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Synthesis And Characterization Of Transformer Oil -Nano Fluids And Comparative Study On The Effect Of Nanoparticles On Chemical And Physical Properties

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Abstract:

Transformer Oil Is An Oil Used For Insulation Which Is Said To Be The Life Of The Transformer. Nanotechnology Has Gained Significant Attention In All Fields. Nano Based Fluids Are The Best Alternative Source For Traditional Transformer Oil Due To The Excellent Physical, Chemical And Electrical Properties. This Study Deals With The Synthesis Of Transformer Oil-Nano Fluids By Using Zno Nanoparticles. These Nano Based Fluids Are Characterized By Sem And Edax Studies. Comparative Study Of Effect Of Nanoparticles On Chemical Parameters, Acid Number (Tan), Moisture Content And Physical Parameters, Viscosity, Density Were Carried Out By Using Standard Procedures. From The Results It Can Be Concluded That The Transformer Oil Based Nano Fluids Comprehensively Improve The Chemical And Physical Properties.

KeyWords*: Transformer Oil, Nano Based Fluids, Zno Nanoparticles, Sem And Edax*

Introduction:

The Responsibility Of Electrical Power System Has To Be Increased To Meet A Continuous Support Of Consumption Of Energy. Nowadays, The Present Power Transmission Systems Should Be Enhanced To High Power Transmission Capacities Without Compromising The Reliability Which Mainly Affects The Transformer And Power Equipment [1]. Transformer Oil Is An Oil Used For Insulation Which Is Said To Be The Life Of The Transformer And Also Acts As A Coolant. The Wide Application Of Mineral Oil For High Voltage Insulation System And Power Apparatus Cooling Has Prompted Vast Research Work Proposed To Improve Both The Physical And Chemical Characteristics Through Nanotechnology After Significant Research Progress In Nano Dielectrics [2]. Nanotechnology Has Gained Significant Role And Importance In All Fields. Nano Fluids Are The Best Alternative Source For Traditional Transformer Oil Due To The Excellent Physical, Chemical And Electrical Properties. In Advanced Systems, Materials Which Are In Nano Size Are Used For Improving The Characteristics Of Fluid Became A Thrust Area Of Research [3]. The Present Study Deals With The Preparation Of Transformer Oil-Nano Fluids, The Analysis Of Chemical And Physical Properties Such As Acid Number (Tan), Moisture Content, Viscosity, Density Were Carried Out In Selected Transformer Oils And Its Comparison With Nano Fluids. These Nano Fluids Are Characterized By Spectral Studies Sem, Edax And Xrd. Two Types Of Transformer Oils Are Paraffin Based And Naphtha Based Transformer Oils [4]. Paraffin Based Oils Were Selected For The Study. The Parameters Are Analyzed For Both The Five Unused And Two Used Oil Samples. The Experimental Values For The Above Parameters Were Compared With The Standard Values And As Well As With The Values Of Nano Fluids.

Materials And Methods:

Preparation Of Nano Fluids:

Nano-Fluid Can Be Prepared By Single - Step Or Two - Step Methods, To Get Better Yield Two - Step Method Is Followed [5]. About 5.7476g Of Zinc Sulfate Heptahydrate Crystals Were Weighed Accurately And Made Upto 200 Ml In A Standard Measuring Flask Using Deionized Water. A Definite

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Volume (25 Ml) Of The Made Up Solution, Deionized Water (25ml) And Sodium Hydroxide (25 Ml) Were Taken In A 250 Ml Beaker And Allowed To Vigorous Stirring By Using Magnetic Stirrer And 50-60 ºc Temperature Was Maintained. The Precipitate Was Filtered And Washed By Ultrasonic Centrifugation Method Using Deionized Water. Finally The Precipitate Was Dried [6]. The Desired Concentrations Of Nano Particles Were Allowed To Suspend In The Sample Transformer Oils To Develop Nano Fluids. All The Prepared Nano Fluids Were Kept In The Muffle Furnace For 24 Hours To Overcome The Disadvantages Of Micro Bubbles Formation [7]. The Synthesized Nano Particles Are Characterized By Sem, Edax And Xrd [8].

Chemical Analysis:

Acid Number (Tan):

Acid Number Is Expressed By The Amount Of Potassium Hydroxide In Mg Required To Neutralize The Free Fatty Acid In 1g Of Oil Sample. To Find Out The Total Acidity Different Methods Like Potentiometric And Color Indicating Titrations Are Used. Quantitative Estimation Of Acid Number For The Transformer Oils Under Study Is Performed By The Volumetric (Color Indicating) Titration Method [9].

Moisture Content:

Karl Fisher Titration Is Commonly Used Analytical Method For Quantifying Moisture Content. The Main Principle Of The Karl Fisher Titration Is Iodine-So_2 Reaction In Aqueous Medium [10]. The Mixture Of Primary Alcohol, Base And The Sulfur Dioxide Is Known As Kf Reagent. The Oxidation Reaction Consumes Water And The Consumption Ratio Of Water And Iodine Is 1:1. The Quantity Of Moisture Content Is Estimated By Iodine Generation During The Titration. Coulometry Is Suited For Samples Which Possess From 1 Ppm To 5% Level.

Physical Analysis:

Viscosity:

It Is A Quantity That Express The Magnitude Of Resistance To Flow. It Also Depends On Shape, Size And Attractions Of The Particles [11]. It Is Measured In Pascal Seconds. Rotational Viscometry Procedure Is Followed To Determine Viscosity Of The Transformer Oils. Shear Dependent Behavior Of The Sample Which Is Detected By Rotating The Spindle At Several Different Speeds.

Density:

Density Of A Material Is Defined As Its Mass Per Volume. $\rho = m/v$. Paraffinic Oil Has A Lower Density Implying A Decreased Tank Weight Of A Specific Volume [12]. Density Of The Fluid Is Measured By The Density Meter. The Density Meter Is Based On The Oscillating U Tube Technique. In The U Tube The Sample To Be Measured Is Filled Which Is Induced To Vibrate. The Eigen Frequency Of The Oscillation Of The U Tube Is Influenced By The Mass And Therefore By The Density Of The Sample.

Results & Discussion:

Characterization Of Nano Fluids:

Sem:

Scanning Electron Microscopy Produce Various Signals Which Have The Information About Topography And The Composition Of The Sample. In Scanning Electron Microscope The Electrons Interact With The Atoms In The Sample. The Result Of Scanning Electron Microscope (Sem) Represents That The Nano Fluids Are In Flakes Like Shape [13]. Figure: 1 Is The Sem Image For The Nano Fluid.

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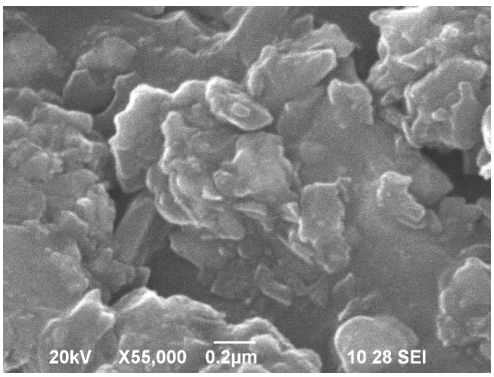

Figure:1 The Sem Image For Nano Fluid

Edax:

Energy-Dispersive X-Ray Spectroscopy Is A Technique Relies On An Interaction Of X-Ray Source With A Sample. In Order To Identify The Elements Edax Analysis Was Performed. During The Edax Measurement Different Areas Were Focused And The Corresponding Peaks Are Shown [14] In Figure:2. In Spectrum The Quantity Of Zn, Na, S And O Were 8.94, 38.06, 7.19 And 45.82% Respectively.

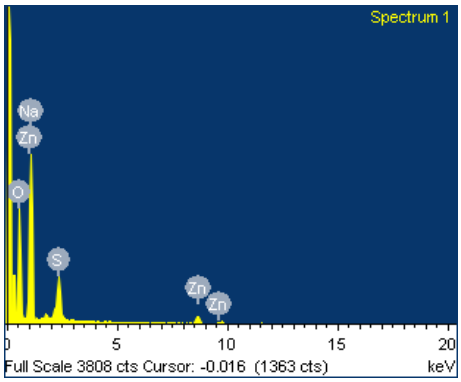

Figure: 2 The Edax Spectrum For Nano Fluid

Xrd:

It Is The Experimental Technique Used To Determine The Atomic And Molecular Structure Of A Crystal. Xrd Pattern Of Nano Fluid (Figure:3) Shows That The Diffraction Peaks Appear At 23.58º; 25.59 º; 32.27 º; 30.29 º; 34.69 º; 36.50 º; 47.40 º; 48.20 º; 52.15 º. From The Results, It May Be Noted That The Pattern Has Good Agreement When Compared To That Of The Standard Zno With The Reference To Jcpds Card No. 36-1451 (Figure: 4) [15]. Xrd Pattern Confirmed The High Crystalline Character Of Zno Due To The Presence Of Strong And Narrow Diffraction Peaks [16]. Debye–Scherrer Equation Was Used To Calculate The Average Crystallite Size: [17]

$$d = \frac{k\,\boldsymbol{\lambda}}{\boldsymbol{\beta}\,\boldsymbol{Cos\theta}}$$

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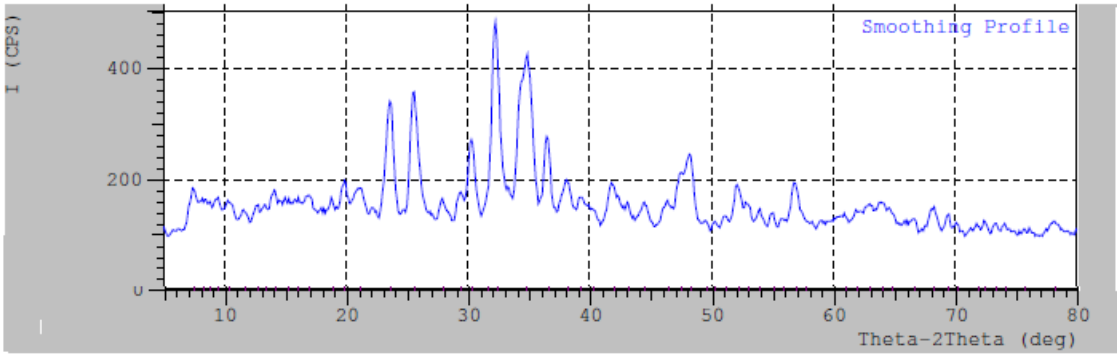

Figure:3 Xrd Spectrum Of Nano Fluid

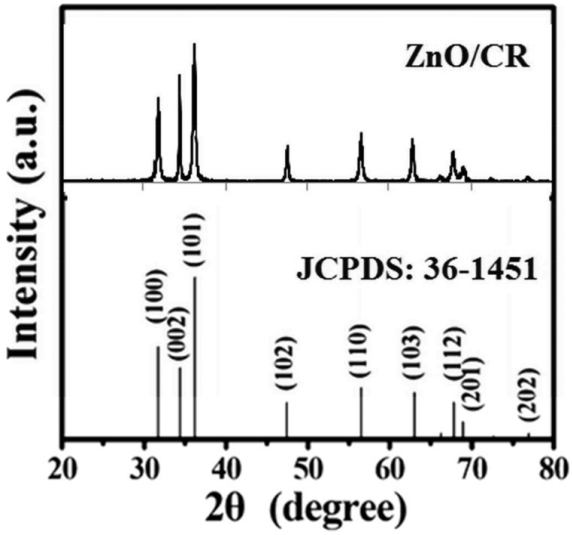

Figure:4 Standard Jcpds Pattern For Zno Nanoparticle

Table-1 Gives The Calculation Of The "D" Value Which Is The Size Of The Nano Fluid.

S.No	2 Theta (Deg)	Theta (Deg)	Cos Θ (Deg)	B	Bradian	D (Nm)
1	23.5795	11.7898	0.9789	0.6854	0.01195	11.84
2	25.5897	12.7949	0.9752	0.7295	0.01272	11.17
3	32.2705	16.1353	0.9606	0.7229	0.01261	11.45
4	30.2900	15.1450	0.9653	0.6487	0.01131	12.69
5	34.6895	17.3448	0.9545	1.2679	0.02211	6.57
6	36.5038	13.2519	0.9497	0.5615	0.00979	14.90

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7	47.4000	23.7000	0.9157	0.7066	0.01232	12.29
8	48.2000	24.1000	0.9128	0.6546	0.01142	13.30
9	52.1488	26.0744	0.8982	0.6690	0.01167	13.01

Table: 1 Calculation Of "D" Value – Size Of The Nano Fluid

The Calculated Crystallite Size (D) Of Zno Is 6.57-14.90 Nm Range, With An Average Of 11.91nm.

Chemical & Physical Parameters:

The Results For The Detection Of Chemical And Physical Parameters Such As Acidity, Moisture Content, Viscosity And Density Are Tabulated.

Table-2 Acidity, Moisture Content, Viscosity And Density Values

Parameters / Samples	Acidity (Mg Koh/G Of Oil)		Moisture Content (Ppm)		Viscosity (Cst)		Density (G/Cc)	
	T O	N F	T O	N F	T O	N F	T O	N F
Unused 1	0.007	0.001	30.2	18.2	28	23	0.87	0.88
Unused 2	0.002	0.001	24.8	19.7	29	22	0.87	0.88
Unused 3	0.006	0.001	14.2	14.0	28.7	23.6	0.87	0.87
Unused 4	0.009	0.002	21.7	17.8	27.8	22.9	0.87	0.88
Unused 5	0.013	0.003	17.4	15.4	28.3	23.4	0.88	0.89
Used 1	0.013	0.006	25.5	20.5	28.8	24.3	0.86	0.87
Used 2	0.015	0.007	32.7	21.7	29.7	24.2	0.86	0.87
Standard Value	<0.03		<50		27		0.89	

T O-Transformer Oil, N F-Nano Fluid

The Value Of Acid Number Within Specified Level Determines The Quality Of The Insulating Oil. It Is Found To Be In The Range Of 0.002-0.015 Mg Koh/G Of Oil In Conventional Transformer Oil And 0.001-0.002 Mg Koh/G Of Oil In Nano Fluid. The Nano Particles Present In The Nano Fluid Decreases The Acidity Of Transformer Oil Due To Its Basicity. The Moisture Content In Oil Is Closely Related To The Deterioration Performance Of An Insulation System And Accurate Prediction Of Moisture Content Plays An Important Role In The Stability And Security Of Power Systems. The Moisture Content Level Lies Between 14.2-32.7 Ppm Is In Oil Samples In Agreeable Level But Nano Fluids Have 14-21.7 Ppm

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Which Is A Suitable One. Viscosity Of An Oil Should Be Regulated Periodically To Improve The Life Of An Equipment. Study On The Test Samples And Nano Fluids (27.8-29.7cst) At 26ºc Have Lower Values. Lower Viscosity Values Are Suited For The High Quality Transformer Oil. Since Density Of Transformer Oil Produces A Larger Impact On Electric Power Transformers, It Should Be Monitored. The Observed Results For Both The Selected Conventional And Nano Fluid Samples For Study Is Between 0.87-0.89g/Cc At 29ºc. The Results Are Found To Be In Close Agreement With The Standard Values.

Conclusion:

The Present Work Focuses On The Synthesis Of Nano Fluids, Chemical And Physical Properties And Its Comparative Study. The Experimental And Analytical Results Are Concluded As The Nano Fluids Are Best Alternative Source For Transformer Oils. By The Investigation Of Analysis The Zno Nanoparticles Are Improve The Quality Of Conventional Transformer Oils.

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