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Capacitive Foam Detection for Transformer Oil Filtering Machine

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***Abstract**: In the world of manufacturing industries it is the competition for automate the system; decrease the time and working cost by doing maximum trails for the same. Similarly the manufactures of transformer oil filtering machine requires a constant observation by human personnel to check the rise of foam in degassing chamber to avoid harmful effect of foam it is important to safeguard it. For this purpose we proposed capacitive based foam detection system to check rise of foam or presence of foam. This system can overcome the system constraints like temperature, pressure and detect rise in foam automatically and activate the control system with the help of relay Initial approach was to decide the appropriate detection technique by studying various devices available in the market, their applications and their suitability for foam detection. The second approach was to test in the live condition by applying it on the current system and its feasibility in foam detection. This system is noncontact cheap and easy to implement.*

***Keywords**: Foam Detection, Capacitive Proximity Switch, Transformer Oil filtering machine.*

I. Introduction to Transformer Oil Filtering Machine

Untreated transformer oil in a working transformer usually contains dissolved water in the range of 50 to 60 PPM and dissolved gases in the range of 10% to 12%. Dissolved moisture and gases along with other contaminants (like sludge) impair the efficiency of the transformer.

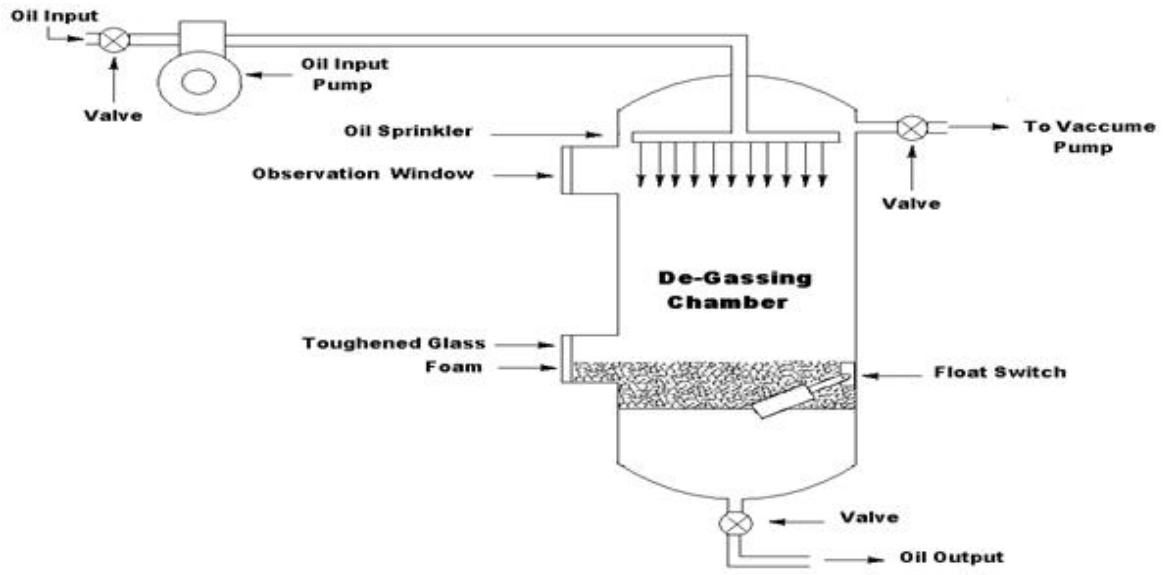

Fig.1.1: Existing transformer oil filtering machine

It is evident that the content of dissolved moisture, gases and other contaminating agents of oil are distinct in the transformer and mainly depend on the place of application of the transformer, like the distribution level transformer, transmission level transformer, generation level transformer, locomotive transformer, furnace transformer etc. In order to achieve the desired transformer performance and an improved transformer life, it is essential to maintain the oil parameters to the prescribed levels as per the standards. Oil parameters, more appropriately the dielectric properties of oil as insulating media, can be maintained at prescribed levels by regular filtration, degasification and dehumidification of oil. Degasification and dehumidification of oil is based on the

principle of separation of components (gases, water) under distinct pressures (here vacuum), viz. on component parameters like, solubility in case of gases and boiling point in case of moisture. Transformer oil filter machines provide appropriate and customized solutions for distinct transformer oil filtration. This process foam presents in transformer oil degassing chamber. There are two reasons for foaming, first: air enters from the inlet side connection (inlet hose) of the machine, second: high moisture and gas content in the oil. Under high vacuum condition in the degassing chamber, the dissolved moisture and gases as well as the leakage air entering from the inlet side, have a tendency of expanding which is seen in the form of foam. Excess foaming is not a desirable feature as it contaminates the vacuum pump oil and makes it turbid. Foam should not exceed level in degassing column. Maintaining the oil level in the degassing chamber is crucial. Excess rise of the level may cause oil to flow in the vacuum pump, in form of foam. If this foam is not detected then it will be passed to the vacuum pump which is undesirable. So the detection of this foam is major problem in oil filtering industries due to certain constraint on it like temperature and pressure of the system.

A. Problem Defination

Boyle's law:
For a fixed amount of ideal gas kept at a fixed temperature, pressure and volume are inversely proportional.
By Boyle's law
$P_1V_1 = P_2V_2$ (Temperature is constant)
P_1 = 1000 mbar = 1 bar = atmospheric pressure
V_1 = 10 liters (air)
P_2 = 1 mbar
Then V_2 comes out to be 10000 V_1 liters
This amount is gas which is in the oil in the degassing chamber. This gas tends to form foam in the system. This foam may rise to a very high level and may enter into the vacuum pump which would disrupt the process and cause problem in operation. Other constraint in the system is operating temperature this is around 100^{o}C. It is important to detect the foam before it rises till the pump.

II. Existing Techniques For Foam Detection

1. DP gauges
2. Capacitance probes
3. Electromagnetic radiation
4. Neutral backscatter
5. Sonic echo devices
6. Flow meters

Most of these do not offer early foam detection. These devices only detect foam after severe foaming has occurred and often not until the foam has upset downstream operations. [4] Because foam build up can occur in many production, refining and petrochemical processes, the need for a technology that acts as an early warning system, accurately detects the presence of foam, responds to changing foam concentrations. For this purpose we design a system which overcomes the constraint and gives fast output signal to the control circuitry.

A. Comparison of Technology

Sr. no	Points	Existing techniques	Proposed technique
1	Techniques used	Float switch, oil replacement, ultrasonic method, foam detection with fieldbus, human observation.	Capacitive proximity switch.
2	Mode of operation	In most of cases its contact type.	Its non-contact type.
3	Maintenance	Regular maintenance incase contact type and regular replacement of vacuum pump oil.	Since non-contact no maintenance required
4	Availability	Not available easily.	Easily available.
5	Complexity	Complex wiring and placement required	Simple system
6	Temperature constraint	Used only for ambient temperature	Non-contact so no temperature restraints.
7	Conditions	Detects only when severe foaming occur and not during initial stage.	Initial stage detection possible
8	Operating time	Operating time is more compared to proposed system	Operating time is very less
9	Reliability	Not as much reliable	Gives accurate detection
10	Cost	Costly can go up to half the price of the system	Very cheap

III. Proposed Foam Detection System

The present work concern with the development of foam detection system with the help of capacitive proximity switch, relay circuit, alarm circuit.

A. Capacitive Proximity Switch

Capacitive proximity sensors can be used to detect metallic and also non-metallic targets like paper, wood, plastic, glass, wood, powder, liquid, etc. without physical contact. The capacitive proximity sensor works on the capacitor principle. The main components of the capacitive proximity sensor are plate, oscillator, threshold detector and the output circuit. The plate inside the sensor acts as one plate of the capacitor and the target acts as another plate and the air acts as the dielectric between the plates. As the object comes close to the plate of the

capacitor the capacitance increases and as the object moves away the capacitance decreases. The detector circuit checks the amplitude output from the oscillator and based on that the output switches. The capacitive sensor can detect any targets whose dielectric constant is more than air.

B. Experimental Setup

The experimental setup consists of

Capacitive sensor

The sensor detects the occurrence of foam above the oil, it requires D.C supply and gives output in the form of pnp signal. It is attached over the observation glass with a help of welded joints.

Relay circuit

It gives the input supply to sensor as well as takes the relay signal and gives signal to alarm with the help of NO and NC contacts.

Alarm circuit

After the relay is activated it closes the NO contact and gives supply to the alarm which gives sound and warns the operator of foam occurrence in the degassing chamber.

IV. Working Principle of Proposed System

Capacitive proximity sensors can be used to detect foam without physical contact. The capacitive proximity sensor works on the capacitor principle. The main components of the capacitive proximity sensor are plate, oscillator, threshold detector and the output circuit. The plate inside the sensor acts as one plate of the capacitor and the target acts as another plate and the air acts as the dielectric between the plates. As the foam comes close to the plate of the capacitor the capacitance increases and as the object moves away the capacitance decreases.

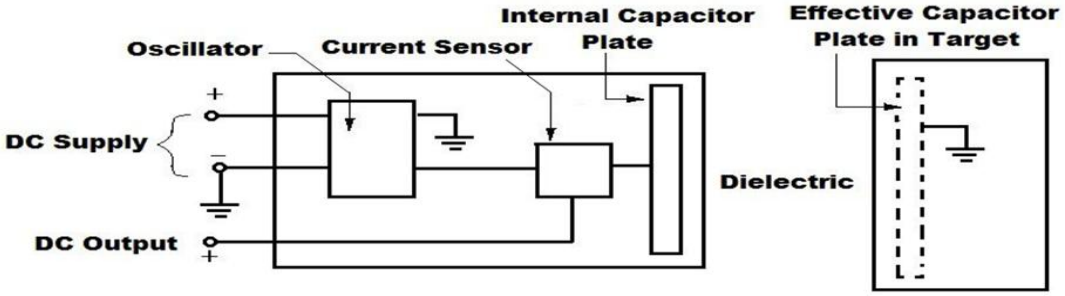

Fig. 4.1: Working Principle of Proposed Capacitive Foam Detection System

The detector circuit checks the amplitude output from the oscillator and based on that the output switches. The capacitive sensor can detect any targets whose dielectric constant is more than air. When the foam formation starts in the de-gassing chamber the foam appears near to the glass window where the capacitive switch is fitted.

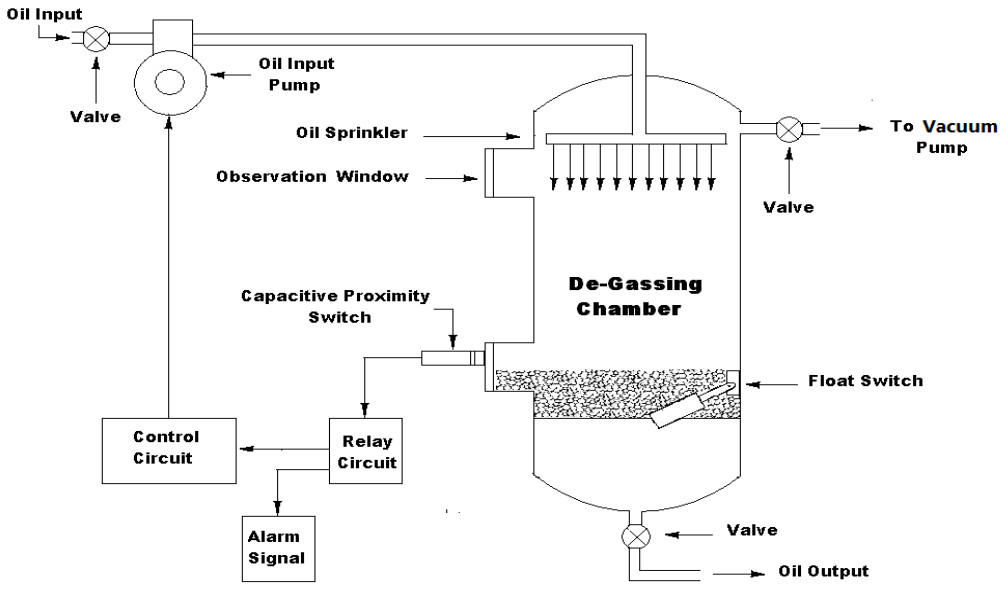

Fig. 4.2: Proposed Foam Detection System

Then the plate inside the sensor acts as one plate of the capacitor and foam acts as another plate and air acts as the dielectric between the plates. As the foam comes close to the plate of the capacitor the capacitance increases and as the foam moves away the capacitance decreases. After the sensing of foam it gives a output signal of pnp

type to the relay which with the help of the NO and NC contacts gives supply to the alarm, these contacts can also use to trip the input pump circuit and the input oil supply is stopped immediately. This is the basic working principle of our main detection system. the basic components are employed in system are relay circuit, alarm signal, control circuit and important one capacitive proximity switch. The control circuit control the oil input pump to the de-gassing chamber of the transformer oil filtering machine. This proposed foam detection system is easy to install and simple. It requires less maintenance as compared to other ones.

A. Key Features of Propopsed System

1. It can successfully detect severe as well as initial occurrence of foam.
2. It is non-contact type detection hence it is not affected by temperature and pressure.
3. The maintenance cost and labor cost is reduced.
4. The operating time of the system is very small as compared to other system.
5. The system gives reliable detection and chance of failures is negligible.
6. With proper fitting it can sustain vibrations of the system.
7. The proposed system is simple and easy to implement.
8. The sensor is easily available in the market.

V. Conclusion

By implementing the capacitive foam detection system for transformer oil filtering machine, it is possible to detect the early foam formation and prevent it to flow through the vacuum pump. The operating time of this system is very less as compared to other existing system. Because of this system the maintenance cost and labor cost is reduced to such a low value. This foam detection technique is simple to assemble so it does not required skilled member. This is major problem which is occurring with most of the transformer oil filtering machine industry and no sensor is available in the market for sensing the foam formation at 80^{o}C-90^{o}C. So our proposed foam detection system has better future scope in market. We can also use this capacitive foam detection system for the Petroleum industry and Food processing industry. It means that our proposed system is not limited to the specific application.

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