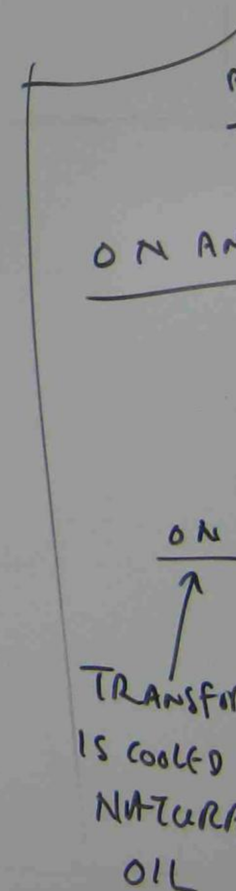
RATING AND COOLING OF TRANSFORMERS

SMALL TRANSFORMERS CAN BE COOLED BY NATURAL AIR. BUT LARGE POWER TRANSFORMERS UTILIZES A GREAT AMOUNT OF ELECTRICAL POWER AND DISSIPATES ENORMOUS HEAT.

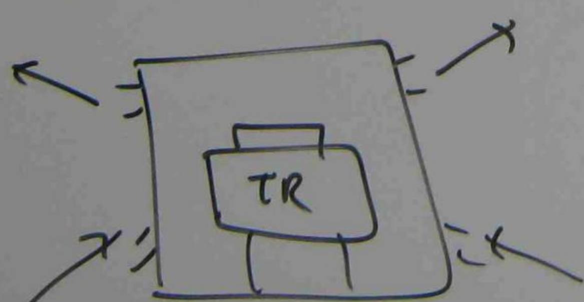
FORCED AIR COOLING (OR) FORCED OIL COOLING METHODS ARE UTILIZED FOR LARGE POWER TRANSFORMERS.



QUESTIONS

(4) SKETCH THE FOLLOWING COOLING ARRANGEMENTS

AN, AF, ONAN, OFAF, ONAF, OFWF



AN - NATURAL AIR COOLING

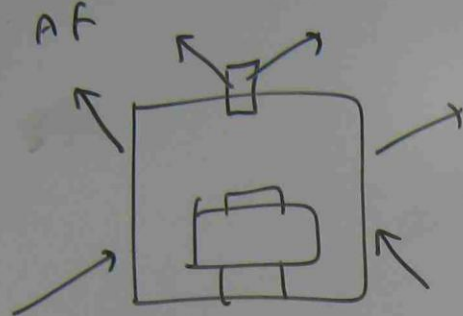
TRANSFORMER IS COOLED BY NATURAL AIR

BUT LARGE POWER

L POWER AND

ODS ARE UTILIZED

AF



AF - FORCED AIR COOLING.

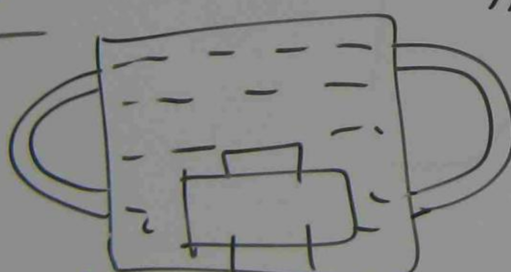
AIR IS FORCED IN TO TRANSFORMER TO COOL WINDING AND CORE.

OFAF

OIL IS FORCED TO CIRCULATE IN TO TRANSFORMER.

THEN THE OIL IS COOLED BY FORCED AIR

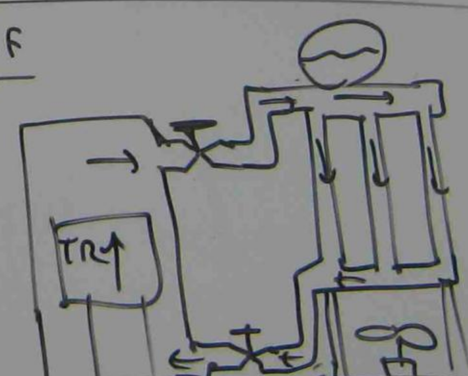
ON AN



ON ← TRANSFORMER IS COOLED BY NATURAL OIL

AN ← THEN THE OIL IS COOLED BY NATURAL AIR

ON AF



TRANSFORMER IS COOLED BY NATURAL OIL. THEN OIL IS COOLED BY FORCED AIR

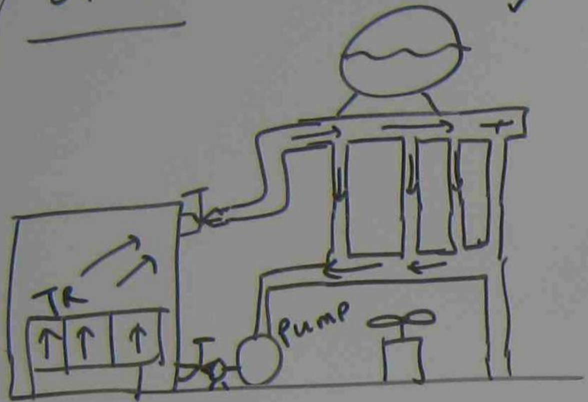
OF

OI

THE

WH

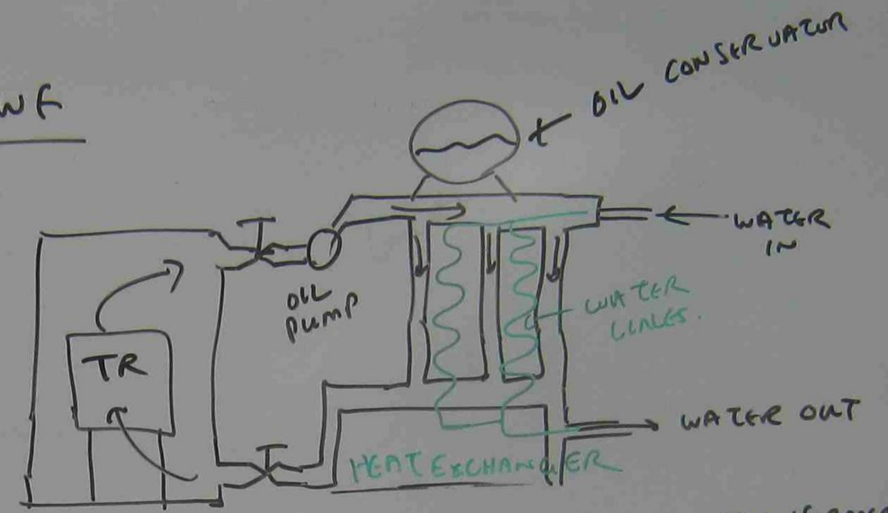
OFAF



OIL IS FORCED TO CIRCULATE IN TO TRANSFORMER.

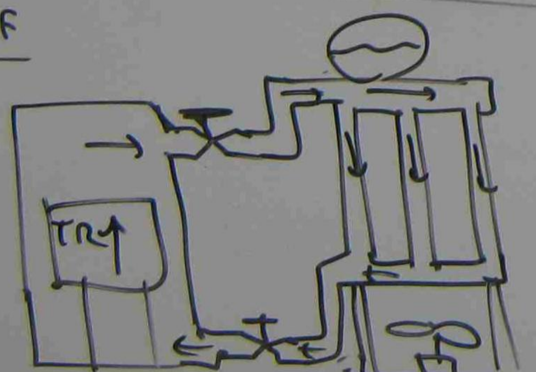
THEN THE OIL IS COOLED BY FORCED AIR

OFWF



OIL IS PUMPED AND CIRCULATED IN TRANSFORMER THEN HOT OIL IS COOLED BY COOLING WATER WHICH IS PUMPED IN TO AND CIRCULATED IN HEAT EXCHANGER

ON AF



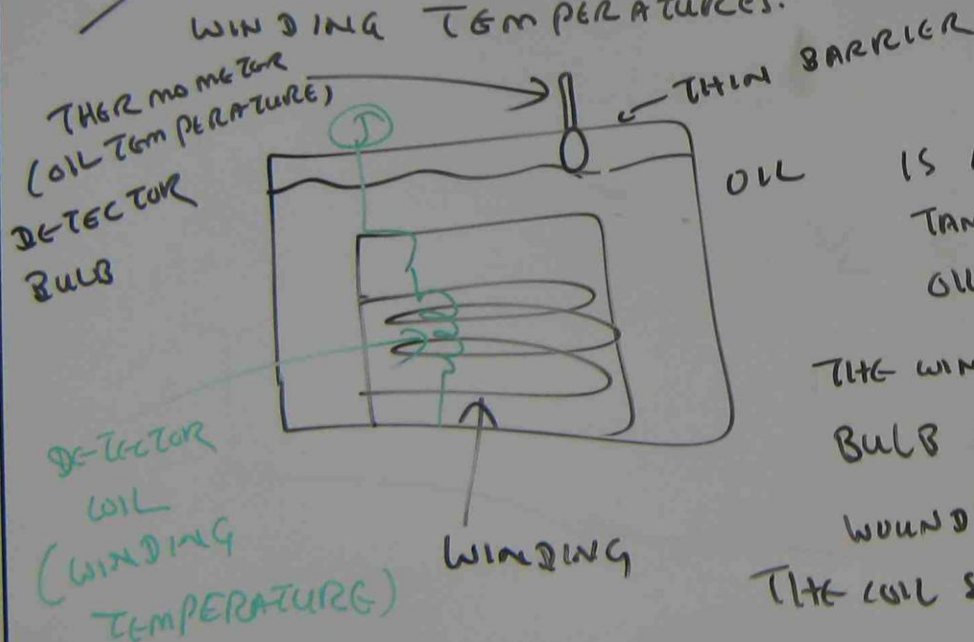
TRANSFORMER IS COOLED BY NATURAL OIL. THEN OIL IS COOLED BY FORCED AIR

Q5 DESCRIBE THE IMPORTANCE OF MEASUREMENT OF TRANSFORMER TEMPERATURE.

TEMPERATURE IS THE PRIME FACTOR IN DETERMINING THE ECONOMIC LIFE OF A TRANSFORMER. IT IS THEREFORE IMPORTANT

TO KNOW THE MAXIMUM OIL AND WINDING TEMPERATURE AT WHICH A TRANSFORMER OPERATES SO AS TO BE ABLE TO PROVIDE TEMPERATURE CONTROL AND TO ISOLATE THE TRANSFORMER IN CASE OF EXCESSIVE TEMPERATURE

Q8/ BRIEFLY DESCRIBE THE METHODS USED IN MEASURING OIL AND WINDING TEMPERATURES.



A TEMPERATURE DETECTOR BULB IS INSTALLED AT THE TOP OF OIL TANK. THE DETECTOR BULB SENSES OIL TEMPERATURE.

THE WINDING TEMPERATURE DETECTION BULB IS INCLOSED IN HEATING COIL WOUND ON INSULATED FORMER. THE COIL SENSES WINDING TEMPERATURE

Q7 DESCRIBE THE CONSTRUCTION AND USE OF DRY TYPE TRANSFORMER

DRY TYPE TRANSFORMERS ARE USED IN THE UPPER FLOORS OF OFFICE BUILDING WHERE FIRE RISK IS OF PARTICULAR CONCERN.
THE CORE AND WINDING OF A DRY TYPE TRANSFORMER ARE IMMERSED IN AIR (OR) GAS WITH NATURAL (OR) FORCED CIRCULATION

Q8 LIST TWO TYPES OF WINDINGS USED IN DRY TYPE TRANSFORMER.

- OPEN WINDING
- ENCAPSULATED WINDING

Q9 LIST THE REQUIREMENTS FOR THE OIL IN OIL IMMERSED TRANSFORMERS.

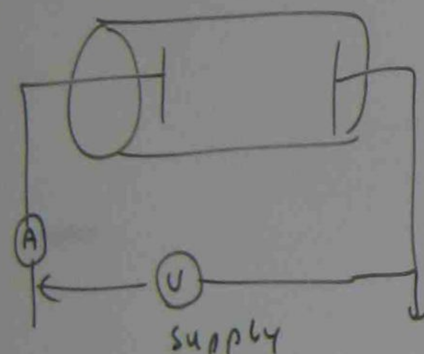
- LOW VISCOSITY SO THAT HEAT CAN BE TRANSFERRED READILY FROM TRANSFORMER TO COOLING SURFACE
- HIGH FLASH POINT
- LOW ACIDITY / LOW SLUDGE
- SATISFACTORY INSULATOR

Q10 LIST THE IMPORTANT CHARACTERISTICS FOR OIL TESTING.

- HIGH ELECTRIC STRENGTH
- NO WATER CONTENT
- LOW LOSS TANGENT
- HIGH RESISTIVITY
- LOW ACIDITY
- LOW SLUDGE
- HIGH FLASH POINT

Q11 DESCRIBE BRIEFLY THE TESTS FOR THE CHARACTERISTICS LISTED IN QUESTION (10).

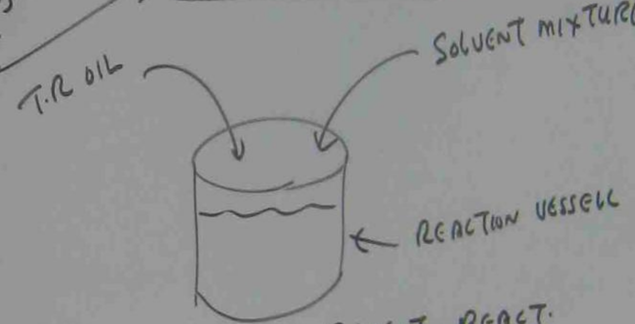
ELECTRICAL STRENGTH



$$R_{ESISTANCE\ OF\ OIL} = \frac{V}{I}$$

WATER CONTENTS

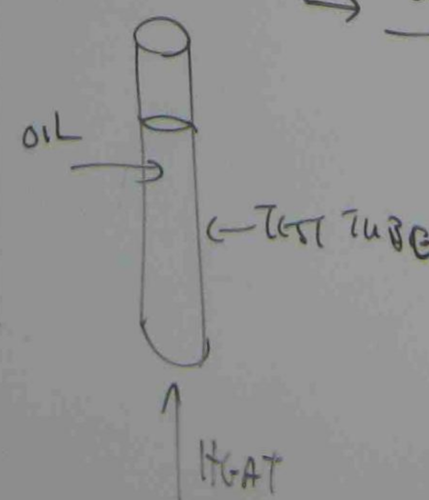
KARL FISHER METHOD



- LET OIL AND SOLVENT REACT.
- FIND THE RATE OF REACTION → CAN KNOW WATER CONTENTS

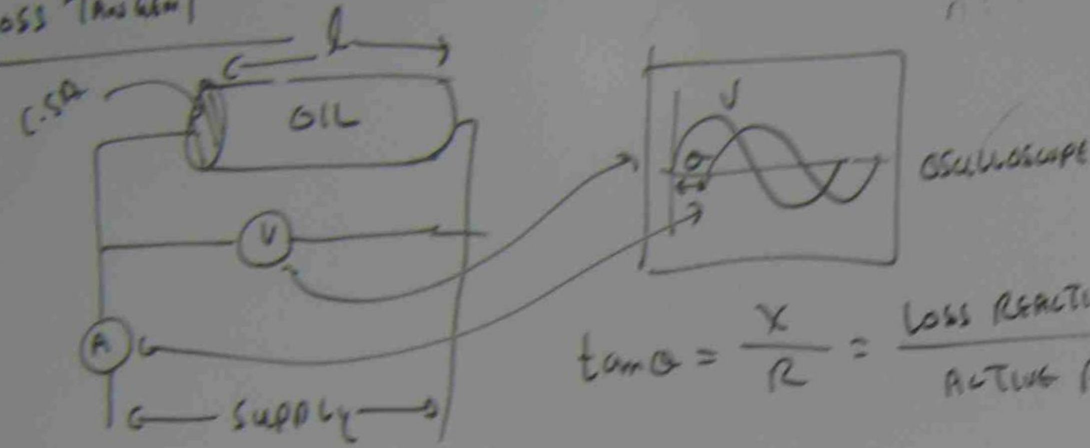
CRACKEL TEST

LISTEN THE AUDIBLE CRACKEL



AUDIBLE

LOSS TANGENT



$$\tan\theta = \frac{X}{R} = \frac{\text{LOSS REACTIVE POWER}}{\text{ACTIVE POWER}}$$

θ SHOULD BE INFINITY

LOSS TANGENT ALSO REPRESENTS THE LOSS OF DIELECTRIC STRENGTH

RESISTIVITY

$$R = \frac{V}{I} \longrightarrow R = \frac{\rho L}{A}$$

ρ = RESISTIVITY

L = LENGTH OF TUBE

A = C.S.A OF TUBE

SLUDGE

HEAT OIL UNTIL SLUDGE IS FORMED

FIND PERCENTAGE OF SLUDGE IN OIL VOLUME

FLASH POINT

HEAT OIL UNTIL FLASH HAPPENS.

NOTE FLASH POINT TEMPERATURE

ACIDITY

POTASSIUM HYDROXIDE (K.OH) BASE

FIND THE VOLUME OF KOH TO NEUTRALIZE THE OIL

H_2SO_4 HCL HNO_3

NaOH

KOH

$2NaOH + H_2SO_4 = 2NaSO_4 + 2H_2O$

Sludge

Q12 DESCRIBE DISSOLVED GAS ANALYSIS (DGA) OF INSULATING OIL.

T/R INSULATION OIL →
- HYDROGEN (H_2)
- METHANE (CH_4)
- ETHANE C_2H_6
- ETHYLENE C_2H_4
- ACETYLENE C_2H_2

DISSOLVED GAS ANALYSIS (D.G.A) OF INSULATION OIL IS USED BY MOST MAJOR SUPPLY
AUTHORITIES IN AUSTRALIA, UK, EUROPE AND USA MONITORING LARGE POWER TRANSFORMERS
IEC NO. 567 & 599 DESIRIBES THE PROCEDURES FOR CARRYING OUT AND
INTERPRETING D.G.A

THE INSULATION OIL DISSOLVES TO H_2, CH_4, C_2H_6, C_2H_4, C_2H_2
THE RATIO METHOD IS TO ANALYZE THE RATIO OF THE GASES TO DIFFERENTIATE
TYPE OF FAULTS : 3ϕ SHORT CIRCUIT, 1ϕ SHORT CKT, 2ϕ SHORT CIRCUIT, L→G FAULT
OVERLOAD, ARCING, DISCHARGE.

P) AN INDUSTRIAL PLANT DRAWS 100 Amp AT 0.7 P.F LAGGING FROM THE SECONDARY OF A 2300/230 V 60 KVA YΔ DISTRIBUTION TRANSFORMER BANK.

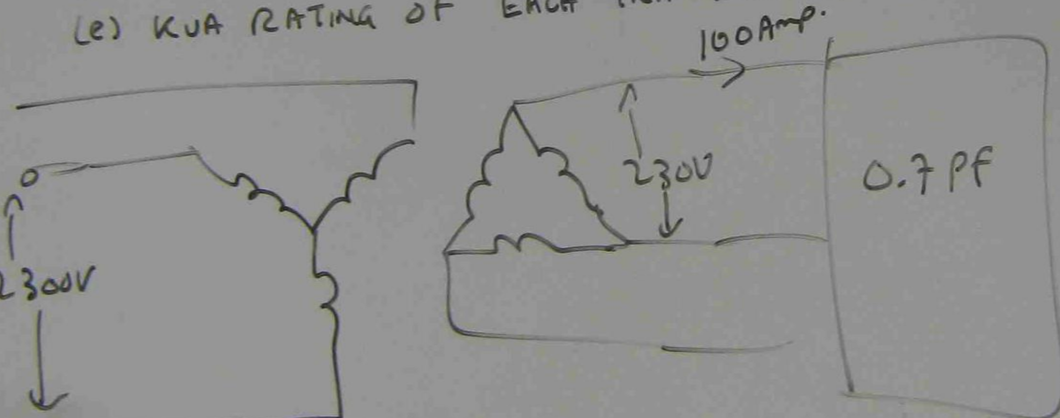
CALCULATE (a) POWER CONSUMED BY THE PLANT IN KW AND APPARENT POWER IN KVA

(b) RATED SECONDARY PHASE AND LINE CURRENTS OF TRANSFORMER BANK

(c) PERCENTAGE LOAD ON EACH TRANSFORMER

(d) PRIMARY PHASE AND LINE CURRENT DRAWN BY EACH TRANSFORMER

(e) KVA RATING OF EACH TRANSFORMER



60KVA

(a) $P_T = \sqrt{3} V_L I_L \cos\phi$

$= 1.7321 \times 230 \times 100 \times 0.7$

$= 27900 W$

$= 27.9 kW$

$KVA = \frac{kW}{P.F} = \frac{27.9}{0.7} = 39.8$ KVA

(b) I_{p_2} RATED $= \dfrac{KVA/3}{V_{ph}} = \dfrac{60/3}{230} = \dfrac{20\times10^3}{230} = 87$ Amp

$I_{L_2} = \sqrt{3}\, I_{p_2} = 1.732 \times 87 = 150.6$ Amp.

(c)

$\%$ LOAD $= \dfrac{\text{LOAD CURRENT (LINE)}}{\text{TRANSFORMER RATED CURRENT (LINE)}} \times 100 = \dfrac{100}{150.6} \times 100 = 66.4\%$

(d) $\dfrac{I_{p1}}{I_{p2}} = \dfrac{E_{ph2}}{E_{ph1}}$

$\dfrac{I_{p1}}{100/\sqrt{3}} = \dfrac{230}{2300/\sqrt{3}}$

$\dfrac{I_{p1}}{100} = \dfrac{1}{10}$

$I_{p1} = \dfrac{100}{10} = 10$ Amp.

$I_{L_1} = I_{p1} = 10$ Amp.

(e) KVA RATING OF EACH TRANSFORMER $= \dfrac{60}{3}$

$= 20$ KVA

TYPES OF 3ϕ TRANSFORMERS THAT MAY BE PARALLELED

0° PHASE SHIFT		30° PHASE SHIFT	
YY $\rightarrow$ Yy_0	0°	$\Delta Y \rightarrow Dy_{11}$	30°
$\Delta\Delta \rightarrow Dd_0$	0°	$Y\Delta \rightarrow Yd_{11}$	30°