

Breakdown Voltage & Flash point Comparison of Mustered Oils of Three Different Brands for High Voltage Applications

Anil Brahmin^{1*}, D.D.Neema², Arpan Dwivedi³, Devanand Bhonsel⁴

¹Associate Professor, Electrical Engineering, Shri Shankaracharya Technical Campus, Bhilai (C.G.),India

²Director, Yugantar Institute of Engineering and Technology Rajnandgaon (C.G.), India

³Associate Professor, Electrical Engineering, Shri Shankaracharya Technical Campus, Bhilai (C.G.),India

⁴Associate Professor, Electrical Engineering, Shri Shankaracharya Technical Campus, Bhilai (C.G.),India

*Corresponding Author: *firstauthor_anilbrahmin@gmail.com*, Tel.: +91-8319119506

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Abstract— In high voltage transformers, the liquid insulations are used as the insulating medium as well as cooling medium. For the past several decades, the mineral based transformer oil is used traditionally for the purpose of liquid insulations. In the environmental aspect, there are several disadvantages in the mineral oil even though it has better insulating properties. By considering the environmental aspect and insulating properties, the researchers tend to find the alternate insulating fluids for the high voltage applications. Increasing power demand forces the development of the high-rated power transformers. In a transformer, petroleum-based mineral oil is used as insulation, currently Transformer oil produces environmental and health issues because it is non-biodegradable. Thus it has been thought that why not to use vegetable oils if found suitable. The present work investigates breakdown voltage, flash point & fire point of three different vegetable oils and result is tabulated. Results obtained from experiments are validated with benchmark results and are found to be in good agreement. The results are reported in dimensional form and presented graphically. The results provide a substantial insight in understanding the behavior of vegetable oil for high voltage applications.

Keywords— Breakdown voltage(BDV); Breakdown Trials(BDT); Flash point; Fire point.

I. INTRODUCTION

Based on recent research and development as coconut oil was used in Shrilanka as alternate insulating oil for power transformers. A coconut oil filled sealed type distribution transformer had been installed in the Wathara area in Kesbewa, Sri Lanka in 2001 January. Its name plate parameters were three phase, 160 kV, 33 kV/400 V, 50 Hz, etc. This transformer has been supplying a 35 kVA bulk consumer (rubber factory) through a 400 V feeder and domestic consumers through another two 400 V feeders for the last 11 years. During its service, the transformer has been feeding an average load of about 40% and exposed to outdoor tropical weather conditions. The transformer worked well without having any reported failures [1].

In this paper, three samples of mustered oils which are having brand names as Patanjali, Tez and Lal Gulab are tested for Breakdown Voltage by standard process and result is compared as per IS-335:1993

The power transformers are generally subjected to sudden loading which results in high current which results in I²R loss in the transformers, because of which temperature of the winding increases and heat is transferred to insulating

oil, thus flash point and fire point of the oil must be high enough. Thus above three samples were also tested for flash and fire point by using pensky marten's apparatus and result is compared as per IS standards.

II. EXPERIMENTAL SETUP

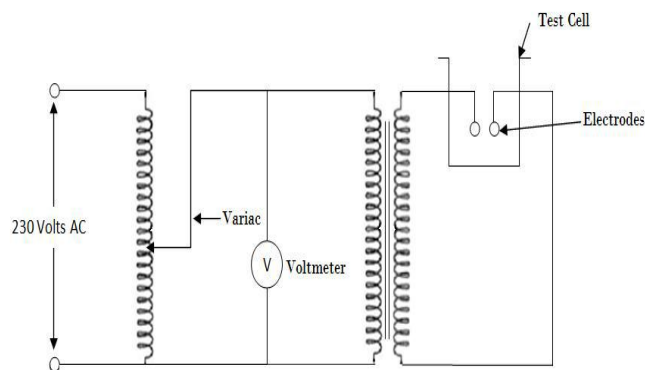


Fig-1-Block diagram of experimental setup for breakdown voltage (0-80 kV)

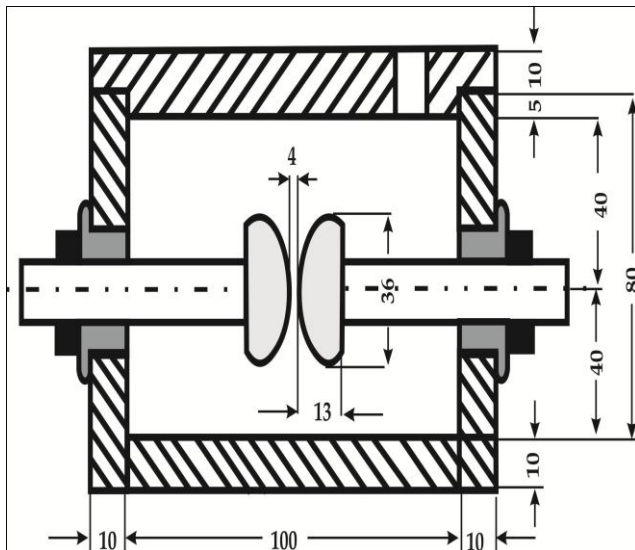


Fig-2 -Detail of electrode with all dimensions in mm

The above figure (1,2) shows the basic circuit setup for the Breakdown Voltage testing. The whole setup is encased inside a Motorized Oil Testing Kit. The kit consists of a test cell in which electrodes are placed and the oil is filled. The other major components are:

1) AC Power Source, 2) Single Phase Variac, 3) A high voltage transformer, 4) Voltmeter, 5) Test cell 6) Electrodes

The supply of 230V is used as an input. The output of this unit is 0 to 80kV is applied to electrodes that are open and placed inside a test cell. The whole setup is governed by safety devices and there is a voltmeter provided to monitor the voltage at every moment. Pensky marten's apparatus is used for flash and fire point testing of oils, the result so obtained are also verified by Infrared Thermometer.

III. TESTING PROCEDURE

1-Transformer oil testing (BDV testing) procedure-

To assess the insulating property of dielectric transformer oil, a sample of the transformer oil is taken and its breakdown voltage is measured.

- The transformer oil is filled in the vessel of the testing device. Two standard-compliant test electrodes with a typical clearance of 4 mm are surrounded by the dielectric oil.

- A test voltage is applied to the electrodes and is continuously increased up to the breakdown voltage with a constant, standard-compliant slew rate of e.g. 2kV/s.

- At a certain voltage level breakdown occurs in form of an electric arc, leading to a collapse of the test voltage.

- An instant after ignition of the arc, the test voltage is switched off automatically by the testing device. Ultra fast switch off is highly desirable, as the carbonization due to the

electric arc must be limited to keep the additional pollution as low as possible.

- The transformer oil testing device measures and reports the root mean square value of the breakdown voltage.

- After the transformer oil test is completed, the insulation oil is stirred and the test sequence is performed repeatedly. (Typically 5 repetitions, depending on the standard)

- As a result the breakdown voltage is calculated as mean value of the individual measurements.

2-Flash point & Fire point test procedure-

Flash point is the lowest temperature at which the lubricating oil gives off enough vapors that ignite for a moment when tiny flame is brought near it. Fire point is the lowest temperature at which the vapors of the oil burn continuously for at least five seconds when a tiny flame is brought near it.

Pensky martens testing Procedure:

- Clean and dry all parts of the apparatus with the help of suitable solvent e.g. CCl₄, ether, petroleum spirit or benzene and dry it to remove any traces of solvent.
- Fill the oil cup with the test oil up to the mark.
- Fix the lids on the top through which are inserted a thermometer and a stirrer. Ensure that the flame exposure device is fixed on the top.
- Light the test flame and adjust it to about 4 mm in diameter.
- Heat the apparatus as temperature of oil increases by 5° to 60° per minute as stirrer is continuously rotated.
- At every 10° C rise of temperature Introduce test flame into the oil vapor. This is done by operating the shutter. On moving knob of shutter, test flame is lowered in oil vapors through opening.
- When test flame causes a distinct flame in interior cup, note down the temperature which represent the flash point.
- Further heat the oil at the rate of 10°C/ min. and continue applying the test flame as before.
- The temperature at which the vapors of the oil give a clear and distinct blue flash for five seconds is recorded as the fire point of the oil.

IV. RESULTS AND DISCUSSION

Breakdown Voltage Test Results

Dielectric breakdown voltage is the measurement of electrical stress that insulating oil can withstand without breakdown. This voltage is usually indicative of the amount of pollutant in the dielectric (usually moisture)

- The samples of oils were taken and placed in air tight containers.

- S1 sample consisted of Patanjali Oil
- S2 sample consisted of Tez Oil
- S3 sample consisted of Lal Gulab Oil
- Each sample was tested 5 times.
- These experiments were replicated twice a day at different temperatures and the mean was taken.
- The result of the experiments is tabulated below for different brands of Mustered oils.

Table 1.

Break down trials	Patanjali Oil Sample			Tez Oil Sample			Lal Gulab Oil Sample		
	BDV in KV (27°C)	BDV in KV (30°C)	Mean BDV (KV)	BDV in KV (27°C)	BDV in KV (30°C)	Mean BDV (KV)	BDV in KV (27°C)	BDV in KV (30°C)	Mean BDV (KV)
BDT1	52	50	51	38	39	38.5	50	54	52
BDT2	49	48	48.5	38	40	39	51	54	52.5
BDT3	48	47	47.5	37	39	38	50	52	51
BDT4	51	50	50.5	39	40	39.5	49	53	51
BDT5	49	48	48.5	37	38	37.5	51	54	52.5
	Average BDV =49.2KV			Average BDV =38.5KV			Average BDV =51.8KV		

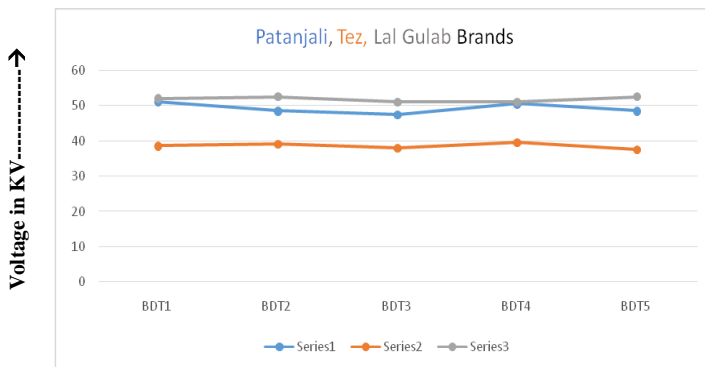


Fig. 3. Graph showing breakdown voltages for various breakdown trials at room Temperature

Table 2. The test results with temperature variation from 25°C to 70°C, for all above three vegetable oils are shown below:

Temperature In °C	Breakdown Voltage in KV		
	Patanjali Brand	Tez Brand	Lal Gulab Brand
25	50	36	50
30	49	38	54
40	44	45	55
50	40	48	55
60	45	32	58
70	46	30	58

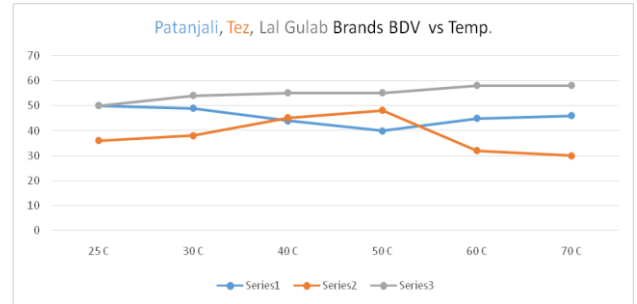


Fig. 4

Table 3

Mustered Oil Brands	Flash Point (°C)	Fire Point (°C)
Patanjali	329	338
Tez	318	330
Lal Gulab	335	342

V. CONCLUSION

This study was undertaken to find out the breakdown voltages of three different mustered oils (Patanjali, Tez and Lal Gulab Brands) in order to determine their suitability as insulating oil in various high voltage applications. From the results obtained, the following conclusions can be made -

- The breakdown voltage measurement was influenced by temperature, in Patanjali as well as in Lal Gulab Brands Oil while the Breakdown voltages of the Tez Brand oils didn't show much variation.
- The mean breakdown voltage of 49.2KV was obtained for Patanjali oil, 38.5KV was obtained for the Tez Oil and 51.8KV was obtained for Lal Gulab oil.
- The Flash Point testing of the oils reveal that the flash point of Patanjali Oil is about 329°C while those of Tez Oil and Lal Gulab Oil are about 318°C and 335°C respectively.
- As per IS 335-1993, The BDV Required for Transformer oil is 30KV, Thus this three oils can be used as an alternate for insulating oil in the Transformers and other electrical equipment's which are subjected to high voltage applications.
- As per IS 335-1993, The Flash/Fire point Required for Transformer oil must be above 140°C, Thus all above Brands of mustered oils can be used according to Indian standards.
- The findings present a data sheet of breakdown voltage as well as the flash point measurement of the three mustered oils viz. Patanjali, Tez and Lal Gulab brands.

Table 4. The final conclusion can be put in the form of the following table:

Mustered Oil	Average Breakdown voltage (kV)	Flash Point (°C)
Patanjali Oil	49.2	329
Tez Oil	38.5	318
Lal Gulab Oil	51.8	335

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Authors Profile

Prof. Anil Brahmin-Renowned Associate Professor of Electrical Engineering in Chhattisgarh. He has awarded B.E.(Hons) in Electrical Engineering from R.E.C. Kurukshetra in the year 1989 and M.Tech. in Electronics & Telecommunication from R.E.C.Kurukshetra in the year 1995, having teaching experience of 28 years. He has Worked at B.I.T. Durg as Lecturer for 3 years, as Sr. Lecturer at Government Engineering College Raipur for 10 years, Reader & Head (Electrical) at Rungta college of Engineering & Technology Bhilai for 5 years. Presently working as Associate Professor & Head (Electrical) at Shri Shankaracharya Technical Campus Bhilai.

**Dr. D. D. Neema-**

Renowned Professor of Electrical Engineering in Chhattisgarh. He has awarded B.E. in Electrical Engineering from SGSITS Indore in the year 1986 and M.Tech. in control System from MBM Engineering College Jodhpur (Rajasthan) in the year 1997, Ph.D. from CSVTU Bhilai in the year 2010, having teaching experience of 32 years. He has Worked as Associate Professor at Rungta college of Engineering & Technology Bhilai for 10 years, Worked as Director at CITRajnandgaon for 7 years. Presently working as Principal at YITM Rajnandgaon.

**Prof. Arpan Dwivedi**

Mr. Arpan Dwivedi pursued BE in Electrical & Electronics Engineering from RGPV University Bhopal, M.P, India and Master of Technology from RGPV University in 2010. He is currently working as Associate Professor at SSGI, Bhilai in Electrical Engineering Department. His main research work focuses on Power Electronics converter development for Renewable energy systems, High Voltage, Hybridization of multiple sources. He has more than 11 years of teaching experience and 4 years of research Experience.

**Prof. Devanand Bhonsle**

Renowned Associate Professor of Electronics & Telecommunication Engineering in Chhattisgarh. He has awarded B.E. in Electronics & Telecommunication Engineering from M.P.C.C.E.T. Bhilai in the year 2004 and M. E. in Electronics & Telecommunication (Specialization in Communication) from S.S.C.E.T. Bhilai in the year 2008. He is pursuing his Ph. D. from CSVTU, Bhilai. He has been working at Shri Shankaracharya Technical Campus Bhilai for 14 years.

