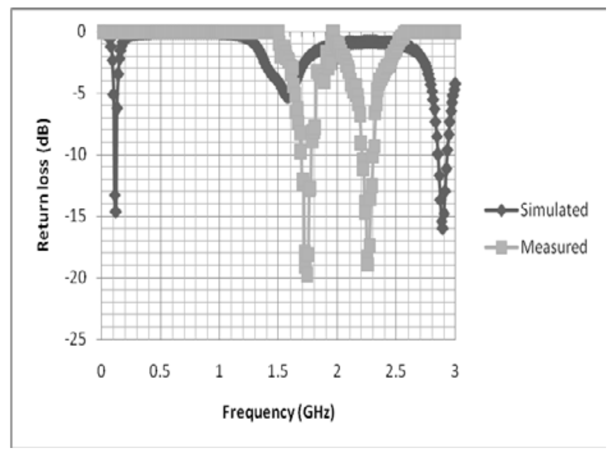

Figure 9 : Return Loss verses frequency plot

Through simulated and measurement analysis (Fig-9), we observe that the bandwidth increases when resonance frequency is greater than working frequency and addition of a PBG structure with rectangular microstrip antenna is very helpful for the same.

V. Conclusion

Based on the theoretical, simulated and analysis of the microstrip antenna with PBG structure, we have discussed the size and design parameters. Then we simulated the antennas that can run at 2.5 GHz frequency and calculated its return loss by using IE3D based on Method of Moment. Through theoretical and simulated analysis, we find bandwidth increases when resonance frequency is greater than the working frequency and this can be easily found by adding a PBG structure with rectangular microstrip antenna.

VI. Acknowledgment

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References Références Referencias

1) D.M.POZAR and D.H SCHAUBERT,"Microstrip Antennas, the Analysis and Design of Microstrip Antennas and Arrays", IEEE Press, New York, USA, 1995.
2) H.Y.D.Yang, "Photonic Bandgap Materials", Electromagnetics, Vol.19, 1999, pp.255-276
3) D.M.POZAR, "Microstrip Antennas", IEEE Proc., Vol.80, pp. 79-91, January 1992.
4) A.K. Ahmad and S.M. Juma" Cavity Model Analysis of Rectangular Microstrip Antenna", IEEE Trans., February 2006.
5) MATLAB 7.0
6) IE3D, Zeland Corporation www.zeland.com

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CFD Prediction of Natural Convection in a Wavy Cavity Filled with Porous Medium

By Khudheyer S. Mushate
Thi-qar University

Abstract- In this paper, the natural convection heat transfer and fluid flow inside a square cavity having two wavy walls has been numerically investigated. The cavity is filled with a porous medium. The two wavy vertical walls are maintained at different isothermal temperatures while the horizontal walls are kept insulated. A general non-orthogonal body-fitted coordinates system was used to transfer the considered physical space in to a computational one. The governing stream function equation was solved by using an iteration method with SOR while the energy equation with an alternate difference implicit scheme(ADI).The study was performed for Rayleigh numbers up to 1000. The effect of amplitude, Rayleigh number and number of wavy walls undulations on the flow and thermal field was studied. The obtained results showed that the number of wavy walls undulations has a significant effect on heat transfer and fluid flow. Also the results indicated that the rate of heat transfer increases as Rayleigh number increases and decreases with the increase of amplitude.

Classification: *GJRE-C Classification: FOR Code: 091502*

CFD PREDICTION OF NATURAL CONVECTION IN A WAVY CAVITY FILLED WITH POROUS MEDIUM

CFD Prediction of Natural Convection in a Wavy Cavity Filled with Porous Medium

Khudheyer S. Mushate

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Nomenclature

A	amplitude
g	gravitational acceleration, m/s^2
H	height of the cavity wall, m
J	Jacobian of the transformation
K	permeability, m^2
Nu	local Nusselt number
Nu_{av}	average Nusselt number
Ra	Rayleigh number
T_c	cold wavy wall temperature, ċ
T_h	hot wavy wall temperature, ċ
u,v	velocity components, m/s
x, y	Cartesian coordinates, m
X Y	dimensionless Cartesian coordinates
α, β ,γ,τ,σ	Transformation parameters in grid generation
ξ, η	coordinates in the transformed domain
ψ	stream function, m^2/s
Ψ	dimensionless stream function
ρ	density, Kg/m^3
a	thermal diffusivity, m^2/s
θ	dimensionless temperature

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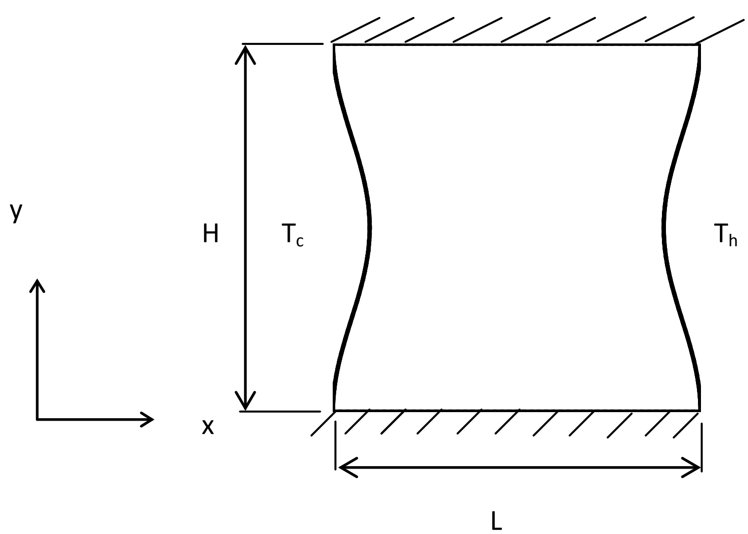
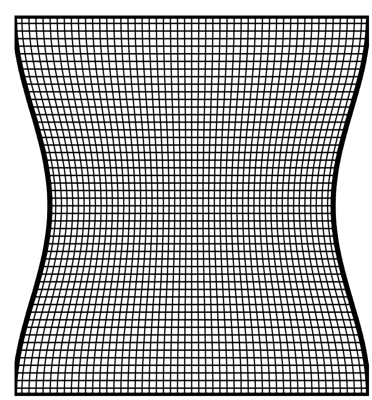
I. Introduction

Study of natural convection heat transfer inside an enclosure has received a great deal of attention due to its implication in most engineering applications. These applications include solar collectors, cooling of micro-electric devices and nuclear reactors. Indeed, most of the researcher's works were concentrated on rectangular or square enclosures. So few studies were found on natural convection in non-rectangular enclosures. The medium inside these enclosures was porous or non-porous. Natural convection heat transfer in wavy enclosures(i.e. non-rectangular enclosures) was motivated by the researchers in recent years. Due to its importance in most technological applications such as geophysical applications and heat exchangers design. The change of surface waviness, waviness mode besides to the location of these waviness is considered a controlling parameters for assessment the flow and thermal field characteristics. Thus the present literature tries to review the previous studies. Al-Amiri [1] investigated the momentum and energy transfer in a lid-driven cavity filled with a porous medium. He used the inertia and viscous effects through the general formulation of momentum and energy transfer. Braden et al. [2] adopted the Darcy model and Buossinesque approximation to investigate the natural convection flow in a porous medium adjacent to vertical or horizontal surface. The surface was heated and cooled sinusoidally along its length. Oothuizen and Patrick [3] studied the natural convection in an inclined square enclosure. The enclosure was differentially heated and partially filled with a porous medium. The study was focused on the average rate of heat transfer across the enclosure. A theoretical study of buoyancy-driven flow and heat transfer in an inclined trapezoidal enclosure filled with a fluid –saturated porous medium was studied by Yasin et al.[4]. The governing equations were solved numerically using a finite difference method. The study was performed for inclination trapezoidal angles ranged from 0° to 180° and Ra from 100 to 1000. Also the wall angles was ranged from 67° too 81°. the condidered results from that study showed that the effect of trapezoidal inclination angle on heat transfer and flow strength is more than the side wall inclination angle.

Sharif [5] performed a numerical study on mixed convection heat transfer in an inclined lid-driven enclosure filled with viscous fluid. He chose non-porous medium and observed that the average Nusselt number increases with cavity inclination angle. Yasin *et. al.* [6] investigated the free convection in porous media filled right-angle triangular enclosure. The governing equations were obtained using Darcy model and solved by a finite difference techniques. Abdalla et al. [7] analyzed the mixed convection heat transfer in a lid driven cavity with a sinusoidal wavy hot surface. The results of his study showed that the average Nusselt number is increased with an increase of amplitude of the wavy surface and Reynolds number. Kumar [8] investigated the free convection induced by a vertical wavy surface with heat flow in a porous enclosure. He verified that the surface temperature was very sensitive to the drifts in the undulations and amplitude. Dalal and Das [9] presented a numerical study for the natural convection in a cavity with a vertical wavy wall. Their results showed that the local rate of heat transfer and the flow field were significantly affected due to the undulation in the right wall. The effect of surface undulations on the free convection heat transfer from a horizontal wavy surface in a porous wavy enclosure was studied by Murthy et al. [10]. They assumed valid Darcy flow model. Their results showed that the waviness of the surface reduced the ratio of heat transfer compared with that of a flat surface. Xu *et. al.* [11] performed a numerical study on unsteady natural convection in differentially heated cavity with a fin on a side wall. Different lengths for $Ra=3.8\times10^{9}$ were performed. The obtained results showed that the fin length significantly impacts on transient thermal flow around the fin and heat transfer through the finned side wall in the early stage of the transient flow development. Hakan and Oztop [12] presented a numerical study to obtain the combined convection field in an inclined porous lid driven enclosure heated from one wall. The study was performed for $10\leq Ra\leq 1\,000$. It was reported that the flow field , temperature distribution and heat transfer are affected by the angle of inclination. As shown in the literature, there is no study on laminar natural convection in a porous cavity with two wavy walls. So the present work aims to enhance the academic research in this field. As shown in Fig.1, the laminar natural convection heat transfer inside a porous square cavity with two vertical wavy walls has been investigated. The cavity is differentially heated. Different values of wavy walls amplitudes, undulations and Rayleigh numbers are examined. The effect of location of the two wavy walls and thermal boundary conditions are examined. The grid generation system used in this work is based on the procedure proposed by Thompson et al. [13.



a. physical domain



b. computational domain

Fig.1 schematic diagram of the problem under consideration

I. *Grid generation*

The numerical calculation of a flow field needs a suitable treatment of boundary conditions which are difficult to incorporate for complex boundary conditions. A grid generation is used to transfer a physical space in to a computational space. The grid generation method is used to map the non-rectangular grid in the physical space into a rectangular uniform grid in the computational space. The grid generation method proposed by Thompson [13] is used to transform the region shown in Fig.1.a in to computation region shown in Fig.1.b.The most common partial differential equation used for grid generation in 2-D is an elliptic Poisson equation.

$$\zeta_{xx} + \zeta_{yy} = P(\zeta,\eta) \quad \text{----------} \ (1)$$

$$\eta_{xx} + \eta_{yy} = Q(\zeta,\eta) \quad \text{-----------} \ (2)$$

Where P and Q are known functions used to control interior grid clustering. All grids used in this work are generated with $P(\zeta,\eta) = Q(\zeta,\eta) = 0.$ The system is completed by addition of Drichlet boundary conditions which specify ζ and η as functions of x and y on the boundary of the region shown in Fig.1 . Calculations were performed on the rectangular region so that dependent and independent variables are interchanged to produce a system of two partial differential equations in the form of:

$$\alpha X_{\zeta\zeta} - 2\beta X_{\zeta\eta} + \gamma X_{\eta\eta} = -J^{-2}[X_{\zeta} P(\zeta,\eta) + X_{\eta} Q(\zeta,\eta)] \text{------} \ (3)$$

$$\alpha Y_{\zeta\zeta} - 2\beta Y_{\zeta\eta} + \gamma Y_{\eta\eta} = -J^{-2}[Y_{\zeta} P(\zeta,\eta) + Y_{\eta} Q(\zeta,\eta)] \text{-----------} \ (4)$$

Where

$$\alpha = X_{\eta}^{2} + Y_{\eta}^{2} \ , \ \gamma = X_{\zeta}^{2} + Y_{\zeta}^{2} \ , \ \beta = X_{\zeta} X_{\eta} + Y_{\zeta} Y_{\eta} \ , \ J = X_{\zeta} Y_{\eta} - X_{\eta} Y_{\zeta}$$

The discretization of equations (3-4) is obtained by using a second order central difference procedure and are solved by iteration method with SOR.

II. Mathematical Model

The two dimensional laminar natural convection heat transfer in a wavy square cavity filled with a porous media has been investigated. To consider the related mathematical model, some assumptions were reported:

- The properties of the porous media is assumed to be constant
- The viscous and inertia effects are ignored and the Boussinesque approximation is valid.

The governing differential equations of the mass continuity, momentum and energy are described as follows. Also some assumption are made on the continuity equation [14,15].

$$\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = 0 \qquad \text{---------------} \ (5)$$

$$\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x} = -\frac{g\beta K}{\upsilon}\frac{\partial T}{\partial x} \qquad \text{----------------} \ (6)$$

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = a\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right) \qquad \text{----------------} \ (7)$$

This is called Darcy model and the equations can be written in dimensionless form after using the following parameters.

$$u = \frac{\partial \psi}{\partial y} \ , \ v = -\frac{\partial \psi}{\partial x} \ , \ X = \frac{x}{H} \ , \ Y = \frac{y}{H} \ , \ \Psi = \frac{\psi}{\alpha} \ , \ \theta = \frac{T - T_c}{T_h - T_c} \ , \ Ra = \frac{g\beta K (T_h - T_c) H}{a\upsilon} \ , \ \tau = \frac{\alpha t}{H^2}$$

$$\frac{\partial^2 \Psi}{\partial X^2} + \frac{\partial^2 \Psi}{\partial Y^2} = -Ra\frac{\partial \theta}{\partial X} \qquad \text{------------------} \ (8)$$

$$\frac{\partial\theta}{\partial\tau}+\frac{\partial\Psi}{\partial Y}\frac{\partial\theta}{\partial X}-\frac{\partial\Psi}{\partial X}\frac{\partial\theta}{\partial Y}=\nabla^2\theta \quad \text{------------------ (9)}$$

The transformation of the new dependent variables (ζ,η) defined in the preceding section leads to replacement of $\psi(x,y)$ in to $\psi(\zeta,\eta)$ and $\theta(x,y)$ to $\theta(\zeta,\eta)$[13].

$$\lambda\Psi_\varsigma+\sigma\Psi_\eta+\alpha\Psi_{\varsigma\varsigma}-2\beta\Psi_{\varsigma\eta}+\gamma\Psi_{\eta\eta}=-JRa(\theta_\zeta Y_\eta-\theta_\eta Y_\zeta) \quad \text{---------- (10)}$$

$$\theta_\tau+\left(-\Psi_\zeta\theta_\eta+\Psi_\eta\theta_\zeta\right)\Big/_J=\left(\lambda\theta_\zeta+\sigma\theta_\eta+\alpha\theta_{\zeta\zeta}-2\beta\theta_{\zeta\eta}+\gamma\theta_{\eta\eta}\right)\Big/J^2 \quad \text{---- (11)}$$

Where

$$\lambda=\left(X_\eta D_y-Y_\eta D_x\right)\Big/_J \quad \text{-------------- (12)}$$

$$\sigma=\left(Y_\zeta D_x-X_\zeta D_y\right)\Big/_J \quad \text{-------------- (13)}$$

$$D_x=\alpha Y_{\zeta\zeta}-2\beta Y_{\zeta\eta}+\gamma Y_{\eta\eta} \quad \text{--------------- (14)}$$

$$D_Y=\alpha X_{\zeta\zeta}-2\beta X_{\zeta\eta}+\gamma X_{\eta\eta} \quad \text{--------------- (15)}$$

1) *Boundary conditions*

In order to solve the mathematical model, the following boundary conditions are used.

$U=V=0,\theta=-0.5,\ \psi=0$ on the cold wall

$U=V=0,\theta=0.5,\ \psi=0$ on the hot wall

$U=V=0,\dfrac{\partial\theta}{\partial X}=\left(\alpha\dfrac{\partial\theta}{\partial\varsigma}-\beta\dfrac{\partial\theta}{\partial\eta}\right)\Big/J\sqrt{\alpha}=0,\ \psi=0$ on the two insulated walls

The local and average Nusselt number along the hot wavy wall is calculated as follows.

$$Nu=-\int_0^1\frac{d\theta}{dx}$$

$$Nu_{av}=\int_0^1 Nu\,dy$$

III. Numerical Solution

Finite difference formulation is used to discretize the considered partial differential equations. The resulting algebraic equations for temperature distribution, eq. 11 were solved by using alternate difference implicit (ADI) method. The iteration method with successive overlaxation scheme (SOR) was used for solving the discretization equation of the stream function,eq.10. The Relaxation factor used for stream function had the value of 1. A home computer program using Fortran 90 language was constructed to handle the considered problem. In order to ensure that the flow and heat transfer characteristics are not affected by the mesh, different grids were used, (31×31), (41×41) and (51×51) respectively. As shown in table1, there is no noticeable change between the used grids and the grid (51×51) is adopted in this work.

Table1. Effect of mesh on Nu_{av} for Ra=500, A=1 and for one undulations

Mesh	Nu_{av}
31×31	4.49
41×41	4.41
51×51	4.39

IV. Results and Discussion

In this section, the computed results of stream function, isotherm lines, local and average Nusselt numbers will be reported. These factors were plotted for different values of wavy walls undulations, amplitude and Rayleigh number. Also the effect of boundary conditions and the location of the two wavy walls are examined.

Fig.2 demonstrates the stream function and isotherm lines distribution for different Rayleigh numbers and one undulation. For (a), when Ra=50, it can be seen that there is four rotating vortices symmetrical about the centerline of the cavity. These vortices occupy the upper and lower part of the cavity especially at the troughs. The isotherm line for Ra=50 seem to be parallel and take the cavity shape. This manifest that the convection currents are very small. When Ra increases to 150, the rotating vortices are seem to be close to each other and the isotherm lines start to deviate and that confirm the presence of convection currents due to increase of the buoyancy forces. When Ra =500, the size of rotating vortices becomes larger and they be closer to each other at both vertical and horizontal centerlines of the cavity. Also the isotherm lines are significantly deviate and symmetrical about the cavity centerline. The thermal boundary is thick near upper and lower parts of the two wavy walls while it is less thick at the cavity centerline especially at the wavy wall crests. This is confirmed at Fig.5.a where the local Nusselt number value is minimum at Y=0.5. For one undulation, when Ra extends to 1000, the size of rotating vortices is larger and more elongation. This indicates that the convection currents are dominant. Also the isotherm lines intensity are larger at the upper and lower part of the wavy walls and less at the cavity centerline. This will enhance heat transfer as shown in Fig.5.b for one undulation. In this Figure, the values of maximum Nusselt number for one undulation are increased nearly by 35%. The effect of Ra on stream function and isotherm lines distribution for two undulations is depicted in Fig.3. it can be seen that the area of crest and trough is decreased but there is multiple crests and trough. For Ra=50, there is six rotating vortices symmetrical about the cavity centerline. The size of vortices are larger at the upper and lower parts of the cavity compared with that near the middle of the cavity. The size of these vortices are increased wit the increase of Ra. Also the shape is elongated to semi elliptical type especially at Ra=500 and Ra =1000. As a results the isotherm lines deviation is increased with the increase of Ra due to increase the buoyancy forces. This behavior is disclosed at Fig.5 (a and b) where the heat transfer is increased at the trough regions and decreased at crest. The lower values is not lies at the cavity centerline (Y=0.5). When the undulation number increase to three, eight rotating vortices is appearing as shown in Fig.4. However the shape and size of these vortices are significantly changed with the increase of Ra. Also the deviation of stream lines are increased with the increase of Ra. This demonstrate at Fig.5(a and b). here the minimum values occur at Y=0. The effect of wavy walls amplitude (A) on stream function and isotherm lines is exhibited at Fig. 7. When A=0.075, the shape of counter vortices is elongated and the size of these vortices are seem to be larger. When A=0.15, there is dramatic changes in stream function distribution. Two elongated upper vortices and two elongated lower vortices are appeared. Two of these vortices are very close to the hot wavy wall crest. There is a significant change in isotherm lines distribution (d and e). For f, the density of isotherm lines is very high near the wavy hot wall crest at Y=0.5. This will enhance heat transfer as shown in Fig.9 where higher values of Nu occur at Y=0.5. Fig.8 demonstrates the effect of wavy wall amplitude for three undulations and Ra =500. For A=0.075, there is a little change in the size of rotating vortices especially near the centerline (Y=0). When A=0.085, the size of these vortices is seem to be less especially at the upper and lower region of the cavity and the isotherm lines seem to be thicker. When A=0.15, the size of the resulting vortices is smaller and the boundary layer is thicker at the trough regions. Fig.6 discloses the variation of average Nusselt number versus Ra at different undulations values. It can be seen that the average Nusselt number is decreased with the increase of undulations number. When the boundary condition for the dimensionless temperature is changed for $\theta = 1$ (on the hot wall) and $\theta = 0$ (on the cold wall) as shown in Fig.10, there is significant changes in the stream function and isotherm lines distribution has been occurred. However the values of local heat transfer are increased. This is dominant for all the studied cases. The two wavy walls are placed at horizontal sides as found in Fig.12, where there is a significant change in number and size of resulting vortices. The isotherm lines densities are less and that leads to decrease the rate of heat transfer as shown in Fig.13. To increase our understanding to the flow field, velocity vectors are plotted for three undulations and for two positions of the wavy walls as shown inFig.14 . As the Figure, shows a part of the velocities hit the crest and the remaining forming recirculation zones. The velocities in core region in (a) is larger than (b). To perform the validation of the present numerical method used, a comparison with the available published results is made as shown in Fig. 15. As the Figure shows, a good agreement is obtained.

V. Concluding Remarks

In this study, the 2D laminar natural convection heat transfer and fluid flow inside a square porous cavity with two vertical wavy walls has been performed. Thus from the current computed results, the following conclusions can be summarized.

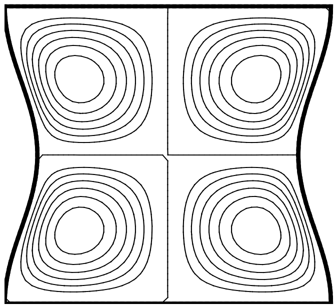
1. For one and three undulations, the minimum local heat transfer occurs at the middle of the hot wavy wall (Y=0). However this is not seen with the two undulations.
2. The average rate of heat transfer is decreased with the increase of undulation number for Ra>200.
3. The Rate of heat transfer is increased with the increase of the amplitude values for $0.05 \le A \le 0.075$. After that the local rate of heat transfer is decreased. However the local rate of heat transfer is enhanced significantly at Y=0.5
4. The number and size of rotating vortices is increased with the increase of undulations number.
5. The location of the two wavy walls is better at the vertical sides compared with that of the horizontal sides.
6. The local Nusselt number exhibited periodic distribution

References Références Referencias

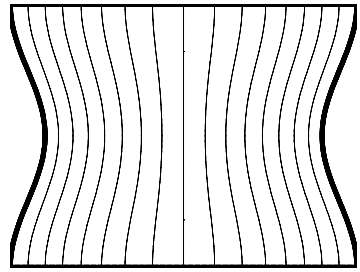
1. Al-Amiri, A.M., " Analysis of momentum and energy transfer in a Lid-driven cavity filled with a porous medium", Int. J. Heat Mass Transfer, Vol.43, pp.3513-3527, 2000.
2. Bardean, R., Ingham, D.B, Heggs, P.J, pop,I.," The unsteady penetration of free convection flows caused by heating and cooling flat surfaces in porous media. Int. J. Heat Mass Transfer, vol.40, pp.665-687, 1997.
3. Oosthuizen P. H., Patrick, H., ''Natural convection in an inclined square enclosure partly filled with porous medium and partially heated wall', American Society of Mechanical Engineers, Heat Transfer Division, (publication) HTD,pp.29-42,1995.
4. Yasin Varol, Hakan, F. Ozttop, Ioan Pop,'' Numerical analysis of natural convection in an inclined trapezoidal enclosure filled with porous medium", Int. J. Thermal Sciences, vol.47, pp.1316-1331,2008.
5. Sharif, M.A.R, "Laminar mixed convection in shallow inclined driven cavities with hot moving Lid on top and cooled from bottom", Appl. Therm. Eng., Vol.27, pp. 1036-1042, 2007.
6. YasinVarol, Hakan F. Oztop, Asaf Varol, " Free convection in porous media filled right-angle triangular enclosure", International Communications in Heat and Mass Transfer, Vol.33, pp.1190-1197, 2006.
7. Abdalla Al-Amiri, Khalil Khanafer, Joseph Bull, Loan pop,'' Effect of sinusoidal wavy bottom surface on mixed convection heat transfer in a lid driven cavity, Int. J. Heat Mass Transfer, Vol. 50,2007.
8. Kumar, B.V.R., ''A study of free convection induced wavy surface with heat flux in a porous enclosure", Numer. Heat transfer A, vol.37, pp.493-510,2000.
9. Dalal, A., Das, M.K, " Natural convection in a cavity with a wavy wall heated from below and uniformly cooled from the top and both sides", Int. J. Heat transfer, Vol. 128, pp. 717-725,2006.
10. Murthy, P.V.S. N., Rathish Kumar, B.V., Singh.P.," Natural convection heat transfer from a horizontal wavy surface in a porous enclosure", Numerc. Heat transfer, A., vol. 31, pp. 207-221, 1997.
11. Xu, F., Patterson, J.C., Lei, C., "Transient Natural convection in a differentially heated cavity with a thin fin of different lengths on a side wall", 16th Australasian Fluid Mechanics Conference Crown Plaza, Gold Coast, Australia, 2-7 December, 2007.
12. Hakan F., Oztop," combined convection in inclined porous lid driven enclosures with sinusoidal thermal boundary condition on one wall, Progress in Computational Fluid Dynamica", Vol.9, 2009.
13. Thompson, J.F., Thomas, F., Mastia, C.W., " Automatic numerical generation of body fitted curvilinear coordinate system for field containing

any number of arbitrary two dimensional bodies', J. Computational Physics, vol.15., pp. 299-319, 1974.

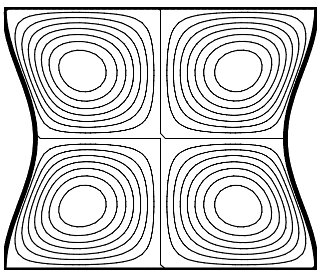
14. Bejan, A., " On the boundary layer regime in a vertical enclosure filled with a porous medium", Heat and Mass Transfer, vol.6, pp. 93-102.
15. Nawaf, H., Saeid, " Natural convection in a square porous cavity with an oscillating wall temperature", The Arabian Journal for Science and Engineering, vol.31, 2006.



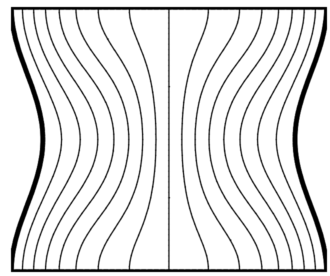
a. Ra=50



e. Ra=50



b. Ra=150



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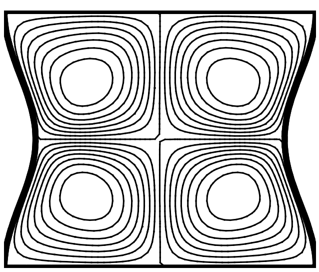
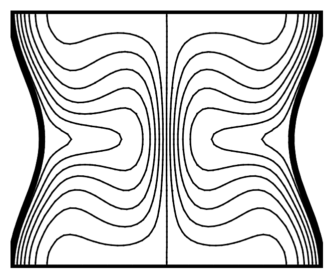
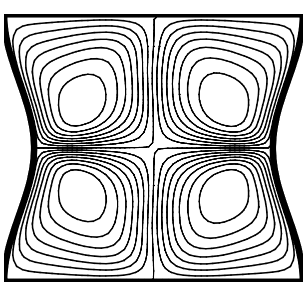


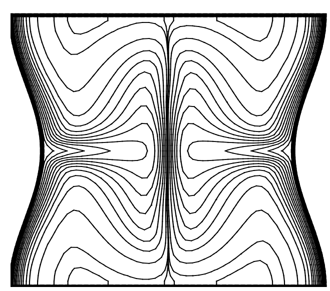
c. Ra=500



g. Ra=500

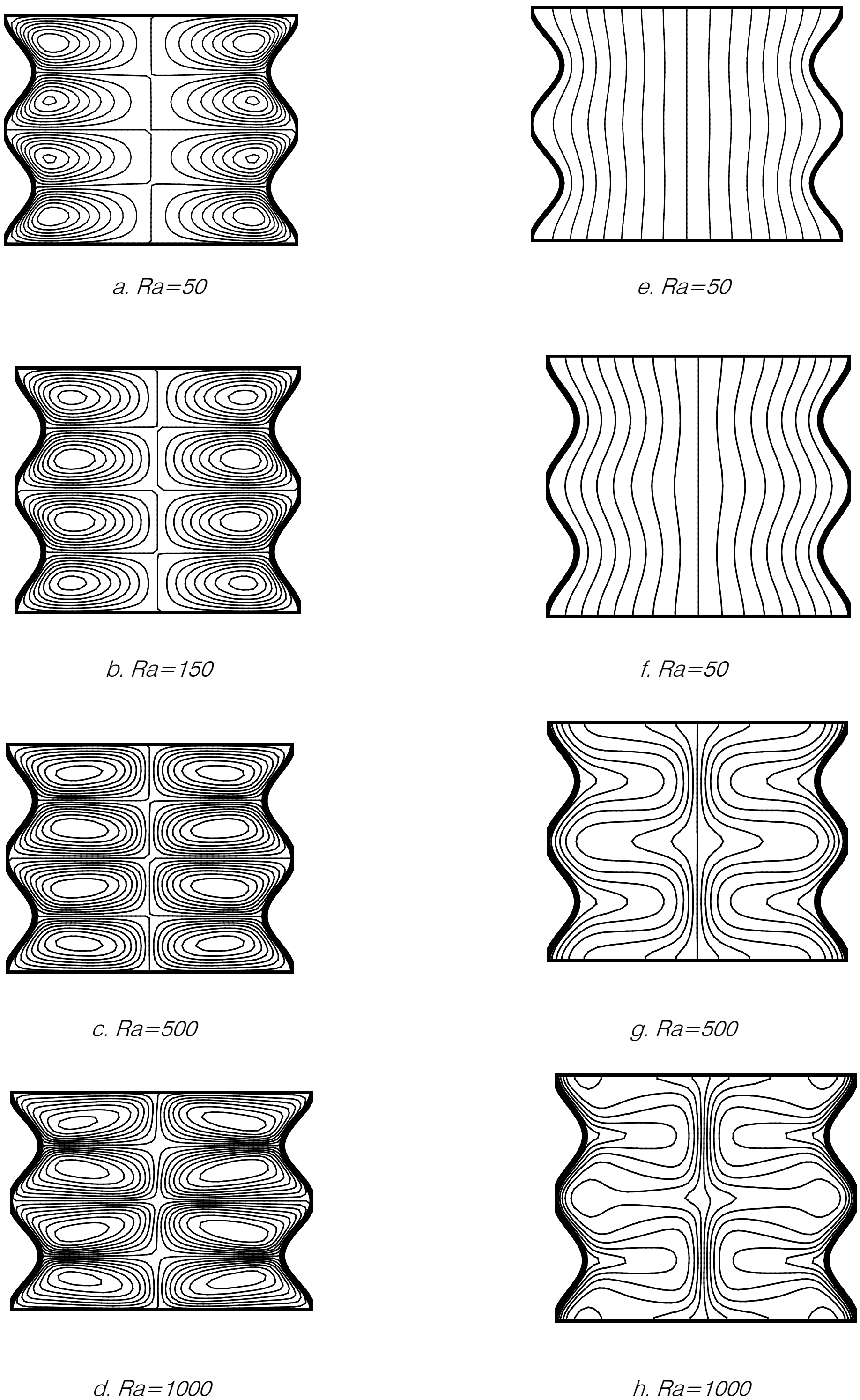


d. Ra=1000



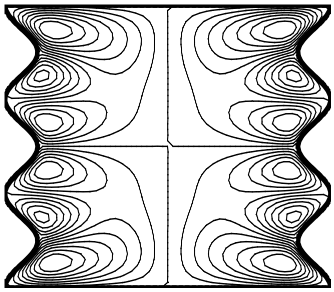
h. Ra=1000

Fig. 2 effect of Ra on stream function and isotherm lines distribution for one undulation and A=0.05

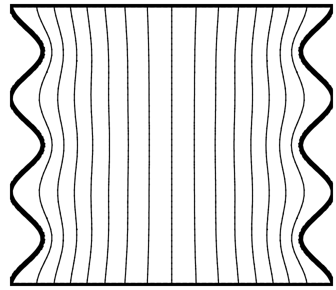


a. Ra=50
e. Ra=50
b. Ra=150
f. Ra=50
c. Ra=500
g. Ra=500
d. Ra=1000
h. Ra=1000

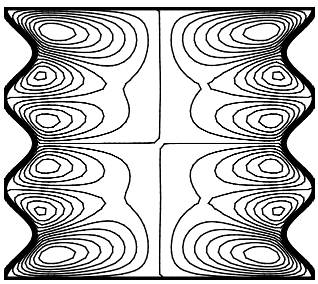
Fig. 3 effect of Ra on stream function and isotherm lines distribution for two undulation and A=0.05



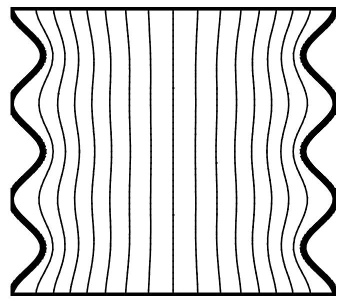
a. Ra=50



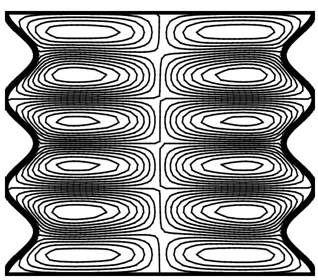
e. Ra=50



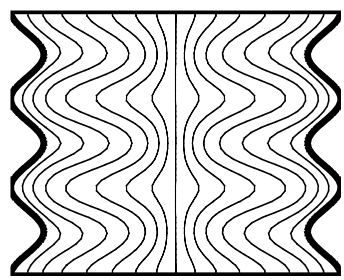
b. Ra=150



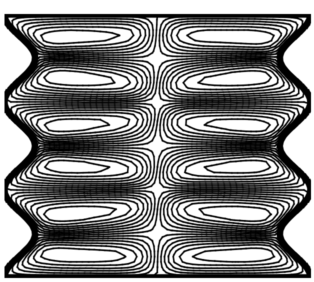
f. Ra=150



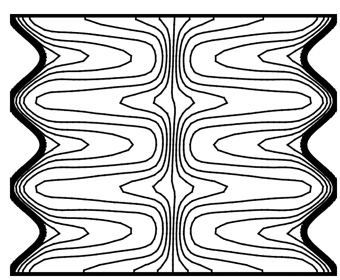
c. Ra=500



g. Ra=500

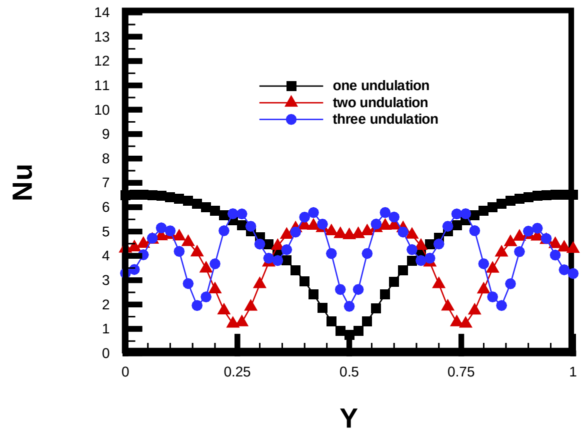


d. Ra=1000

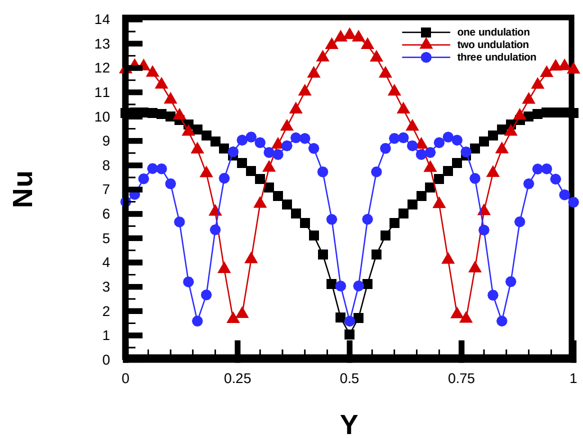


f. Ra=1000

Fig. 4 effect of Ra on stream function and isotherm lines distribution for three undulation and A=0.05



a. Ra =500



b. Ra =1000

Fig5 variation of Nu for different undulations and different Rayleigh Numbers and A=0.05

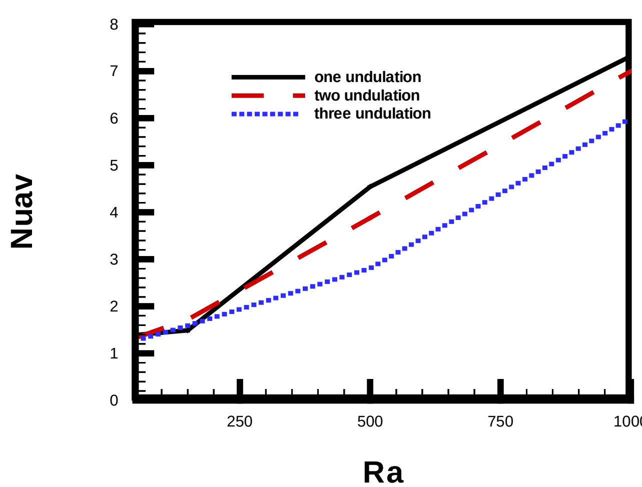
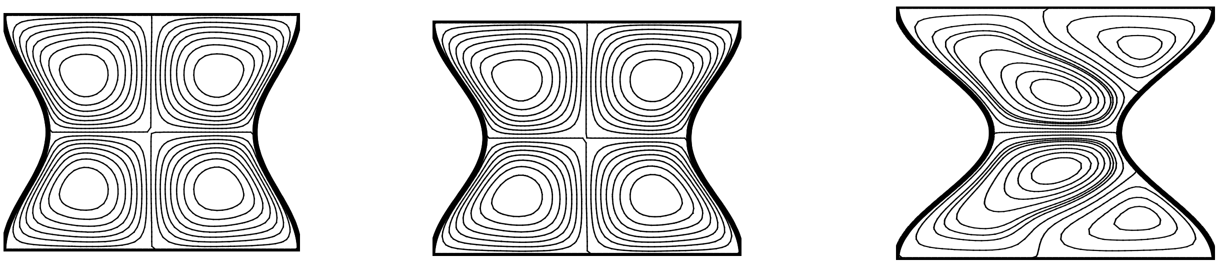
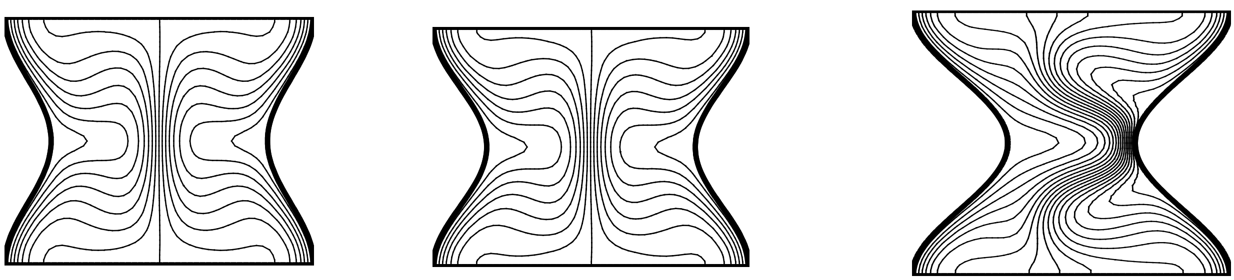


Fig. 6 variation of average Nusselt number versus Rayleigh for different undulation Numbers and A=0.05

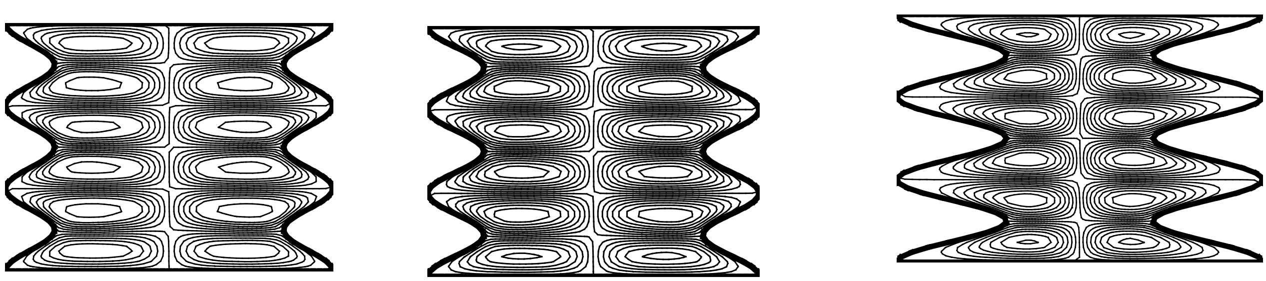


a. A=0.075 *b. A=0.085* *c. A=0.15*

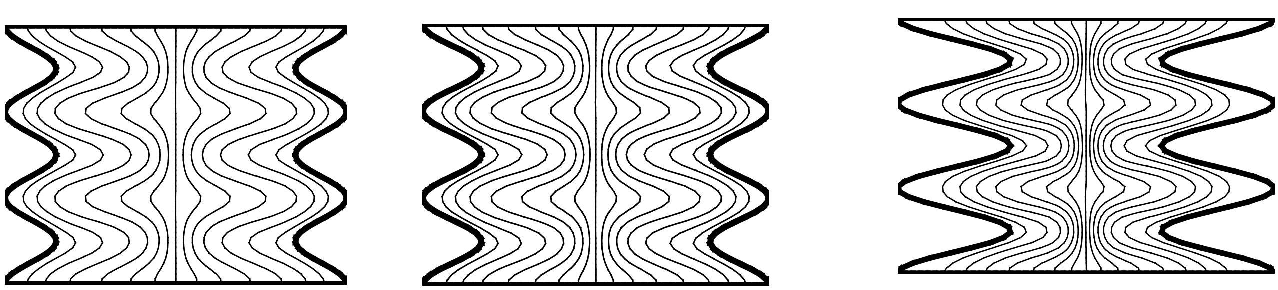


d. A=0.075 *e. A=0.085* *f. A=0.15*

Fig. 7 effect of wavy walls amplitude on stream function and isotherm lines distribution for one undulation and Ra =500



a. A=0.075 *b. A=0.085* *c. A=0.15*



d. A=0.075 *e. A=0.085* *f. A=0.15*

Fig. 8 effect of wavy walls amplitude on stream function and isotherm lines distribution for three undulations and Ra =500

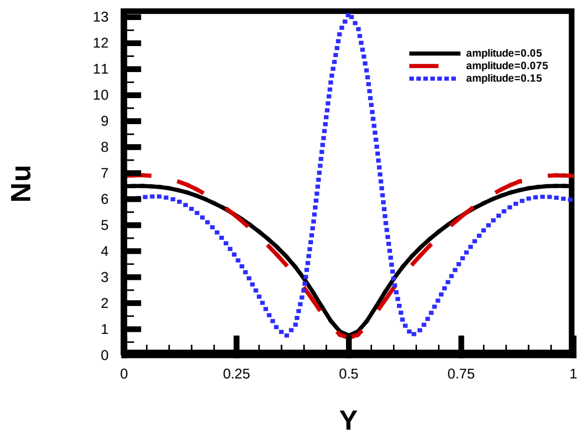


Fig.9 effect of amplitude on variation of Nu for one undulation and Ra=500

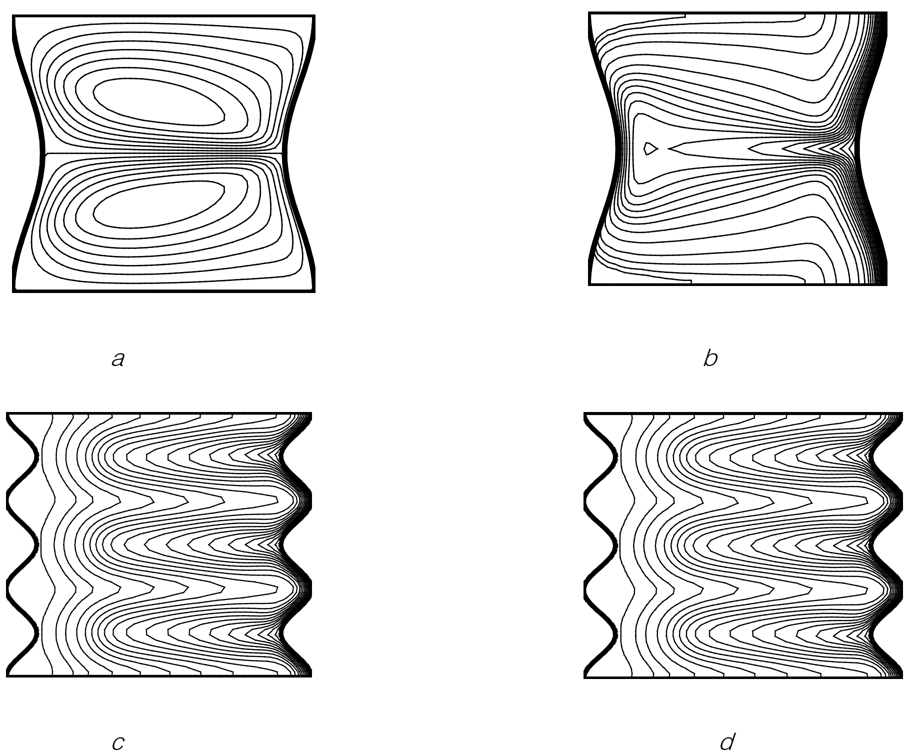


Fig.10 effect of thermal boundary conditions on stream function and isotherm lines distribution for Ra=500 and A=0.05

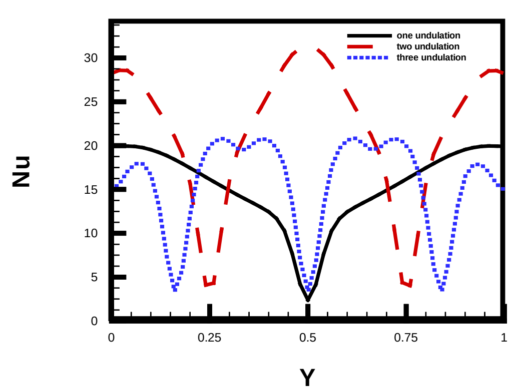
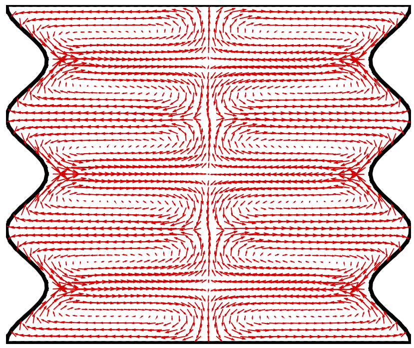
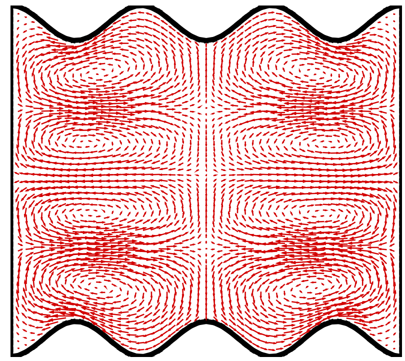


Fig.11 variation of Nu for different undulations, A=0.05 and Ra=500

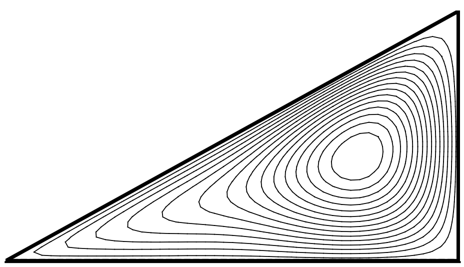


a. two vertical wavy walls

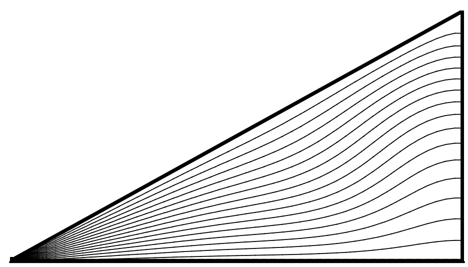


b. two horizontal wavy walls

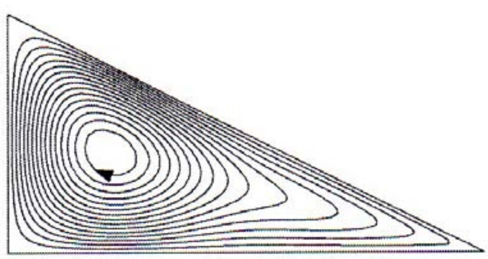
Fig. 12 velocity vectors for Ra= 500, A=0.05 and with three undulations



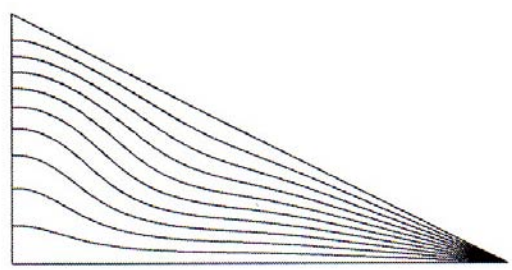
a. present results of stream function



b. present results of isotherm contours



c .published results of stream function



d .published results of isotherm contours

Fig .13 validation of the present code with published results [6] For Ra = 50, AR=0.5

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An Assessment of Build ability Problems In The Nigerian Construction Industry

By Aina, O.O. And Wahab, A.B.
Obafemi Awolowo University

Abstract- The study examined the occurrence of buildability problems and the factors that cause buildability problems in construction projects in Nigeria. Questionnaires were used to collect data from architects, contractors and structural engineers. The result shows the occurrence of buildability problems was ranked most at a period of one year with an index value of 4.55, 4.53 and 4.20 among the architects, contractors and structural engineers. The study shows that the complexity of project, faulty and defective working drawings, resistance of client to buildability programmes, budgetary limitation and non-standardization of design are ranked most as the cause of buildability problems. The study concludes that working drawings, specifications and other contract documents must be prepared by construction professionals; they should be aware of the likely impacts of buildability problems and the communication skill among construction parties must be effective at all stages of construction projects.

Keywords : *Building production, Building process, Buildability, Project Delivery, Project Problems.*

Classification: GJRE-E Classification: FOR Code: 090502

Strictly as per the compliance and regulations of:

An Assessment of Build ability Problems In The Nigerian Construction Industry

Aina, O.O. And Wahab, A.B.

Abstract : The study examined the occurrence of buildability problems and the factors that cause buildability problems in construction projects in Nigeria. Questionnaires were used to collect data from architects, contractors and structural engineers. The result shows the occurrence of buildability problems was ranked most at a period of one year with an index value of 4.55, 4.53 and 4.20 among the architects, contractors and structural engineers. The study shows that the complexity of project, faulty and defective working drawings, resistance of client to buildability programmes, budgetary limitation and non-standardization of design are ranked most as the cause of buildability problems. The study concludes that working drawings, specifications and other contract documents must be prepared by construction professionals; they should be aware of the likely impacts of buildability problems and the communication skill among construction parties must be effective at all stages of construction projects.

Keywords : Building production, Building process, Buildability, Project Delivery, Project Problems.

I. Introduction

Analysis of the construction process is commonly expressed in terms of establishing equilibrium among the three primary concerns of time, cost and quality. Any client would want to construct a facility of the highest quality; and it is the goal of the project team to maximize quality while minimizing cost and time. Modern buildings are complex edifices and the design, construction and commissioning of a new building is a long complicated process that involves input from a number of parties. There is the need for structured and formal systems of construction management to address the aspects of performance, workmanship and quality. The concept of building performance shows that satisfactory performance, site organisation and methods must be carried out to the highest level of integrity and competence so as to ensure the concept of buildability (Obiegbu, 2004).

Buildability as a term is not well known, and in fact, this term is not found in dictionaries, but in practice the concept has been known since the beginning of the construction industry. In ancient times, the design was dictated about how the project should be built, and the construction was done by the master builder (Uhlik and Lores 1998). Bamisile (2004) defined buildability as the ability to construct a building efficiently, economically and to an agreed or specified standard from its constituent materials, components and sub-assemblies. A widely accepted definition of buildability is that of the Construction Industry Research and Information Association (CIRIA, 1983), which quite explicitly states that 'buildability is the extent to which the design of a building facilitates ease of construction, subject to the overall requirements for the completed building. Buildability, as defined by the Construction Industry Institute (CII, 1986), has the "optimum integration of construction knowledge and experience in planning, engineering, procurement and field operations to achieve overall project objectives". Fisher and Rajan, (1986) defined buildability as a measure of the ease or expediency with which a facility can be constructed." Also, buildability is often described as integrating construction knowledge, resources, technology and experience into the engineering and design of a project.

Buildability is increasingly becoming a major requirement in building practice. The industry's clients are continuously demanding the best value for money, in terms of the efficiency with which the building is carried out. The integration of good buildability into good overall design is the responsibility of the design team. Research in Uganda and elsewhere in the world have shown that good buildability leads to major cost benefits for clients, designers, and builders (Tindiwensi, 1996; Gray, 1990). Secondly, the achievement of good buildability depends upon both designers and builders being able to see the whole construction process through each other's eyes. This is the biggest problem because it requires expertise in the two aspects by both roles and moreover, the procurement practices do not favour this. Involving people with construction knowledge and experience at the very beginning of the project results in maximizing benefits. It has been shown that the integration of construction knowledge during the planning, design and procurement phases of a project brings extraordinary benefits into the delivery of the project. This is due to the fact that these are the phases in which one is able to influence the overall project the most (Lores, 1997).

To review the design after completion is not a buildability programme. It has to start from the beginning, because it is very difficult to make substantial

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changes in the design once you are through with it. Buildability considerations have to be started at the same time as the initial project planning and should continue during the entire life of the project. In short, buildability optimizes the following elements from start to finish: Overall project planning, Planning and designing, Construction – delivering schedule, Cost and estimate, Construction methods (Russell et al. 1992). The Construction Industry Institute (CII) made many case studies to highlight the importance and the effectiveness of buildability. In one case study (Residence Community in San Antonio, Texas), the resulting savings reduced project costs by approximately 10 percent ($3.5 Million) and enabled the project to be completed on schedule. In another case study (Refinery Expansion), the project was completed 14 months ahead of schedule with a 23 percent ($253 million) savings from the original estimate. A third one; (Arctic Oil Production Facility in Alaska) had a project cost reduction from $3.8 billion to $ 1.4 billion.

II. Need for the Study

Construction projects usually involve heavy total cost. Therefore, time and resources play a vital and critical role in deciding the cost factor of every project. Hence, by doing the job right the very first time, total project cost can be reduced substantially by identifying mistakes, analyzing the situation and solving any problem. The construction industry in Nigeria is one of the biggest industries and any extra cost means huge losses to the contractors and higher expenses to the clients. To avoid such loss in construction rework, extensive research on buildability needs to be conducted to improve the construction process. Buildability in Nigeria is a new concept, and not many studies have been done on this subject. To bring this subject of buildability to light will benefit the owners, constructors and designers; and therefore to consider buildability in their projects could prove highly beneficial in the industry. The need for buildability was not given much importance in the past, in spite of a major development plan in the region. Buildability implementation in the region could be of great importance to achieve overall project cost benefits, as this concept has already been tested and used in many countries around the world and proved to be very effective at optimizing the total cost throughout the project life cycle. Hence, the study aims at determining the extent of occurrence of buildability problems on construction projects, to examine the factors that cause buildability problems and evaluate the level of buildability problems on construction projects in Nigeria.

III. Conceptual Issues on Buildability

Buildability has been used since the beginning of construction and it is not new. People may not have known the term "Buildability" but they used the basic concept of buildability. "In ancient times, the design was dictated by how the project was going to be built, and the design and construction were done by the "Master Builder". The construction was based on traditions, general rules, and the trial and error method (Uhlik and Lores, 1998). Historical facts prove the existence of a buildability concept since long time ago. But the need for development of the concept began to be felt seriously in the construction industry due to great number of problems and difficulties that were faced during the 1960s and 1970s. During this period, the construction industry in many parts of the world declined in efficiency and quality. In 1983, the Construction Industry Institute (CII) was officially established at the University of Texas at Austin. It was an association of owners, contractors, academic institutions, and other construction professionals. The mission of the CII is to improve construction industry cost-ineffectiveness, and provide continuing research in construction. One area of research funded by the CII is the interface between design and construction practices, for which it has designated a Buildability Task Force. Two primary objectives of the buildability task force are to promote the benefits of buildability improvement to industry professionals, and to provide a package of concepts for improving buildability (Kartam, 1996). The benefit of buildability can occur at all stages of project Although, the Pareto Principle dictates that, the earlier in the process that buildability is implemented, the greater will be the potential of time and cost savings and quality improvements. Chen et al (1991) claimed that the implementation of buildability management can lead to significance quantifiable improvements in project performance in terms of time, cost and quality. In addition to the quantifiable measures, buildability management can also lead to qualitative improvements in the project process as well as the building project.

Buildability and buildability programme are two different terms with only a minor change in the meaning. Buildability was early defined in the most simple words as "the ability of construct effectively". In order to effectively construct, integration of construction knowledge, resources, technology and experience into the engineering and design of a project become very essential. To make this process; integration more effective and achievable, a buildability program is applied. A buildability programme is the application of a discipline, systematic optimization of the construction-related aspects of project during the planning, designing, procurement, construction, test and start up phase by knowledgeable and experience construction personnel who are part of the project team. The programme's purpose is to enhance the project's overall objective. Developing a buildability programme for a project results in lower costs, better productivity, earlier project completion and earlier start-up: in short a totally better project (ASCE, 1991). In order to effectively apply a buildability programme, the involvement of experienced construction personnel with the project right from the earliest stage is necessary to ensure the construction focus and experience to properly influence the owners, planners, designers and material suppliers. Such experienced and knowledgeable construction personnel to manage the buildability programme could possibly be staff members of the project owner, a separate construction management firm, the designer, or the constructor.

IV. Research methodology

By looking at the subject from various different angles, and to avoid any potential conflicts and discrepancies in the collected data; general contractors, structural engineers, architects were the only type of parties selected for use in this survey. Other parties were not included in this survey. Sample size consists of a comprehensive list of the entire element in a sample. It has to do with people the researcher intends to contact directly. For this study, the sampling size comprises the 30 numbers of contractor, 30 numbers of engineers and 30 numbers of architects in construction companies in Lagos. Questionnaire was used to collect data of the study. The questionnaire was designed in two sections. The first section, section A was to obtain information about the characteristics of the organization; the second section, section B involved questions on procurement and buildability.

In this research, two methods of data analysis were used: descriptive and statistical analyses. The Relative Occurrence Index (ROI) was used to know the extent of occurrence of buildability problem within a particular period of time on construction sites. The ROI for each occurrence of buildability problem was computed. The likert's scale used was (i = 1-5) where i= 5 is for many time, i = 4 is for three time, i=3 is for two time, i = 2 is for one time, i = 1 is for 0 time. The nearer the ROI to 5, the higher is the degree of occurrence of buildability problem on construction sites. The aggregate importance attached to the various occurrence of buildability problem on construction sites is denoted by ROI.

The Relative Causes Index (RCI) was used to know the degree of each factor that causes buildability problem on construction sites. The RCI for each cause of buildability problem was computed from the analysis of the rating indicated by the respondents. The likert's scale used was (i = 1-5); where i= 5 is for very high causes, i = 4 is for high causes, i=3 is for average causes, i = 2 is for below average causes, i = 1 is for not a cause. The nearer the RCI to 5, the higher is the degree of causes of buildability problem on construction sites. The aggregate importance attached to the various causes of buildability problem on construction site is denoted by RCI.

The Relative Impact Index (RII) was used to know the degree of the each factor that cause buildability problem on construction site. The RII for each impact of causes of buildability problem was computed from the analysis of the rating indicated by the respondents. The likert's scale used was (i = 1-5), where i= 5 is for very high impact, i = 4 is for high impact, i=3 is for average impact, i = 2 is for below average impact, i = 1 is for not an impact. The nearer the RII to 5, the higher is the degree of impact of causes of buildability problem on construction site. The aggregate importance attached to the various impacts of causes of buildability problem on construction site is denoted by RII.

V. Discussion of results

A total number of one hundred (100) questionnaires were administered but fifty- seven (57) questionnaires were retrieved. Table 1 shows the characteristics of the respondents. It shows the general information on the size of the company, year of experience, age, year of experience and sex. The table shows that the respondents, architects were equally engaged in the employment of both medium and large sized firms (50.00%); but the structural engineers were more in the medium sized firm (66.70%) than in the large sized firm (33.30%). The table shows that most of the respondents have been involved in construction works between 6-10 years with an average of about 50.00%. Most of the respondents had bachelors' degrees in related disciplines in construction industry. This indicates that the qualifications, years of experience and sizes of companies of the respondents, averagely medium would give them opportunity to have reliable information on issues related to buildability.

Table 1: Sample Characteristics of the Respondents

Characteristics	Architect		Contractor		Structural Engineer	
Size of Company	Frequency	%	Frequency	%	Frequency	%
Medium	10	50.00	11	57.90	12	66.70
Large	10	50.00	8	42.10	6	33.30
Total	20	100.00	19	100.00	18	100.00
Year of Experience	Frequency	%	Frequency	%	Frequency	%
1-5	4	20.00	0	0.00	3	16.70
6-10	10	50.00	10	52.60	7	38.90
11-15	5	25.00	7	36.80	7	36.80
16-20	1	5.00	2	10.60	1	5.60
Total	20	100.00	19	100.00	18	100.00
Qualifications	Frequency	%	Frequency	%	Frequency	%
HND	13	22.00	1	15.30	8	44.40
B.Sc.	45	72.00	15	78.90	10	55.60
M.Sc.	1	6.00	3	15.80	0	0.00
Total	18	100.00	19	100.00	18	100.00
Age	Frequency	%	Frequency	%	Frequency	%
31-35	6	31.60	3	17.60	3	16.70
36-40	10	52.60	7	41.20	11	61.10
41-45	3	15.80	6	35.30	4	22.20
45-50	0	0.00	1	5.90	0	0.00
Total	19	100.00	17	100.00	18	100.00
Sex	Frequency	%	Frequency	%	Frequency	%
Male	19	100.00	19	100.00	17	100.00
Female	0	0.00	0	100.00	0	0.00
Total	19	100.00	19	100.00	17	100.00

VI. Index of Occurrence of Buildability Problems

Table 2 shows the rate of occurrence of buildability problems among the three classes of respondents selected during the course of the study. The nearer the ROI to 5, the higher is the degree of occurrence of buildability problem on construction sites. The aggregate importance attached to the various occurrence of buildability problem on construction site is denoted by ROI. The table shows that the occurrence of buildability problems was noted to be more at a period of one year with an index value of 4.55, 4.53 and 4.20 among the architects, contractors and structural engineers. Buildability problems occurred least in a period of one week with an index value of 1.10, 1.05 and 1.10 among the architects, contractors and structural engineers respectively.

Table 2: Relative Occurrence Index of Buildability Problems

Occurrence of Buildability Problems	Architects ROI	Ranking	Contractor ROI	Ranking	Structural Engineer ROI	Ranking
One Year	4.55	1	4.53	1	4.20	1
Six months	3.70	2	3.68	2	3.60	2
Three months	3.05	3	2.85	3	2.70	3
One month	2.05	4	2.00	4	1.90	4
One week	1.10	5	1.05	5	1.10	5

VII. Index of Factors That Cause Buildability Problems

The factors responsible for the occurrence of buildability problems were shown in Table 3. The hypothesized factors were analyzed by the use of Relative Causes Index (RCI). The Relative Causes Index (RCI) was used to know the degree of each factor that causes buildability problem on construction sites. From the table, the following causes of buildability problem: 'complexity of the project' (5.00), 'faulty defective of working drawing' (5.00), 'lack of tools and the equipment by the contractors' (5.00), 'incomplete specification' (5.00), 'Lack of construction experience by the client' (5.00), 'budgetary limitation' (5.00), 'non-standardization of design' (5.00), 'resistance of client to buildability programmes' (5.00) are the very high causes of buildability problem. Causes such as 'separate design and construction operation' (4.90), 'lack of awareness of construction technology by designers' (4.90), 'lack of awareness of buildability concept' (4.80), 'poor communication skill' (4.80), 'no documentation of lesson learnt' (4.75) are above the value of high causes of buildability problem and are approximately in value of very high causes of buildability problem.

Causes of buildability problem such as 'adversarial relationship between designers and contractors' (4.00) was within the value of high causes of buildability problem. Causes such as 'construction input is requested too late to be of any value' (3.75), 'Reluctance of contractor to offer pre-construction advice' (3.45), 'discontinuity of key project personnel' (3.45), 'maintenance of stating quotation' (3.30) are above average causes and below high cause but construction input is requested too late to be any of value is approximately in the value of high causes of buildability problem. Causes such as 'no commitment from client' (2.72), 'lack of financial incentive for designer' (2.58), 'lack of mutual respect between designer and contractors' (2.50), 'perception that buildability delay projects' (2.35) are above the value of below average causes but below the value of average causes. They are approximately in the value of average causes of buildability problem. Among the structural engineers, the table shows the following causes of buildability problem: 'complexity of the project' (4.94), 'Lack of tools and the equipment by the contractors ' (4.94), 'incomplete specification (4.94), 'faulty defective of working drawing' (4.94), 'budgetary limitation' (4.94), resistance of client to buildability programmes (4.94) and standardization of design,'(4.94), Poor communication skill (4.94), are very high causes of buildability problem. Causes such as 'Separate design and construction operations' (4.89), 'Lack of awareness of construction technology by designer (4.83), 'lack of awareness of buildability concept' (4.83), 'No documentation of lessons learnt' (4.83), 'Lack of construction experience by the client' (4.50), are above the value of high causes of buildability problem and are approximately in value of very high causes of buildability problem., 'Reluctance of contractor to offer pre-construction advice' (4.11) is below the value of very high causes of buildability problem and are approximately in value of high causes of buildability problem 'construction input is requested too late to be any of value' (3.67) is above the value of average causes of buildability problem and are approximately in value of high causes of buildability problem. Causes of buildability problem such as 'discontinuity of key project personnel' (3.39), Lack of mutual respect between the designers and contractor'(3.33), 'No commitment from client'(3.17),'maintenance of stating quotation' (3.06) are below the value of high causes of buildability problem and are approximately in value of average causes of buildability problem. 'lack of financial incentive for designer' (2.89) is above the value of below average causes of buildability problem and is approximately in value of average causes of buildability problem, 'perception that buildability delay projects' (1.78) is approximately in value of below average causes of buildability problem.

Table 3: Relative Index of Factors that Cause Buildability Problems

Causes of Buildability Problems	Architects RCI	Architects Ranking	Contractor RCI	Contractor Ranking	Structural Engineer RCI	Structural Engineer Ranking
Complexity of the project	5.00	1	5.00	1	4.94	1
Faulty defective working drawing	5.00	1	5.00	1	4.94	1
Lack of tools and equipment by contractors	5.00	1	4.56	11	4.94	1
Incomplete specification	5.00	1	4.95	6	4.94	1
Resistance of client to buildability programmes	5.00	1	5.00	1	4.94	1
Budgetary limitation	5.00	1	5.00	1	4.94	1
Non-standardization of design	5.00	1	5.00	1	4.94	1
Lack of construction experience by the client	5.00	1	4.58	9	4.50	13
Separate design and construction operations	4.90	9	4.95	6	4.89	9
Lack of awareness of construction technology by the designers	4.90	9	4.58	9	4.83	10
Lack of awareness of buildability concepts	4.80	11	4.72	8	4.83	10
Poor communication skills	4.80	11	4.53	12	4.94	1
No documentation of lessons learnt	4.75	13	4.16	14	4.83	10
Adversarial relationship between designers and contractors	4.00	14	4.40	13	2.83	21
Construction input is requested too late						

to be of any value	3.75	15	2.74	20	3.67	15
Discontinuity of key project personnel	3.45	16	4.05	14	3.39	16
Reluctance of contractor to offer preconstruction advice	3.45	16	3.32	16	4.11	14
Maintaining the stating equation	3.30	18	3.11	18	3.06	19
No commitment from client	2.72	19	3.32	16	3.17	18
Lack of financial incentives for designer	2.58	20	2.00	21	2.89	20
Perception that buildability delay projects	2.35	21	1.79	22	1.78	22
Lack of mutual respect between the designers and contractors	2.5	22	2.95	19	3.33	17

VIII. Index of Impact of Causes of Buildability Problems

The Relative Impact Index (RII) was used to know the degree of each factor that causes buildability problem For the architects, Table 4 shows the following impacts of the causes of buildability problem. Complexity of the project has an index value of (5.00), 'resistance of client to buildability programmes (5.00), 'non- standardization of design' (5.00), 'faulty defective of working drawing' (5.00), 'budgetary limitation' (5.00), are very high impact of the causes of buildability problem. Impact of the causes such as 'lack of tools and the equipment by the contractors' (4.95), 'Lack of construction experience by the client' (4.9), 'separate design and construction operation' (4.8), 'incomplete specification' (4.8), 'lack of awareness of buildability concept' (4.8), 'lack of awareness of construction technology by designers' (4.8), 'poor communication skill' (4.8), 'no documentation of lesson learnt' (4.75), are above the value of high impact of the causes of buildability problem and are approximately in the value of very high impact of the causes of buildability problem. Impact of the causes of buildability problem such as 'adversarial relationship between designers and contractors' (4.14), 'construction input is requested too late to be of any value' (3.65), are approximately in the value of high impact of cause of buildability problem. Impact of the causes of buildability problem such as 'discontinuity of key project personnel' (3.45), 'maintenance of stating quotation' (3.30), 'reluctance of contractor to offer pre-construction advice ' (3.25)), are below the value of high impact of the causes of buildability problem and are approximately in the value of average impact of the causes of buildability problem., 'no commitment from client' (2.89), 'perception that buildability delay projects' (2.55), 'lack of financial incentive for designer' (2.50) are above the value of below average impact of causes but approximately in the value of average impact of causes of buildability problem 'lack of mutual respect between designer and contractors' (2.40) is approximately in the value of below average impact of causes of buildability problem.

From the table, the following impact of causes of buildability problem can be seen: 'complexity of the project' (5.00), 'lack of tools and the equipment by the contractors' (5.00), 'resistance of client to buildability programmes' (5.00), 'non- standardization of design' (5.00), 'faulty defective of working drawing' (5.00), 'budgetary limitation' (5.00), are very high impact of causes of buildability problem. Impact of causes such as 'incomplete specification' (4.95), 'separate design and construction operation' (4.89), 'poor communication skill' (4.74), 'no documentation of lesson learnt' (4.71), 'lack of awareness of construction technology by designers' (4.53), 'Lack of construction experience by the client' (4.53), 'lack of awareness of buildability concept' (4.50) are above the value of high impact of causes of buildability problem and are approximately in value of very high impact of causes of buildability problem. Impact of causes of buildability problem 'adversarial relationship between designers and contractors' (4.00), is in the value of high impact of causes of buildability problem. 'discontinuity of key project personnel' (3.95) is above the value of average impact of causes of buildability problem but approximately in value of high impact of causes of buildability problem.. Causes such as: 'reluctance of contractor to offer pre-construction advice ' (3.32), 'maintenance of stating quotation' (3.26) 'no commitment from client' (3.16), 'are below the value of high impact of causes but are approximately in the value of average impact of causes of buildability problem. Impact of causes such as 'lack of mutual respect between designer and contractors' (2.84); 'construction input is requested too late to be of any value' (2.68), 'lack of financial incentive for designer' (2.58) are above the value of below average impact of causes but approximately in the value of average impact of causes of buildability problem. Impact of causes 'perception that buildability delay projects' (2.00) is in the value of below average impact of causes of buildability problem.

From the table above, the following impact of the causes of buildability problem: 'complexity of the project' (5.00), 'resistance of client to buildability programmes (5.00), 'non- standardization of design' (5.00), ' 'budgetary limitation' (5.00), are very high impact of the causes of buildability problem. Impact of the causes such as 'incomplete specification' (4.94), faulty defective of working drawing' (4.94), 'lack of awareness of construction technology by designers' (4.8), 'lack of awareness of buildability concept' (4.83), 'separate design and construction operation' (4.83), 'lack of tools and the equipment by the contractors' (4.80), 'no documentation of lesson learnt' (4.78) are above the value of high impact of the causes of buildability problem and are approximately in the value of very high impact of the causes of buildability problem. 'Lack of construction experience by the client' (4.44), 'construction input is requested too late to be of any value' (3.72), 'construction input is requested too late to be of any value' (3.72) are approximately in the value of high impact of causes of buildability problem. 'adversarial relationship between designers and contractors' (3.44), 'discontinuity of key project personnel' (3.39), 'no commitment from client' (3.11), 'maintenance of stating quotation' (3.06) are below the value of high impact of causes but approximately in the value of average impact of causes of buildability problem. 'lack of financial incentive for designer' (2.94), 'lack of mutual respect between designer and contractors' (2.72) are above below average impact of causes of buildability problem but are approximately in the value of average impact of the causes of buildability problem, perception that buildability delay projects' (1.33) approximately in the value of not an impact of causes of buildability problem.

Table 4: Relative Index of Impacts of Buildability Problems

Causes of Buildability Problems	Architects RCI	Architects Ranking	Contractor RCI	Contractor Ranking	Structural Engineer RCI	Structural Engineer Ranking
Complexity of the project	5.00	1	5.00	1	5.00	1
Faulty defective working drawing	5.00	1	5.00	1	4.94	6
Lack of tools and equipment by contractors	4.95	6	5.00	1	4.80	11
Incomplete specification	4.80	8	4.95	7	4.94	6
Resistance of client to buildability programmes	5.00	1	5.00	1	5.00	1
Budgetary limitation	5.00	1	5.00	1	5.00	1
Non-standardization of design	5.00	1	5.00	1	5.00	1
Lack of construction experience by the						

client	4.90	7	4.53	11	4.44	13
Separate design and construction operations	4.80	8	4.89	8	4.83	9
Lack of awareness of construction technology by the designers	4.80	8	4.53	11	4.89	8
Lack of awareness of buildability concepts	4.80	8	4.50	13	4.83	9
Poor communication skills	4.80	8	4.74	9	5.00	1
No documentation of lessons learnt	4.75	13	4.71	10	4.78	12
Adversarial relationship between designers and contractors	4.14	14	4.00	14	3.44	16
Construction input is requested too late to be of any value	3.65	15	2.68	20	3.72	14
Discontinuity of key project personnel	3.45	16	3.95	15	3	17
Reluctance of contractor to offer preconstruction advice	3.25	18	3.32	16	3.72	14
Maintaining the stating equation	3.30	17	3.26	17	3.06	19
No commitment from client	2.89	19	3.16	18	3.11	18
Lack of financial incentives for designer	2.50	21	2.58	21	2.94	20
Perception that buildability delay projects	2.55	21	2.00	22	1.33	22
Lack of mutual respect between the designers and contractors	2.40	22	2.84	19	2.72	21

IX. Conclusion and Recommendation

From the analysis and interpretation of the result, it was observed that the occurrence of buildability problem is increasing in proportional to the period of time. Hence, the occurrence is increasing in ascending order with period of time (the highest occurrence of buildability problem occurred at period of 1 year and descending from six months, three months one month and lower at one week period of time. The very high causes of buildability problem from the comparison of the result of three different parties of respondent are: complexity of the project, faulty defective of working drawings, resistance of client to buildability programmes, budgetary limitation, non standardization of design which are ranked as 1 by the three different parties. Incomplete specification, separate design and construction operation, lack of awareness of construction technology, lack of awareness of buildability concept, poor communication skill is approximately in the value of very high cause buildability problem. Other causes such as no document of lesson learnt, adversarial relationship between designer and contractor, construction input is request too late to be of any value, discontinuity of key project personnel are between high cause and average causes of buildability problem. Also, from the analysis, interpretation and comparison of three different types of respondents, it can be observed that the causes of buildability that have very high impact on construction site are ranked as 1, namely; complexity of the project, resistance of client to buildability programme, budgetary limitation, non standardization of drawing follow by faulty defective of working drawing, lack of construction experience by the client, separate design and construction, incomplete specification etc.

This research has identified some causes of buildability problems as having very high impact on construction site. The following suggestions if well adhered to could bring about possible reduction in the causes of buildability problem on construction project. The project should not be so complex in a way that leads to buildability problem. Working drawings should be designed by the practicing design experts with construction experience in order to avoid faculty defective of working drawings. Clients should not be resisted to the buildability programme. Sufficient fund must be budgeted for construction work and design must be of the standard one. The specifications should be complete and comprehendible. Both designers and contractors should be aware of construction technology. The parties involved in the construction project should be aware of buildability concepts. The communication skill among the parties involved must be effective. Also, those causes of buildability with high impact on the construction project must be understood by all the parties involved in the construction of the project.

References Références Referencias

1) ASCE, C. M. C. o. t. C. D. (1991). Buildability and buildability programs: White papers. *Journal of Construction Engineering and Management, 117*(1), 67-89.
2) Bamisile, A. (2004). Building Production Management. Foresight Press Limited, Lagos, Nigeria, pp. 23-145.
3) Business Roundtable, Integration Construction Resources And Technology into Enguneering, Report B-1. A Construction Industry Cost Effectiveness Project Report .New York, The Business Roundtable,1982.
4) Chen, S.E., McGeorge, D. and Vernam, B.L. (1991). Report to the Government Architect Construction. New South Wales, Buildability stage 1. Tundra, University of New Castle.
5) CIRIA (1983) Buildability: an assessment. London: Construction Industry Research and Information Association (CIRIA).
6) Construction Industry Institute, Buildability: a Primer, Publ. 3-1, University of Texas at Austin, TX., 1986.
7) Fisher, D.J., and Rajan N. (1996). Automated Buildability: Analyze of Workzone Traffic Control Planning, J. Constr. Engineering and Management, vol, 122, No. 1, March.
8) Gray, C (1990) Buildability; the Construction Contribution. Occasional Paper No. 29, The Chartered Institute of Building, Englemere, Kings Ride, Ascot, UK.
9) Kartam, N.A. (1996). Making Effective use of Construction Lessons Learned in Project Life Cycle. J. Constr. Engineering and Management Vol. 122, No. 1, March. Pp. 14-21.
10) Lores HG.V. Assessment of Buildability Practices among General Contractors in the South East of the United States. Thesis, University of Florida, Gainesville, f.L. 1997
11) Obiegbu, M.E. (2004). Buildability and Maintainability Analysis. The Professional Builder, Journal of the Nigerian Institute of Building, pp. 3-8.
12) Russell, J.S. and Gugel, J.G. (1992). Comparison of Two Corporate Buildability programs. Journal of Construction Engineering and Management, Vol. 119. No 4. Pp. 23-32.
13) .Tindiwensi, D (1996) Steel Structure Buildability Considerations in Developing Countries. Paper to Structural Steel Developing Africa, Conference'96, Sandton, Gauteng, South Africa.
14) Uhlik, F.T., and Lores, G.V. (1998). Assessment of Buildability Practices among General Contractors. Jour. Of Architectural Engineering, Vol. 4 No.3.

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Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page

- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- 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

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- 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:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.
- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- 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.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

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.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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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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