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Quality assessment of 11 KV transformer by internal dissolved gas analysis using CFD

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Abstract: Transformer oil is usually a highly refined mineral oil that is stable at high temperatures and has excellent electrical insulating properties. When high voltages are applied to this insulating material it deteriorates and also with life span .This generates hydrocarbons in the mineral oil. The collection and analysis of gases in an oil insulated transformer was discussed as early as 1928.Many years of empirical and theoretical study have gone into the analysis of transformer fault gases.DGA usually consists of sampling the oil and sending the sample to a laboratory for analysis. On line monitoring of electrical equipment is an integral part of the smart grid. Large power transformers are filled with oil that cools and insulates the transformer winding. Mineral oil is the most common type in outdoor transformers. Fire resistant fluids also used include polychlorinated biphenyls (PCB) and silicone.

INTRODUCTION

Transformer oil is expected to function as an insulating medium and heat transfer agent. The behavior of oil can be related to its molecular composition and physical properties[1]. This paper presents the analysis of various dissolved gases present in the transformer oil and their various characteristics[2] . The insulating liquid is in contact with the internal components. Gases formed by normal and abnormal events within the transformer are dissolved in the oil. By analyzing the volume types, proportions and rate of production of dissolved gases, much diagnostic information can be gathered. Since these gases can reveal the fault of a transformer. In China, online dissolved gas analysis systems with fluorinated ethylene-propylene membranes have been installed in many transformers for measurement of dissolved gases, and this article proposes a method of quickly estimating the gas concentrations well before the permeation equilibrium is reached[3]. For the incipient fault analysis historical data of DGA test is used to calculate transformer health[4].

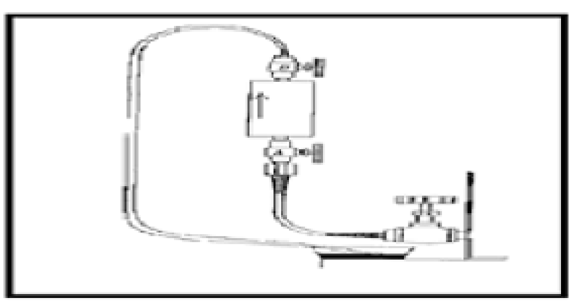

Fig1.DISSOLVED GAS ANALYSIS SET UP

The setup consists of an oil sample tube and glass syringe. Oil sample tube is a gas tight borosilicate glass tube of capacity150ml or 250 ml,having two airtight Teflon valves have been provided with a screw thread which helps in convenient connection of synthetic tubes while drawing sample from transformer. Oil syringe are another means obtaining an oil sample from a transformer. The volume of the syringe has a large range but can be commonly found in the 50ml range. The DGA technique involve extracting or stripping the gases from the oil and injecting them into a gas chromatograph. (GC).Detection of gas concentration usually involves the use of a flame ionization detector (FID)and a thermal conductivity detect(TCD).Most systems also employ a ethanizer,which converts any carbon monoxide and carbon dioxide present into methane so that it can be burned and detected on the FID,a very sensitive sensor.

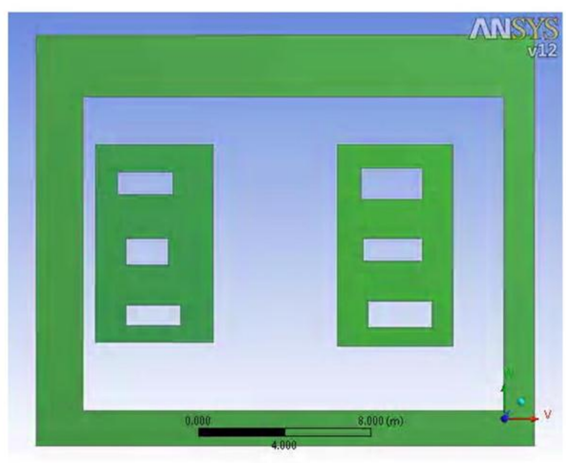

Fig2. TRANSFORMER MODELING WITH CFD

SL NO	Name of Gases	Permissible limits as per DGA	SEB NORMS FOR DGA		
			<4 Years	4 to 10 Years.	>10 Years
1	Acetylene (C_2H_2)	150 PPM	30PPM	50PPM	150PPM

2	Ethylene (C_2H_4)	400 PPM	150PPM	200PPM	400PPM
3	Methane (CH_4)	300PPM	69PPM	150PPM	300PPM
4	Hydrogen (H_2)	300PPM	150PPM	150PPM	300PPM
5	Ethane (C_2H_6)	1000PPM	50PPM	150PPM	1000PPM
6	$C0_2$	12000PPM	5000PPM	5000PPM	12000PPM
7	CO	700PPM	300PPM	500PPM	700PPM

Temperature at which these gases evolve generate in the Transformer: Methane (CH_4)>120^0C
Ethane (C_2H_6)>120^0C
Ethylene (C_2H_4)>150^0C
Acetylene (C_2H_2)>700^0C

IEC 599 Code for analysis of Transformer oil

Ratio of Gases	C_2H_2/C_2H_4	CH_4/H_2	C_2H_4/C_2H_6
<0.1	0	1	0
<0.1to 1	1	0	0
1 to 3	1	2	1
>3	2	2	2

Sr .No.	Faults	C_2H_2/C_2H_4	CH_4/H_2	C_2H_2/C_2H_6
1.	No fault	0	0	0
2.	Partial discharge of low density	0	1	0
3.	Partial discharge of high density	1	1	0
4.	Discharge of low energy	1-2	0	1-2
5.	Discharge of low energy	1	0	2
6.	Thermal fault lowtemperatue < 150^0C	0	0	1
7.	Thermal fault of temperature 300^0C to700^0C	0	2	1
8.	Thermal fault of Temp>700^0C	0	2	--

The analysis of above can be as under:

1 .For sr.no.1:- It indicates normal aging.
2. For sr.no.2:-Discharge in gas filled cavities results from incomplete impregnation or super-saturation or cavities or high humidity.
3. For sr.no.3:-As above but leading to tracking or perforation of solid insulation.
4.For sr.no.4:-Continuous sparking in oil between bad conditions of different potential or to floating potential. Breakdown of oil between solid materials.
5. Forsr.no.5:-Discharge with power flow through arcing breakdown of oil between windings or coils or between coils to earth. Selector breaking current.
6. For sr.no.6:-General insulation overheating.
7.For sr.no.7,8&9:-Localoverheatingofcore due to concentration of flux. Increasing hot spots in core shorting links in core, over heating of copper due to eddy currents. Bad contacts/joints (Pyrolitic carbon formation) upto core and tank circulating currents.

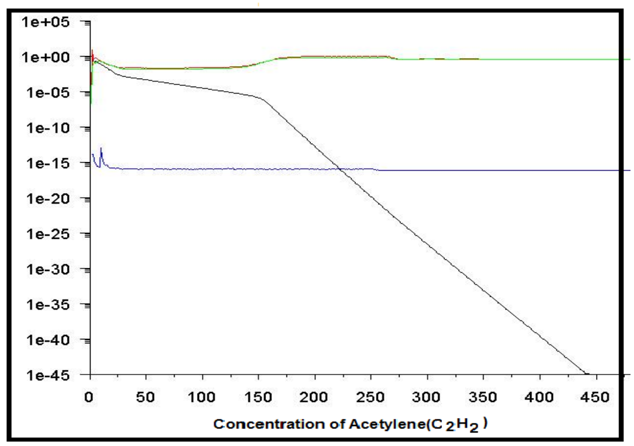

Fig3.Pressure,density and the temperature behaviour of Acetylene(C_2H_2) is shown in the figure:-

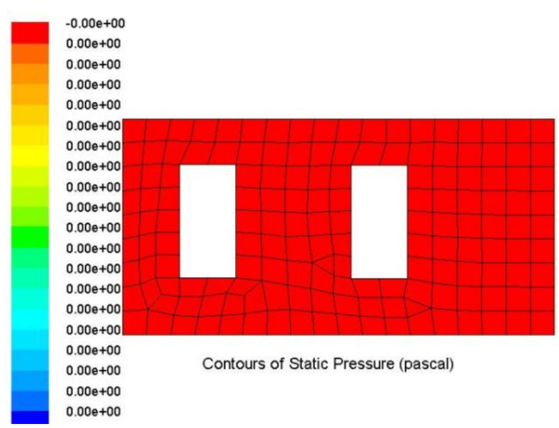

Fig4.Contour of static pressure of Acetylene(C_2H_2)

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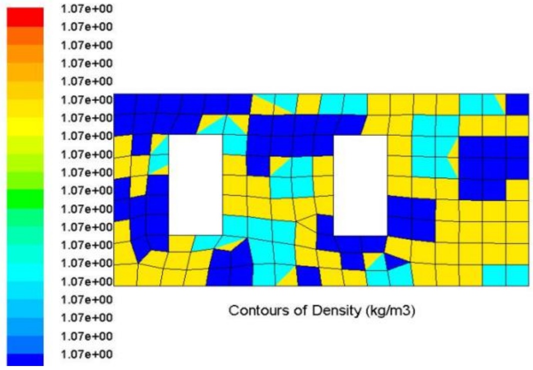

Fig5.Contour of density of acetylene(C_2H_2)

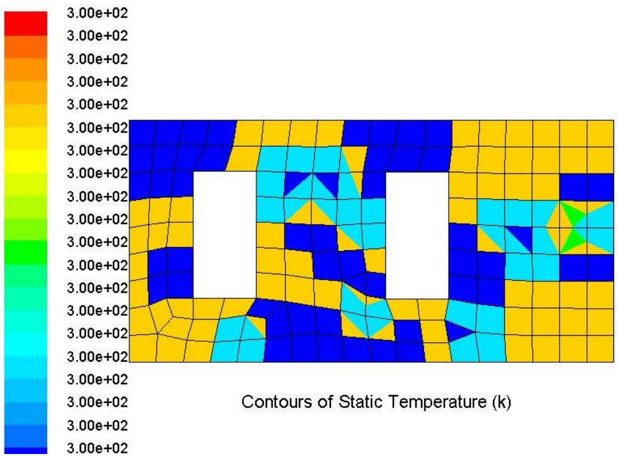

Fig6.Contour of static temperature of acetylene(C_2H_2)

Fig6.Pressure,density and the temperature behaviour of ethylene is shown in the figure:-

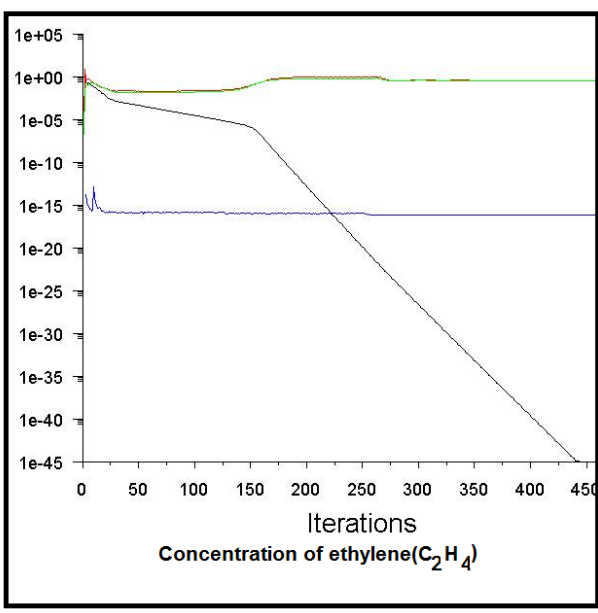

Fig7.Concentration of ethylene (C_2H_4)

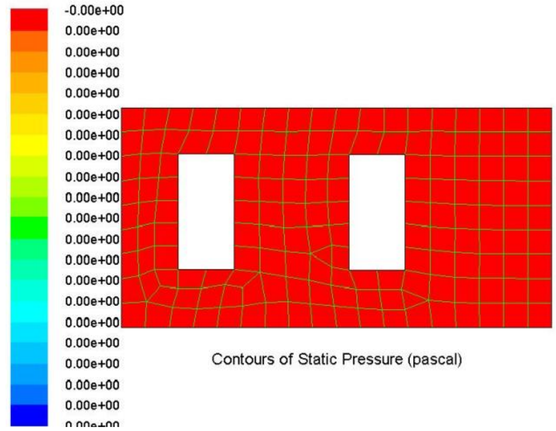

Fig8.Contours of static pressure of ethylene(C_2H_4)

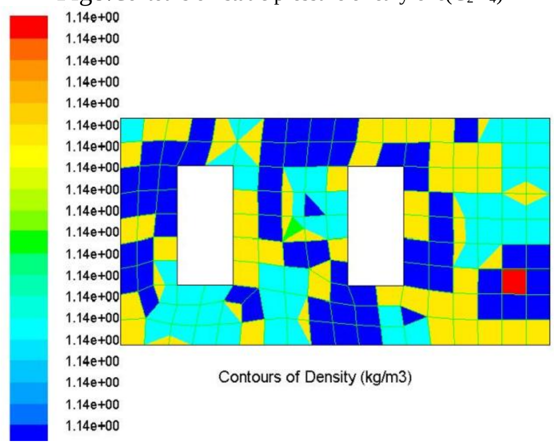

Fig9.Contours of density of ethylene(C_2H_4)

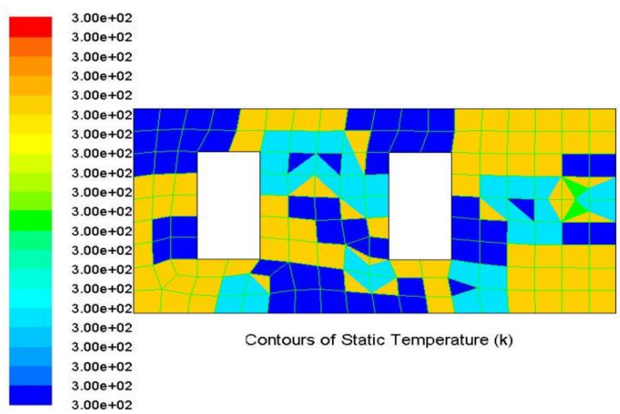

Fig10.Contours of static temperature of ethylene(C_2H_4)

Fig11.Pressure,density and the temperature behaviour of methane(CH_4) is shown in the figure:-

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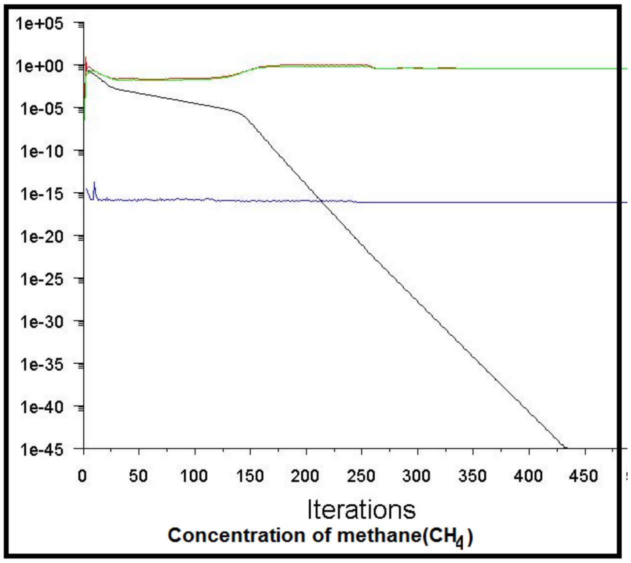

Fig12.Concentration of methane(CH_4)

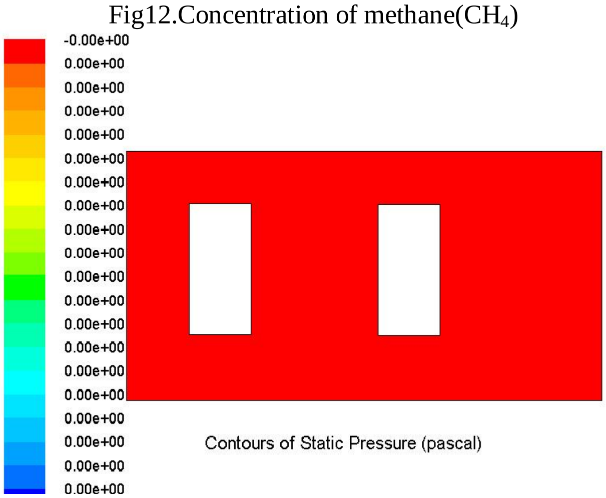

Fig13.Contours of static pressure of methane(CH_4)

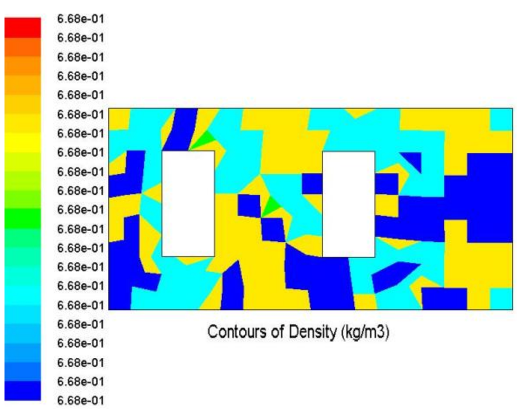

Fig14.Contours of density of methane (CH_4)

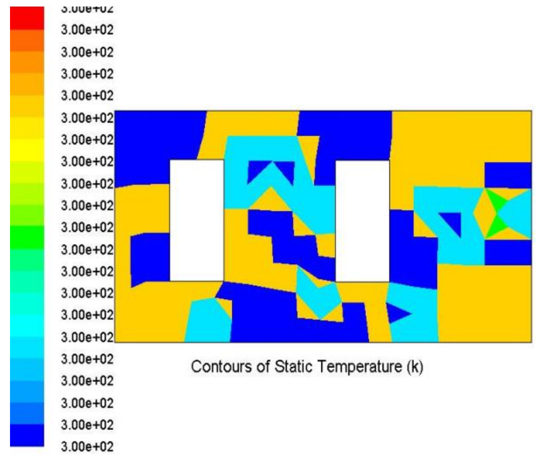

Fig15.Contours of static temperature of methane(CH_4)

Fig16.Pressure,density and temperature behaviour of Carbon dioxide (CO_2) is shown in figure

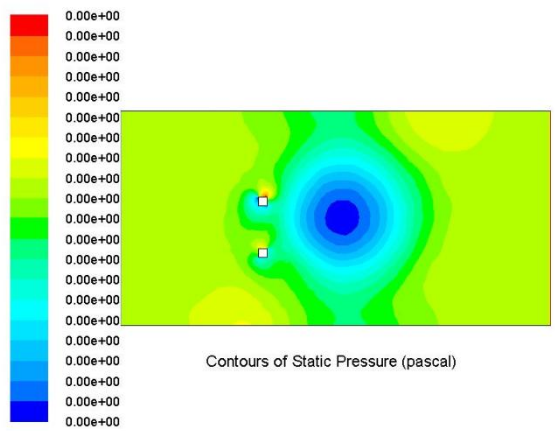

Fig17. Contours of static pressure of carbon di oxide(Co_2)

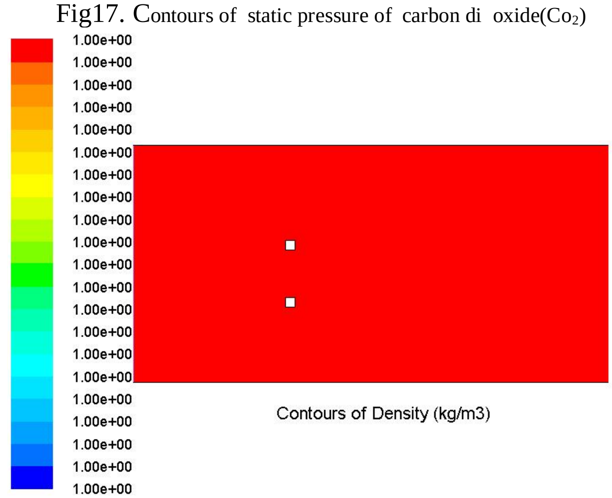

Fig18. Contours of density of carbon di oxide(Co_2)

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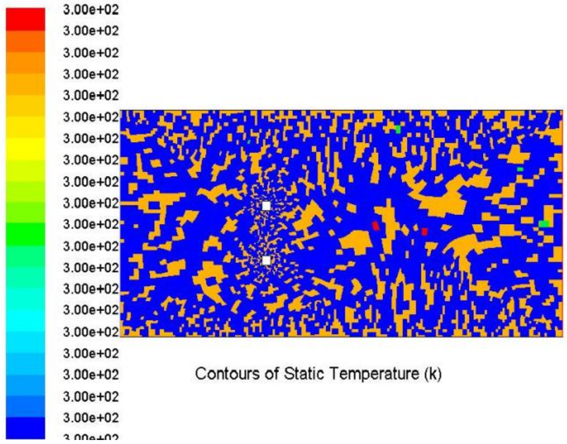

Fig19. Contours of static temperature of carbon di oxide(Co_2)

Fig20.Pressure,density and temperature behaviour of Carbon monoxide (CO) is shown in figure

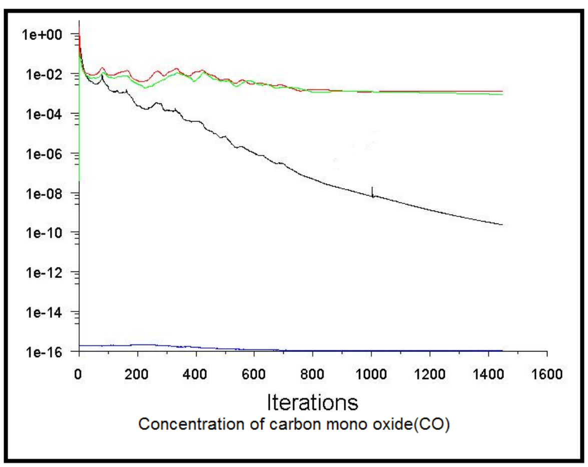

Fig21.Concentration of carbon mono oxide(co)

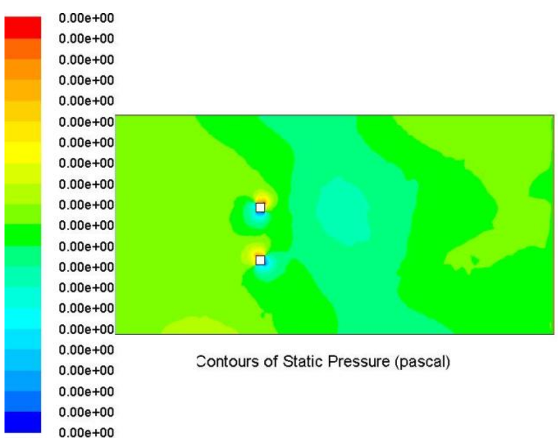

Fig22.Contours of static pressure of carbon mono oxide(CO)

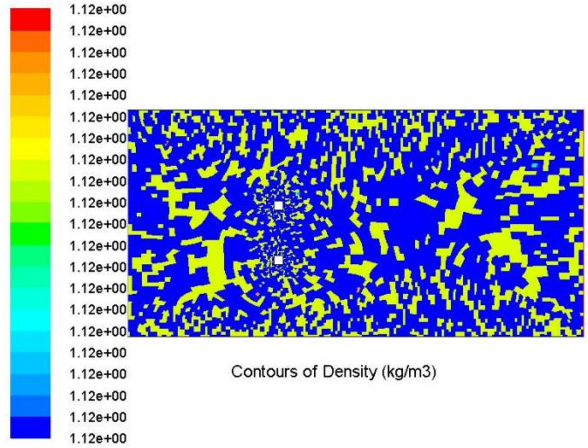

Fig23. Contours of density of carbon mono oxide(CO)

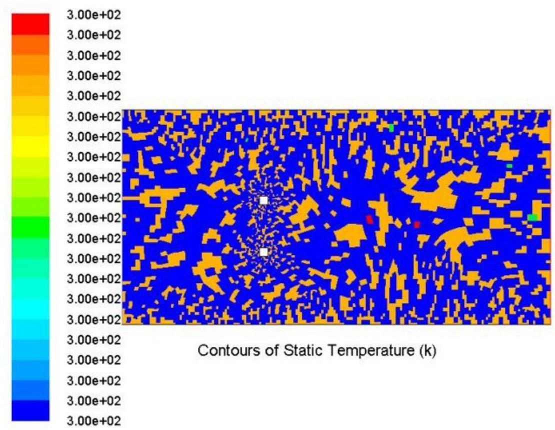

Fig24. Contours of static pressure of carbon mono oxide(CO)

Analysis

When severe fault occurs in transformers there are several gases that are created like carbon monoxide (CO) and carbon dioxide(CO_2),acetylene,ethylene,methane and ethane. The leakage and diffusion accident of inflammable and explosive toxic gas has become a serious problem in the field of environment and security[5].

From these gases the type of fault,their localise zone that also be detected.From the CFD(ANSYS)analysis the pressure,density and temperature behavior of each gases are ploted.The concentration behavioor followes the rule of VIBGYOR.

From the density of carbon di oxide(CO_2), carbon monoxide (CO),the carbon particles are detected and their concentration zone also be detected.These carbon particles causes arcing when any fault occur in transformer.The concentration of methane ,ethylene are at higher levels and acetylene are at low level.These are detected by these gases. The transformer condition information and the life estimation of oil can also be detected in a low cost way [6].

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CONCLUSION

The quality or useful life of the transformer oil depends on the rate of growth various dissolved gases and therefore on the operationg condition.The deviation in useful life due to changes from field operating conditions(new sample) to nominal operating condition(new sample) yields the measure of degradation in quality of the dielectric.The method helps in knowing in advance the useful life of the costly high voltage eqipments and therefore ensure economy in maintenance.

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BIOGRAPHIES

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Mithu Mukherjee completed her B.E degree 2004 from BIET,Suri West Bengal, India. She obtained her M.Tech degree in 2007 from National Institute of Technology, Durgapur, West Bengal,India both in Electrical Engineering. She was former assistant professor in Electrical Engineering of BIET,Suri,West Bengal,presently working as lecturer in Electrical Engineering at Sree Ramkrisna Silpa Vidyapith(Govt.Polytechnic). She has published several articles in international and national journals. He has also presented a number of research papers in various conferences in India. He has eight years of teaching experience in engineering colleges.