Influence of Various Temperatures on the Drying Time of 220/66 KV Transformer Insulations in Vapour Phase Drying Process

Mohd. Tareq Siddiqui, Jayant T. Pattiwar, Avinash P. Paranjape, Ashok J Keche

Abstract: Cellulose based insulation in the form of different papers and pressboard play a vital role in transformer manufacturing as very high level of voltages are encountered during transformer operation. Cellulose being hygroscopic in nature contains 8-10% moisture by weight. The life of a transformer is critically dependant on the state of cellulose insulation so much so that, paper with 1.5% moisture content ages 10 times faster than with only 0.3% moisture. For obvious reasons, it is very important that the moisture is removed from transformer insulation. As of today, the latest technology available for this moisture extraction is the vapour phase drying process. This paper evaluates the influence of temperatures at various locations on the drying time of two 220kv transformer insulations in vapour phase drying process.

Keywords: Temperature, drying time, moisture, transformer

I. INTRODUCTION

Adequate amount of insulation in the form of cellulose based insulation due to long and positive experience is being used in transformer manufacturing as very high voltages are involved during power transfer from primary to secondary. Cellulose insulation has a significant role in transformer’s life & performance characteristics [1]. However, cellulose based insulation being a hygroscopic material, may contain 8 to 10% of moisture by weight at ambient temperature [2]. This moisture is injurious to the health of the transformers since it reduces the dielectric strength, raises the dielectric power factor, increases the risk of thermal breakdown of solid insulation, lowers the lowest hot-spot temperature range for possible bubble formation, accelerates thermal aging of paper insulation, and can be the root cause of a catastrophic failure [3]. It is therefore imperative to remove this moisture from the insulation. In the drying processes used for insulation drying, temperature attained in the insulation is one of the most important factors [4].

This paper presents a statistical analysis and evaluates the effects of temperatures at various locations viz., outer, middle & innermost layers of insulation in transformer insulation drying using vapour phase drying process for two 220/66 KV, 50 MVA transformers with 4 ton insulation.

II. VAPOUR PHASE DRYING OF 220/66KV (I)

For the process of vapour phase drying, the 220/66KV, 50 MVA transformer with 4 ton insulation was loaded into the vacuum chamber. The vacuum chamber has a provision of thermonic fluid heating. Initially the chamber is evacuated for about 2 hours. The vacuum pressure of 20.81 mbar was observed at this point. Thereafter, the vacuum chamber is heated through thermonic fluid for about 10 hours. It was observed at this point that the temperature of the outermost layer of insulation was 76°C while that of the middle layer was 65°C and that of the innermost layer was 55 °C. Also, during this heating, the pressure in the vessel increased to 56.8mbar. The reason for this increase in pressure is the vapourisation of moisture form the outer layers of insulation. Then, the vacuum chamber is subjected to further pressure reduction for about 3 hours at the end of which the vacuum pressure was found to be 39.16mbar. Second heating cycle was then taken for about 2 hours wherein temperature of the outermost layer of insulation was 96°C while that of the middle layer was 87°C and that of the innermost layer was 77 °C and vacuum pressure was 61.15mbar. Further pressure reduction was carried out for about 2 hours before kerosene vapours are introduced in the vacuum chamber. Kerosene vapours are introduced in the vacuum chamber for about 8 hours. As a result of injection of kerosene vapours, the temperature of the insulation increases such that the temperature of the outermost layer reaches up to 115°C, while that of the middle layer is 105°C and that of the innermost layer is 96°C. The final vacuum achieved at the end of the cycle was found to be 0.1 mbar. Also, the total amount of moisture removed was about 24 litres at the end of cycle.

The following tables illustrates the readings of temperatures and the moisture removal per hour during the drying cycle.

In the table, t1 is the temperature of the outermost layer of the insulation, t2 is the temperature of the middle layer of insulation & t3 is the temperature of the innermost layer of the insulation which is nearest to the core. It may be clearly seen from the table that the temperatures in the insulation are not the same throughout. Maximum temperature is observed on the outermost layer while, minimum temperature is observed on the innermost layer. The different temperatures at different locations in the insulation have different effect on the drying time of the insulation.
In the drying processes used for insulation drying, temperature attained in the insulation is one of the most important factors [4]. However, to establish temperature at which location in the insulation, will have the maximum influence on the drying time, Taguchi & Regression analysis were performed using Minitab software between temperatures and drying time and temperatures & rate of moisture removal.

III. TAGUCHI ANALYSIS BETWEEN TEMPERATURES & TIME (I)

While maintaining the quality standards, it is always desirable to have lower drying times. Here quality pertains to the amount of moisture removed. Taguchi analysis between temperatures & drying time was therefore performed by taking temperatures as input factors & drying time as response variable. Signal to noise ratios were also evaluated for “Smaller the Better” (drying time). The values obtained from the analysis may summarized in tables 2 & 3.

Table- II: Response Table for Signal to Noise Ratios

```
| Level | t1     | t2     | t3     |
|-------|--------|--------|--------|
| 1     | 0      | 0      | 0      |
| 2     | -6.0206| 0      | -6.0206|
| 3     | -9.5424| -6.0206| -9.5424|
| 4     | -12.0412| -9.5424| -12.0412|
| 5     | -13.9794| -12.0412| -13.9794|
| 6     | -15.563| -13.9794| -15.563|
| 7     | -16.902| -15.563| -16.902|
| 8     | -18.0618| -16.902| -18.0618|
| 9     | -19.0849| -18.0618| -19.0849|
| 10    | -20     | -19.0849| -20     |
| 11    | -20.8279| -20     | -20.8279|
| 12    | -21.5836| -20.8279| -21.5836|
| 13    | -22.5889| -21.5836| -22.5889|
| 14    | -22.9278| -22.5889| -22.9278|
| 15    | -23.5218| -22.9278| -23.5218|
| 16    | -24.0824| -23.5218| -24.0824|
| 17    | -24.6409| -24.0824| -24.6409|
| 18    | -25.1055| -24.6409| -25.1055|
| 19    | -26.0897| -25.1055| -26.0897|
| 20    | -26.7012| -26.0897| -26.7012|
| 21    | -27.6042| -26.7012| -27.6042|
| 22    | -27.9588| -27.6042| -27.9588|
```

Fig. 1. Temp. Vs Time, Taguchi Graphs (I)

```
| Level | t1     | t2     | t3     |
|-------|--------|--------|--------|
| 1     | 0.5    | 0      | 1      |
| 2     | 2      | 1      | 3      |
| 3     | 4      | 3      | 4      |
| 4     | 5      | 4      | 5      |
| 5     | 6      | 5      | 6      |
| 6     | 7      | 6      | 7      |
| 7     | 8      | 7      | 8      |
| 8     | 9      | 8      | 9      |
| 9     | 10     | 9      | 10     |
| 10    | 11     | 10     | 11     |
| 11    | 12     | 11     | 12     |
| 12    | 13     | 12     | 13     |
| 13    | 14     | 13     | 14     |
| 14    | 15     | 14     | 15     |
| 15    | 16     | 15     | 16     |
| 16    | 17     | 16     | 17     |
| 17    | 18     | 17     | 18     |
| 18    | 19     | 18     | 19     |
| 19    | 20     | 19     | 20     |
| 20    | 21.6667| 20     | 21     |
| 21    | 22     | 21     | 22.5   |
| 22    | 23     | 22     | 24     |
| 23    | 24     | 23     | 25     |
| 24    | 25     | 24     | 26     |
| 25    | 26     | 25     | 27     |
| Delta| 25.5   | 25     | 26     |
```

The graphs generated are as follows.

IV. REGRESSION ANALYSIS BETWEEN TEMPERATURES & TIME (I)

To further assess which temperature has the maximum influence on the drying time, regression analysis was performed. Drying time was taken as the response & temperatures was taken as the predictor. The regression equation obtained is as follows.

\[
\text{Time in Hrs.} = -11.2 + 0.0995 t_1 + 0.100 t_2 + 0.130 t_3
\]

Regression in tabular form can be illustrated as follows.
The regression graphs are as follows.

![Regression Graphs](image)

**Fig. 2. Temp. Vs Time, Regression Graphs (I)**

V. TAGUCHI ANALYSIS BETWEEN TEMPERATURES & MOISTURE REMOVAL RATE. (I)

By taking temperatures as input factors & moisture removal rate as a response variable Taguchi analysis between temperatures & moisture removal rate was performed to determine the effect of different temperatures on the moisture removal rate and by extension on the drying time. Signal to noise ratios were evaluated for “Larger the Better” (moisture removal rate). The values obtained from the analysis may summarized in tables 5 & 6.

![Magnitude Table](image)

**Table- IV: Regression Analysis of Temperatures Vs Time (I)**

| Predictor | Coef | SE Coef | T  | P   |
|-----------|------|---------|----|-----|
| Constant  | -1.17| 0.8263  | -13.48 | 0   |
| t1        | 0.09952| 0.00754 | 1.02  | 0.318|
| t2        | 0.1002| 0.1675  | 0.6   | 0.556|
| t3        | 0.1304| 0.1026  | 1.27  | 0.216|

The graphs generated are as follows.

![Magnitude Table](image)

**Table- V: Response Table for Signal to Noise Ratios**

| Level | t1  | t2  | t3  |
|-------|-----|-----|-----|
| 1     | -0.11098 | -3.8764 | 5.6369 |
| 2     | 3.6369 | 3.6369 | 4.811 |
| 3     | 4.811 | 4.811 | 4.811 |
| 4     | 4.811 | 4.811 | 4.811 |
| 5     | 4.811 | 4.811 | 4.811 |
| 6     | 4.811 | 4.811 | 4.811 |
| 7     | 4.811 | 4.811 | 4.811 |
| 8     | 4.811 | 4.811 | 4.811 |
| 9     | 4.811 | 4.811 | 4.811 |
| 10    | 4.811 | 4.811 | 4.811 |
| 11    | 4.811 | 4.811 | 4.811 |
| 12    | 4.811 | 4.811 | 4.811 |
| 13    | 8.469 | 8.469 | 8.469 |
| 14    | 12.1276 | 8.469 | 12.1276 |
| 15    | 12.1491 | 12.1491 | 12.1491 |
| 16    | 12.1491 | 12.1491 | 12.1491 |
| 17    | 14.2193 | 14.2193 | 14.2193 |
| 18    | 18.5884 | 18.5884 | 18.5884 |
| 19    | 24.0244 | 18.5884 | 27.626 |
| 20    | 25.8048 | 22.626 | 23.7278 |
| 21    | 27.4398 | 23.7278 | 25.2259 |
| 22    | 27.4473 | 25.4229 | 26.8433 |
| 23    | 27.4656 | 26.2689 | 27.4398 |
| 24    | 27.47177 | 27.4472 | 27.4472 |
| 25    | 27.4398 | 27.4472 | 27.4472 |
| 26    | 27.4656 | 27.4472 | 27.4472 |
| 27    | 27.4472 | 27.4472 | 27.4472 |
| Delta | 27.5854 | 31.342 | 27.5854 |
| Rank  | 2.5 | 2.5 | 2.5 |

![Magnitude Table](image)

**Table- VI: Response Table for Means (I)**

| Level | t1 | t2 | t3 |
|-------|----|----|----|
| 1     | 1.08 | 0.64 | 1.52 |
| 2     | 1.52 | 1.52 | 1.68 |
| 3     | 1.74 | 1.52 | 1.74 |
| 4     | 1.74 | 1.74 | 1.74 |

![Magnitude Table](image)

**Table- VII: Regression Analysis of Temperatures Vs Moisture Removal Rate (I)**

| Predictor | Coef | SE Coef | T  | P   |
|-----------|------|---------|----|-----|
| Constant  | -11.823 | 2.574 | -4.59 | 0   |
| t1        | 0.1792 | 0.303 | 0.43 | 0.674|
| t2        | 0.10774 | 0.5204 | -2.07 | 0.05|
| t3        | 1.3618 | 0.3187 | 4.27 | 0   |

The graphs generated are as follows.

![Magnitude Table](image)

**Fig. 3. Temp. Vs Moisture Removal Rate, Taguchi Graphs (I)**

VI. REGRESSION ANALYSIS BETWEEN TEMPERATURES & MOISTURE REMOVAL RATE. (I)

Regression analysis was performed with moisture removal rate as the response & temperatures as the predictor. The following regression equation was obtained.

Total Water = -11.8 + 0.129 t1 - 1.08 t2 + 1.36 t3

The following tabular form of regression was also obtained.

![Magnitude Table](image)

**Table- IV: Regression Analysis of Temperatures Vs Time (I)**
For the process of vapour phase drying, the 220/66 KV, 50 MVA transformer coil with 4 ton insulation was loaded into the vacuum chamber. Initially the chamber is evacuated for about 3 hours. The vacuum pressure of 21.73 mbar was observed at this point. Thereafter, the vacuum chamber is heated through thermic fluid for about 18 hours. It was observed at this point that the temperature of the outermost layer of insulation was 113°C while that of the middle layer was 101°C and that of the innermost layer was 90°C. Also, during this heating, the pressure in the vessel increased to 80.31 mbar. The reason for this increase in pressure is the vapourisation of moisture form the outer layers of insulation. Then, the vacuum chamber is subjected to further pressure reduction for about 2 hours. Next, a second heating cycle is taken for 4 hours during which the temperature of the outermost layer reaches 113°C while that of the middle layer reaches 102°C and that of the innermost layer reaches 89°C. The pressure observed at this point is 60.46 mbar. Again, a pressure reduction cycle is taken for about 2 hours during which, the pressure reaches 14.63 mbar. A third heating cycle is taken for about 4 hours at the end of which the pressure becomes 59.78 mbar. Before introducing kerosene vapours, a pressure reduction cycle is taken for about 3 hours. Kerosene vapours are introduced in the vacuum chamber for about 12 hours. As a result of injection of kerosene vapours, the temperature of the insulation increases such that the temperature of the outermost layer reaches up to 110°C, while that of the middle layer is 99°C and that of the innermost layer is 83°C. The final vacuum achieved at the end of the cycle was found to be 0.1 mbar. Also, the total amount of moisture removed was about 38 litres at the end of cycle. The following tables illustrates the readings of temperatures and the moisture removal per hour during the drying cycle.

### Table VIII: Vacuum Chamber Readings (II)

| Time in Hrs. | Total Water/ hr | t1  | t2  | t3  | Vacuum Level (mbar) |
|--------------|----------------|-----|-----|-----|---------------------|
| 0            | 0.34           | 36  | 36  | 36  | 973.51              |
| 1            | 0.34           | 38  | 37  | 38  | 974.31              |
| 2            | 0.34           | 39  | 39  | 38  | 173.74              |
| 3            | 1.37           | 49  | 44  | 42  | 21.73               |
| 4            | 1.37           | 53  | 47  | 44  | 27.84               |
| 5            | 1.37           | 61  | 55  | 49  | 31.31               |
| 6            | 1.37           | 68  | 64  | 54  | 35.79               |
| 7            | 1.37           | 79  | 72  | 61  | 37.57               |
| 8            | 1.37           | 82  | 74  | 65  | 37.99               |
| 9            | 1.37           | 86  | 75  | 67  | 38.4               |
| 10           | 1.37          | 87  | 77  | 60  | 39.18               |
| 11           | 1.37           | 90  | 79  | 70  | 39.67               |

### Table IX: Response Table for Signal to Noise Ratios “Smaller Is Better” (II)

| Level | t1 | t2 | t3 |
|-------|----|----|----|
| 1     | 0  | 0  | 0  |
| 2     | -6.0206 | -6.0206 | -9.5424 |
| 3     | -9.5424 | -9.5424 | -12.0412 |
| 4     | -12.0412 | -12.0412 | -13.9794 |
| 5     | -13.9794 | -13.9794 | -15.563 |
| 6     | -15.563 | -15.563 | -16.902 |
| 7     | -16.902 | -16.902 | -18.0618 |
| 8     | -18.0618 | -18.0618 | -19.0849 |
| 9     | -19.0849 | -19.0849 | -20.2879 |
| 10    | -20.2879 | -20.2879 | -21.5836 |
| 11    | -21.5836 | -21.5836 | -23.5218 |
| 12    | -23.5218 | -23.5218 | -23.607 |
| 13    | -23.607 | -23.607 | -24.0824 |
| 14    | -24.0824 | -24.0824 | -24.0824 |
| 15    | -24.0824 | -24.0824 | -24.0824 |
| 16    | -24.0824 | -24.0824 | -24.0824 |
| 17    | -24.0824 | -24.0824 | -33.4864 |
| 18    | -29.4679 | -29.4679 | -33.8019 |
| 19    | -32.9904 | -32.1525 | -33.0614 |
| 20    | -33.0614 | -33.0614 | -33.0614 |
| 21    | -33.0614 | -33.0614 | -33.0614 |
| 22    | -33.0614 | -33.0614 | -33.0614 |
| 23    | -33.0614 | -33.0614 | -33.0614 |
| 24    | -33.0614 | -33.0614 | -33.0614 |
| 25    | -33.0614 | -33.0614 | -33.0614 |
| 26    | -33.0614 | -33.0614 | -33.0614 |
| 27    | -33.0614 | -33.0614 | -33.0614 |
| Delta | 32.5527 | 32.5626 | 34.8073 |
| Rank  | 2   | 3   | 1   |

### VIII. TAGUCHI ANALYSIS BETWEEN TEMPERATURES & TIME. (II)

Taguchi analysis between temperatures & drying time was performed by taking temperatures as input factors & drying time as response variable. Signal to noise ratios were also evaluated for “Smaller the Better” (drying time). The values obtained from the analysis may summarized in tables 9 & 10.
The graphs generated are as follows.

**IX. REGRESSION ANALYSIS BETWEEN TEMPERATURES & TIME. (II)**

To assess which temperature has the maximum influence on the drying time, regression analysis was performed. Drying time was taken as the response & temperatures was taken as the predictor. The regression equation obtained is as follows.

\[
\text{Time in hrs} = -21.8 + 1.67t_1 + 4.42t_2 - 2.28t_3
\]

Regression in tabular form can be illustrated as follows.

**Table- XI: Regression Analysis of Temperatures Vs Time (II)**

| Predictor | Coef  | SE Coef | T     | P     |
|-----------|-------|---------|-------|-------|
| Constant  | -21.752 | 9.923 | -2.19 | 0.032 |
| t1        | -1.674 | 1.006 | -1.66 | 0.102 |
| t2        | 4.419  | 1.241 | 3.56  | 0.005 |
| t3        | -2.283 | 0.7729| -2.95 | 0.001 |

The regression graphs are as follows.

**X. TAGUCHI ANALYSIS BETWEEN TEMPERATURES & MOISTURE REMOVAL RATE. (II)**

By taking temperatures as input factors & moisture removal rate as response variable Taguchi analysis between temperatures & moisture removal rate was performed to determine the effect of different temperatures on the moisture removal rate and by extension on the drying time. Signal to noise ratios were also evaluated for “Larger the Better” (moisture removal rate). The values obtained from the analysis may summarized in tables 12 & 13.

**Table- XII: Response Table for Signal to Noise Ratios “Larger Is Better” (II)**

| Level | t1    | t2    | t3    |
|-------|-------|-------|-------|
| 1     | -9.37 | -9.37 | -9.37 |
| 2     | -9.37 | -9.37 | -9.37 |
| 3     | -9.37 | -9.37 | -9.37 |
| 4     | 2.734 | 2.734 | 2.734 |
| 5     | 2.734 | 2.734 | 2.734 |
| 6     | 2.734 | 2.734 | 2.734 |
| 7     | 2.734 | 2.734 | 2.734 |
| 8     | 2.734 | 2.734 | 2.734 |
| 9     | 2.734 | 2.734 | 2.734 |
| 10    | 2.734 | 2.734 | 2.734 |
| 11    | 2.734 | 2.734 | 2.734 |
| 12    | 2.734 | 2.734 | 2.734 |
| 13    | 2.734 | 2.734 | 2.734 |
| 14    | 2.734 | 2.734 | 2.734 |
| 15    | 2.734 | 2.734 | 2.734 |
| 16    | 2.734 | 2.734 | 2.734 |
| 17    | 31.632 | 2.734 | 31.588 |
| 18    | 23.855 | 17.439 | 28.138 |
| 19    | 31.144 | 30.156 | 31.253 |
| 20    | 29.404 | 28.028 | 31.265 |
| 21    | 30.376 | 27.491 | 31.632 |
| 22    | 28.124 | 30.081 | 26.441 |
| 23    | 30.106 | 24.492 | 24.992 |
| 24    | 25.621 | 27.072 | 27.133 |
| 25    | 19.690 | 20.957 | 25.747 |
| 26    | 19.511 | 25.747 | 13.274 |
| 27    | 41.003 | 39.637 | 41.003 |
| Rank  | 1.5   | 3     | 1.5   |

**Table- XIII: Response Table for Means (II)**

| Level | t1    | t2    | t3    |
|-------|-------|-------|-------|
| 1     | 0.34  | 0.34  | 0.34  |
| 2     | 0.34  | 0.34  | 0.34  |
| 3     | 0.34  | 0.34  | 1.37  |
| 4     | 1.37  | 1.37  | 1.37  |
| 5     | 1.37  | 1.37  | 1.37  |
| 6     | 1.37  | 1.37  | 1.37  |
| 7     | 1.37  | 1.37  | 1.37  |
| 8     | 1.37  | 1.37  | 1.37  |
| 9     | 1.37  | 1.37  | 1.37  |
| 10    | 1.37  | 1.37  | 1.37  |

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The graphs generated are as follows.

Fig. 7. Temp. Vs Moisture Removal Rate, Taguchi Graphs (II)

XI. REGRESSION ANALYSIS BETWEEN TEMPERATURES & MOISTURE REMOVAL RATE. (II)

Regression analysis was performed with moisture removal rate as the response & temperatures as the predictor. The following regression equation was obtained.

Total Water = -23.9 - 2.41 t1 + 4.81 t2 - 1.88 t3

The following tabular form of regression was also obtained.

| Coef | SE Coef | T | P  |
|------|---------|---|----|
| -23.888 | 9.526 | -2.51 | 0.015 |
| 2.098 | 0.959 | 2.24 | 0.06 |
| 4.813 | 1.192 | 4.04 | 0.048 |
| -1.8764 | 0.7419 | 2.53 | 0.014 |

The graphs generated are as follows.

Fig. 8. Temp. Vs Moisture Removal Rate, Regression Graphs (II)

XII. RESULTS & DISCUSSIONS

The delta value and rank in Taguchi analysis (I) between temperatures and drying time is the same for the temperature of all layers of insulation as can be seen in tables 2 & 3. However, there are limitations due to which the outermost layer temperature cannot be further increased. Hence, it can be concluded that since there is still scope for increasing the innermost layer temperature, it will be the most influential on the drying time.

As can be clearly seen in table 4 for regression analysis (I) between temperatures and drying time that, P value for temperature of the innermost layer of insulation is minimum. It can therefore be concluded that the temperature of the innermost layer is the most influential temperature for drying time.

As can be clearly seen in tables 5 & 6 for Taguchi analysis (I) between temperatures and moisture removal rate that the delta value & rank of the outermost & innermost layer temperature i.e t1 & t3 is same and is less than the values for t2. But, t2 cannot be increased independently and due to limitations on increasing the outermost layer temperature it cannot be increased further. Hence, it can be concluded that the temperature of the innermost layer is the most influential temperature.

It is clearly evident from table 7 for regression analysis (I) between temperatures and moisture removal rate that, P value for temperature of the innermost layer of insulation t3 is minimum & hence it is the most influential temperature on the moisture removal rate.

The delta value and rank in tables 9 & 10 for Taguchi analysis (II) between temperatures and drying time is the highest for the innermost layer temperature i.e t3. Therefore, it is clearly evident that, of all the temperatures, the innermost layer temperature of insulation has maximum influence on the drying time.

As can be clearly seen in table 11 for regression analysis (II) between temperatures and drying time that, P value for temperature of the innermost layer of insulation is minimum. It can therefore be concluded from regression analysis that the temperature of the innermost layer is the most influential temperature for drying time.

As can be clearly seen in tables 12 & 13 for Taguchi analysis (II), the delta value and rank between temperatures and moisture removal rate is the same for the temperatures t1 & t2. However, there are limitations due to which the outermost layer temperature cannot be further increased. Hence,
it can be concluded that since there is still scope for increasing the innermost layer temperature, it will be the most influential on the drying time.

In table 14 it can be seen that the P value in regression analysis (II) between temperatures and moisture removal rate is minimum for temperature of the innermost layer of insulation t3 & hence it is the most influential temperature on the moisture removal rate.

XIII. CONCLUSION

Form the results of the Taguchi and Regression analysis obtained for vapour phase drying, it is clearly seen that, the temperature of the innermost layer of the insulation which is nearest to the transformer core is the most decisive temperature in reducing the overall drying time and increasing the moisture removal rate. The innermost layer temperature is predominant in positively influencing to reduce the drying time and increasing the moisture removal rate. It can therefore be concluded that if the temperature of the innermost layer of insulation is increased, the overall drying time may be reduced as, this increase in temperature will serve to increase the moisture removal rate.

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AUTHORS PROFILE

Mohd. Tareq Siddiqui is a research scholar in Dr.Babasaheb Ambedkar Marathwada University, Aurangabad pursuing his research in vapour phase drying of transformer insulation.

Dr. Jayant T. Pattiwar is a research guide in the faculty of science & technology in Dr.Babasaheb Ambedkar Marathwada University, Aurangabad. His area of specialization is design. He has a vast experience in industry as well as academia.

Dr. Ashok J. Keche is Head of the Department of Mechanical Engineering in MIT Aurangabad. His area of specialization is Machine Design and Manufacturing Engineering.

Dr. Avinash P. Paranjape is a professor emeritus in Govt. College of Engineering Aurangabad. He is a chartered engineer as well as a consultant for many industries in and around Aurangabad.