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Experimental measurements concerning the stator insulation partial discharge level of a hydro-generator of high power

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Abstract. The paper presents a determining and evaluating method from an experimental point of view of the partial discharges level from the insulation of the stator of a synchronous hydro- generator of high power that appear at different temperatures. The temperature is measured directly on the coil with placed thermo- resistant elements between the superior and inferior bars. Also, the level of partial discharges with the coil age in a cold state, at the temperature level of the surrounding environment from within the stator, but also in a warm state at different temperatures, is measured. Through this method there is created the possibility of highlighting some eventual degradations of the coil insulation of a hydro- generator.

1. Introduction

Partial downloads are generally consequently a local concentration of electrical insulation stress or on the surface of the insulation [1-3]. Generally such discharges occur in the form of pulse currents in the dielectric and outer circuit thereof with a duration much less than 1μs. Yet can occur and continuous forms downloads, such as the so-called low-intensity discharge ("pulse-less") in gaseous dielectrics [4-6].

Generally it can be considered that partial discharges in insulation systems are " symptoms" phenomena which is produced in that insulation and in most cases can be associated with insulation defects due to either the manufacturing technology, be of solicitation complex (mechanical, electrical, thermal, chemical etc.) on the material in which the insulation is achieved [7-18]. Though pierce from vacuole does not immediately lead to shorting dielectric, the phenomenon of partial discharge walls space respectively, finally leading to deterioration of the insulation [19-21].

Each discharge dissipates a small amount of energy, which will be located inside the cavity present in insulation.This energy spreads in all directions in the form of heat [22-25].

Apparent task analysis is important Is important to determine the corrective measures that need to be taken. The normal level of partial discharge is characterized by values up to 100 pC, it has a low impact on insulation but affects its lifetime equipment. The critical level appears after the threshold 1000 pC, at this stage the insulation is in an intense process of degradation. Values higher, 1000 pC affects considerably whether the action of the phenomenon takes a long time leaving carbonization traces in the insulation an effective method of assessment of the real state of the winding insulation stator is to monitor the level of partial discharge, highlighting any in homogeneities in the mass of the insulation, leading to serious damage of the insulation by shutting down the generator [8], [26-28].

In this paper the level of partial discharge for different voltages was determined and verified whether there was a change in temperature during the experimental determinations that could influence the parameters DP.

The temperature is measured directly on the thermal resistance coil placed between the top and the lower bar. It also measures the level of partial discharge the coil in the cold state with the ambient temperature inside the stator and at different temperatures in the hot state. The average values for the different levels of partial discharge voltages were represented graphically according to different temperatures and depending on the voltage at the generator terminals.

2. Partial Discharge Measurement System

The system used to measure the partial discharges shown in the Figure 1 is built of: coupling device, transmission and measurement devices.

Coupling device it is an integral part of the measuring system and a test circuit, its components being specially designed to achieve optimal sensitivity with a specific test circuit.

The coupling device (Figure 1b) is generally an active or passive network with four terminals (quadripole) and converts the input current into output voltage signals [8], [10].

These signals are transmitted to the measuring device DP from Figure 1a, through a transmission system. The frequency response of the coupling device, defined by the ratio of the output voltage to the input current It is selected so as to prevent the test voltage frequency and its harmonics to reach the measuring device.

Figure 1. Partial Discharge Measurement System

Measuring device DP with coupling device, constitutes a measurement system DP broadband characterized by a transfer impedance $z(f)$ having frequencies lower limit values f_1 and an upper limit f_2 and adequate mitigation until f_1 and over f_2.

The response of this device to a non-oscillating current pulse due to a download part is generally a strongly damped oscillation. Both apparent charge and polarity Impulse current of DP can be determined from this response, and the pulse resolution time is very small. The wiring diagram of the plant for partial discharge measurement is shown in Figure 2, [8], [10].

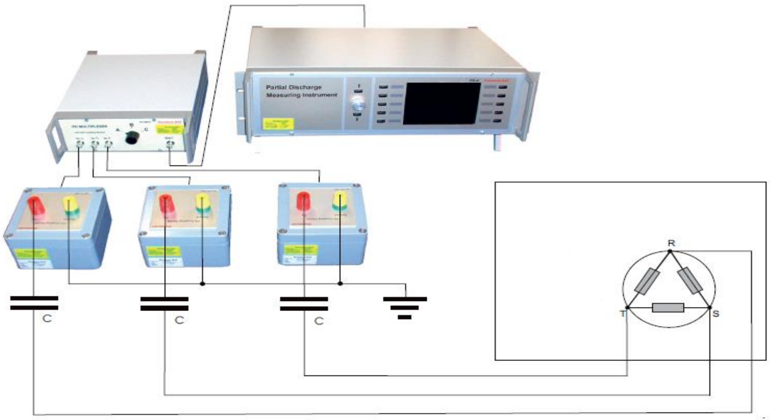

Figure 2. Installation wiring diagram of measuring partial discharges

3. Measurement results

Attempts have been made with the generator in idle functioning. Determining the level of partial discharges has been done at different values of the generator terminals: U_{line}=4kV, U_{line} =8,1 kV, U_{line} =12,3 kV, U_{line} =14 kV, U_{line} =15 kV, U_{line} =16kV.

For each voltage level partial discharges were measured on each phase, considering a number of 30 entries. From the average values measured, average values were determined for each phase. The results of the level of partial discharges for different voltages are given in the following Tables 1÷6:

Table 1. Results of the level of partial discharges for U_{line}=4 kV

No.	Phase A		Phase B		Phase C		No.	Phase A		Phase B		Phase C	
	U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]		U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]
1	2,10	398,4	2,20	2,20	2,20	281,3	16	2,10	398,4	2,10	2,10	2,10	318,8
2	2,10	407,8	2,10	2,10	2,10	337,5	17	2,10	365,6	2,10	2,10	2,10	300
3	2,10	407,8	2,10	2,10	2,10	328,1	18	2,10	403,1	2,10	2,10	2,10	393,8
4	2,10	398,4	2,20	2,20	2,20	309,4	19	2,10	393,8	2,10	2,10	2,10	323,4
5	2,10	407,8	2,10	2,10	2,10	356,3	20	2,10	407,8	2,10	2,10	2,10	318,8
6	2,10	281,3	2,10	2,10	2,10	332,8	21	2,10	398,4	2,10	2,10	2,10	332,8
7	2,10	323,4	2,20	2,20	2,20	365,6	22	2,10	403,1	2,10	2,10	2,10	346,9
8	2,10	398,4	2,20	2,20	2,20	337,5	23	2,10	300	2,10	2,10	2,10	337,5
9	2,10	403,1	2,10	2,10	2,10	337,5	24	2,10	407,8	2,10	2,10	2,10	332,8
10	2,10	407,8	2,10	2,10	2,10	360,9	25	2,10	351,6	2,10	2,10	2,10	426,6
11	2,10	351,6	2,10	2,10	2,10	304,7	26	2,10	398,4	2,10	2,10	2,10	346,9
12	2,10	412,5	2,10	2,10	2,10	328,1	27	2,10	393,8	2,10	2,10	2,10	332,8
13	2,10	370,3	2,10	2,10	2,10	332,8	28	2,10	398,4	2,10	2,10	2,10	304,7
14	2,10	290,6	2,10	2,10	2,10	281,3	29	2,10	398,4	2,10	2,10	2,10	276,6
15	2,10	435,9	2,10	2,10	2,10	328,1	30	2,10	356,3	2,10	2,10	2,10	351,6

Under the conditions of a nominal voltage de 4 kV to the generator terminals, we observe a very low level of partial discharges de 276,6 pC on the phase C, reaching to a value de 426,6 pC on the phase C.

Table 2. Results of the level of partial discharges for U_{line}=8,1kV

No.	Phase A		Phase B		Phase C		No.	Phase A		Phase B		Phase C	
	U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]		U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]
1	4,20	792,2	4,20	543,8	4,3	581,3	16	4,20	806,3	4,20	576,6	4,3	628,1
2	4,20	735,9	4,20	637,5	4,3	656,3	17	4,20	801,6	4,20	534,4	4,3	651,6
3	4,20	801,6	4,20	660,9	4,3	651,6	18	4,20	796,9	4,20	529,7	4,3	543,8
4	4,20	801,6	4,20	581,3	4,3	651,6	19	4,20	501,6	4,20	637,5	4,3	637,5
5	4,20	768,8	4,20	562,5	4,3	581,3	20	4,20	642,2	4,20	515,6	4,3	632,8
6	4,20	609,4	4,20	553,1	4,3	548,4	21	4,20	796,9	4,20	600	4,3	660,9
7	4,20	806,3	4,20	543,8	4,3	623,4	22	4,20	3796,9	4,20	628,1	4,3	646,9
8	4,20	764,1	4,20	604,7	4,3	642,2	23	4,20	890,6	4,20	534,4	4,3	726,6
9	4,20	796,9	4,20	656,3	4,3	590,6	24	4,20	750	4,20	604,7	4,3	656,3
10	4,20	806,3	4,20	632,8	4,3	590,6	25	4,20	792,2	4,20	642,2	4,3	656,3
11	4,20	600	4,20	562,5	4,3	632,8	26	4,20	801,6	4,20	534,4	4,3	567,2
12	4,20	801,6	4,20	557,8	4,3	651,6	27	4,20	478,1	4,20	618,8	4,3	651,6
13	4,20	782,8	4,20	590,6	4,3	614,1	28	4,20	464,1	4,20	618,8	4,3	628,1
14	4,20	787,5	4,20	632,8	4,3	632,8	29	4,20	787,5	4,20	534,4	4,3	581,3
15	4,20	670,3	4,20	600	4,3	656,3	30	4,20	806,3	4,20	628,1	4,3	637,5

The experimental results presented in Table 3 indicate a certain degree of imbalance of the partial phase discharge level. In conditions of a rated voltage of 8,1 kV the generator terminals, observe a low level of partial discharges de 464,1 pC on phase A, reaching to a value de 890,6 pC on phase A, the exception is for the case 22 where task apparent it is of 3796,9 pC on phase A.

Table 3. Results of the level of partial discharges for U_{line}=12,3kV

No.	Phase A		Phase B		Phase C		No.	Phase A		Phase B		Phase C	
	U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]		U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]
1	6,20	1171,9	6,20	946,9	6,30	843,8	16	6,20	1120,3	6,20	707,8	6,30	843,8
2	6,20	1125	6,20	768,8	6,30	890,6	17	6,20	731,3	6,20	900	6,30	937,5
3	6,20	1171,9	6,20	773,4	6,30	890,6	18	6,20	1017,2	6,20	1082,8	6,30	937,5
4	6,20	1110,9	6,20	778,1	6,30	843,8	19	6,20	792,2	6,20	735,9	6,30	1171,9
5	6,20	1134,4	6,20	895,3	6,30	937,5	20	6,20	1143,8	6,20	796,9	6,30	890,6
6	6,20	1021,9	6,20	773,4	6,30	750	21	6,20	745,3	6,20	754,7	6,30	843,8
7	6,20	1157,8	6,20	768,8	6,30	843,8	22	6,20	923,4	6,20	895,3	6,30	937,5
8	6,20	1195,3	6,20	942,2	6,30	890,6	23	6,20	1120,3	6,20	759,4	6,30	937,5
9	6,20	890,6	6,20	792,2	6,30	937,5	24	6,20	1007,8	6,20	890,6	6,30	843,8
10	6,20	703,1	6,20	735,9	6,30	937,5	25	6,20	1134,4	6,20	750	6,30	890,6
11	6,20	1167,2	6,20	759,4	6,30	937,5	26	6,20	956,3	6,20	890,6	6,30	890,6
12	6,20	1031,3	6,20	895,3	6,30	843,8	27	6,20	1129,7	6,20	656,3	6,30	890,6
13	6,20	885,9	6,20	895,3	6,30	890,6	28	6,20	1054,7	6,20	750	6,30	937,5
14	6,20	895,3	6,20	946,9	6,30	843,8	29	6,20	815,6	6,20	900	6,30	890,6
15	6,20	1101,6	6,20	778,1	6,30	937,5	30	6,20	1134,4	6,20	885,9	6,30	843,8

The experimental results presented in Table 3 indicate a certain degree of imbalance in the level of partial discharge phases. In conditions a rated voltage of 12,3 kV at the generator terminals, we notice a low level of partial discharge 703,1 pC on phase A, reaching value of 1171,9 pC on phase A respectively C.

Table 4. Results of the level of partial discharges for U_{line}=14kV

No.	Phase A		Phase B		Phase C		No.	Phase A		Phase B		Phase C	
	U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]		U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]
1	7,10	1359,4	7,20	1218,8	7,20	3093,8	16	7,10	1359,4	7,20	1312,5	7,20	1031,3
2	7,10	1265,6	7,20	1031,3	7,20	2812,5	17	7,10	843,8	7,20	1031,3	7,20	2953,1
3	7,10	1218,8	7,20	1031,3	7,20	1453,1	18	7,10	1453,1	7,20	1406,3	7,20	1875
4	7,10	1593,8	7,20	1031,3	7,20	1078,1	19	7,10	1031,3	7,10	1031,3	7,20	2343,8
5	7,10	1781,3	7,10	843,8	7,20	3046,9	20	7,20	7218,8	7,20	984,4	7,20	1406,3
6	7,10	1312,5	7,20	1125	7,20	2296,9	21	7,10	1312,5	7,20	1031,3	7,20	11953,1
7	7,10	1031,3	7,20	796,9	7,20	4921,9	22	7,10	1406,3	7,20	1031,3	7,20	2250
8	7,10	1312,5	7,20	1031,3	7,20	2109,4	23	7,10	1078,1	7,20	890,6	7,20	1687,5
9	7,10	1312,5	7,20	1031,3	7,20	1406,3	24	7,10	11953,1	7,10	937,5	7,20	2296,9
10	7,10	1265,6	7,20	1031,3	7,20	2437,5	25	7,10	1078,1	7,10	1031,3	7,20	3609,4
11	7,10	1453,1	7,20	843,8	7,20	1546,9	26	7,10	1312,5	7,10	1031,3	7,20	3000
12	7,10	1453,1	7,20	890,6	7,20	1687,5	27	7,10	843,8	7,10	890,6	7,20	3000
13	7,10	1312,5	7,20	890,6	7,20	2343,8	28	7,10	1078,1	7,10	1312,5	7,20	1640,6
14	7,10	1312,5	7,20	1078,1	7,20	2671,9	29	7,10	1312,5	7,20	937,5	7,20	1500
15	7,20	1640,6	7,20	937,5	7,20	1312,5	30	7,10	1031,3	7,10	1031,3	7,20	1828,1

The experimental results presented in Table 4 indicate a certain degree of imbalance in the level of partial discharge phases. In conditions a rated voltage of 14 kV at the generator terminals, we notice a low level of partial discharge 843,8 pC on phase A and B, reaching value of 11953,1 pC on phase C.

Table 5. Results of the level of partial discharges for U_{line}=15kV

No.	Phase A		Phase B		Phase C		No.	Phase A		Phase B		Phase C	
	U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]		U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]
1	7,60	5296,9	7,60	4125	7,70	11953,1	16	7,60	3375	7,60	3140,6	7,70	2625
2	7,60	11953,1	7,60	3843,8	7,70	6796,9	17	7,60	5484,4	7,60	3703,1	7,70	2484,4
3	7,60	4781,3	7,60	2203,1	7,70	2812,5	18	7,60	3421,9	7,60	3046,9	7,70	1359,4
4	7,60	6703,1	7,60	1687,5	7,70	2625	19	7,60	2859,4	7,60	3796,9	7,70	2250
5	7,60	5062,5	7,60	2531,3	7,70	1546,9	20	7,60	3656,3	7,60	1781,3	7,70	2156,3
6	7,60	5812,5	7,60	4453,1	7,70	2296,9	21	7,60	4031,3	7,60	11953,1	7,70	2812,5
7	7,60	4875	7,60	2296,9	7,70	3468,8	22	7,60	8062,5	7,60	3421,9	7,70	3375
8	7,60	11953,1	7,60	3656,3	7,70	1312,5	23	7,60	11953,1	7,60	1734,4	7,70	1453,1
9	7,60	3375	7,60	2859,4	7,70	3562,5	24	7,60	2953,1	7,60	11953,1	7,70	2250
10	7,60	3281,3	7,60	3140,6	7,70	2062,5	25	7,60	11953,1	7,60	11953,1	7,70	1640,6
11	7,60	6000	7,60	1312,5	7,70	3984,4	26	7,60	5109,4	7,60	11953,1	7,70	1265,6
12	7,60	9562,5	7,60	3187,5	7,70	2671,9	27	7,60	2437,5	7,60	2812,5	7,70	2250
13	7,60	5718,8	7,60	11953,1	7,70	1781,3	28	7,60	3562,5	7,60	5765,6	7,70	2578,1
14	7,60	4359,4	7,60	1640,6	7,70	1406,3	29	7,60	2625	7,60	2062,5	7,70	11953,1
15	7,60	11953,1	7,60	3140,6	7,70	11953,1	30	7,60	4828,1	7,60	4453,1	7,70	8203,1

The experimental results presented in Table 5 indicate a certain degree of imbalance in the level of partial discharge phases. In conditions a rated voltage of 15 kV at the generator terminals, we notice a low level of partial discharge 1265,6 pC on phase C, reaching value of 11953,1 pC on all three phases.

Table 6. Results of the level of partial discharges for U_{line}=16kV

No.	Phase A		Phase B		Phase C		No.	Phase A		Phase B		Phase C	
	U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]		U_A [kV]	PD_A [pC]	U_B [kV]	PD_B [pC]	U_B [kV]	PD_B [pC]
1	8,00	11953,1	8,00	3703,1	8,10	2156,3	16	8,00	3468,8	8,00	3515,6	8,10	4218,8
2	8,00	3984,4	8,00	2578,1	8,10	3843,8	17	8,00	2578,1	8,00	2109,4	8,10	1968,8
3	8,00	11953,1	8,00	11953,1	8,10	4546,9	18	8,00	3468,8	8,00	2343,8	8,10	3375
4	8,00	1453,1	8,00	11953,1	8,10	5296,9	19	8,00	1593,8	8,00	2953,1	8,10	5250
5	8,00	11953,1	8,00	3468,8	8,10	2859,4	20	8,00	11953,1	8,00	3375	8,10	4359,4
6	8,00	8156,3	8,00	8250	8,10	4359,4	21	8,00	2578,1	8,00	5625	8,10	5484,4
7	8,00	11953,1	8,00	3421,9	8,10	2484,4	22	8,00	11953,1	8,00	4921,9	8,10	11953,1
8	8,00	11953,1	8,00	2578,1	8,10	2296,9	23	8,00	11953,1	8,00	3750	8,10	11953,1
9	8,00	6093,8	8,00	3046,9	8,10	2437,5	24	8,00	11953,1	8,00	2250	8,10	7875
10	8,00	11953,1	8,00	3890,6	8,10	4734,4	25	8,00	1828,1	8,00	3562,5	8,10	11953,1
11	8,00	11953,1	8,00	2718,8	8,10	3750	26	8,00	1453,1	8,00	1734,4	8,10	11953,1
12	8,00	11953,1	8,00	2203,1	8,10	4406,3	27	8,00	11953,1	8,00	1921,9	8,10	10781,3
13	8,00	11109,4	8,00	3750	8,10	2625	28	8,00	11953,1	8,00	4078,1	8,10	11953,1
14	8,00	3234,4	8,00	3187,5	8,10	2203,1	29	8,00	11953,1	8,00	3140,6	8,10	4921,9
15	8,00	2906,3	8,00	2671,9	8,10	2671,9	30	8,00	7593,8	8,00	3656,3	8,10	4453,1

The experimental results presented in Table 6 indicate a certain degree of imbalance in the level of partial discharge phases. In conditions a rated voltage of 16 kV at the generator terminals, we notice a very high level of partial discharge 1593,8 pC on phase C, reaching value of 11953,1 pC on phases A and C.

The measurement results of the level of partial discharges for the average values of voltage are given in the Table 7 and in Figure 3, where is presented the average values of partial discharges levels on the three phases for: U_{line} = 4 kV; U_{line} = 8,1 kV; U_{line} = 12,3 kV; U_{line} = 14 kV; U_{line} = 15 kV; U_{line} = 16 kV.

Table. 7 Average values for the partial discharges

Average values for U_{line} [kV	Phase A		Phase B		Phase C	
	U_A [kV]	DP_A [pC]	U_B [kV]	DP_B [pC]	U_C [kV]	DP_C [pC]
4	2,10	382,33	2,10	324,99	2,11	332,20
8.1	4,20	841,27	4,20	588,60	4,30	627,05
12.3	6,20	1019,69	6,20	826,87	6,30	896,88
14	7,11	1831,26	7,17	1023,46	7,20	2553,14
15	7,60	5900,01	7,60	4518,75	7,70	3629,69
16	8,00	8026,56	8,00	3943,75	8,10	5437,51

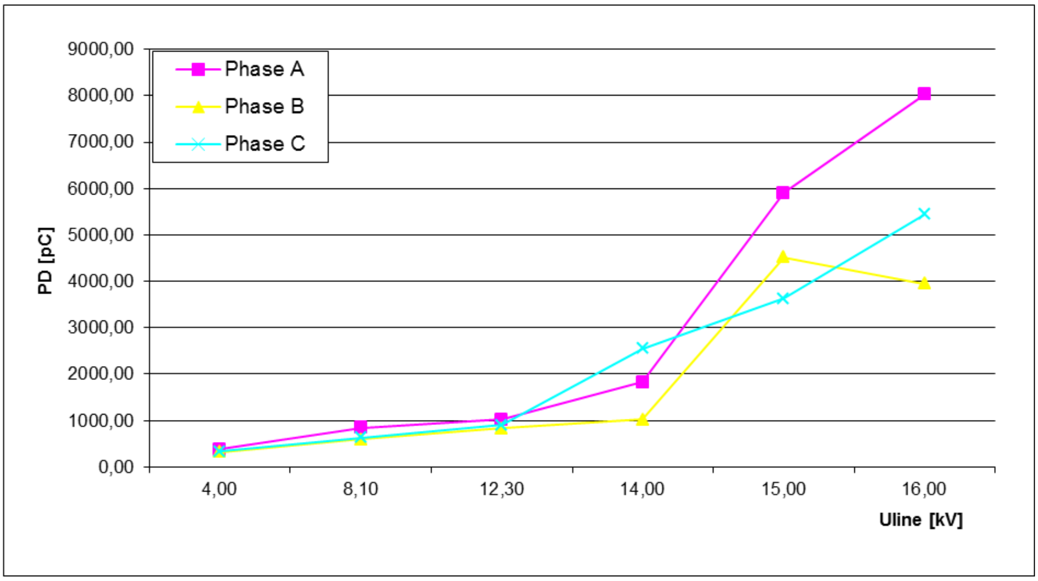

Figure 3. The partial discharges levels on the three phases

In Figure 3 we notice am increase in the level of partial discharge, according to the applied tension at the generator terminals, that is a sudden increase for the tension value at the generator terminals starting at U_{line}=14kV, especially on phase A and a slow increase of the tentsion at the generators terminals between U_{line}=4kV and U_{line}=14kV.

The results of the measurements presented in Figure 4 highlights degradations of the generators tested coiling, especially on phase A, in case in which the level of partial discharges surpasses a lot the recommended value of 1000 pC. This fact is due to the high degree of condense on the cooling conducts passing above the rotor.

For each different values of the line tension, there have been measured on the 3 phases of the hydro- generator: the partial discharges and the temperatures (upper radial bearing temperature, axial bearing temperature, inferior radial bearing temperature, turbine bearing temperature and ambient temperature), their values being inscribed in Table 8.

Table. 8 Average values of partial discharges and temperatures at different values of the line tensions

Uline [kV]	DPA [pC]	DPB [pC]	DPC [pC]	L.R.S. [^{O}C]	L.A.X. [^{O}C]	AIR [^{O}C]	L.R.I. [^{O}C]	L.T. [^{O}C]
4	382,33	324,99	332,20	51.87	63.66	27.8	49.8	45
8.1	841,27	588,60	627,05	52	63.8	27.5	50.2	46
12.3	1019,69	826,87	896,88	52	64	27.3	50.2	48.5
14	1831,26	1023,46	2553,14	52.25	64	27.7	50.4	50
15	5900,01	4518,75	3629,69	52	64	28.3	50.4	51
16	8026,56	3943,75	5437,51	52.37	64	28.7	50.4	51.5

For the measure of the coiling temperature, is placed between the bars of some of the coils thermoresistances, placed in the most requested thermal points.

For the measure of the bearing temperature, the sensors are placed in some of the segments, as well as in the bearing bath, thermoresistances. The transducer is part of plant monitoring of the boiler and is introduced into the oil bearing bath. In Figure 4, the average value of the partial discharge levels is represented graphically on the three phases according to the radial upper bearing temperature.

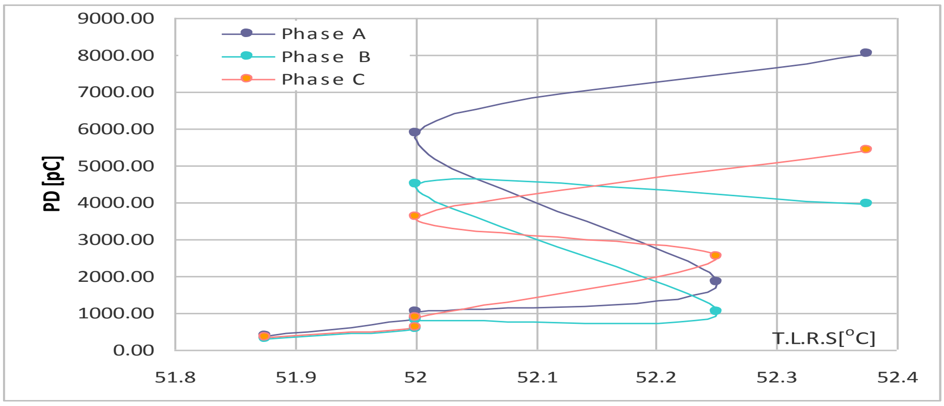

Figure 4. Radial upper bearing temperature

In Figure 5, the average value of the partial discharge levels is represented graphically on the three phases according to the axial bearing temperature.

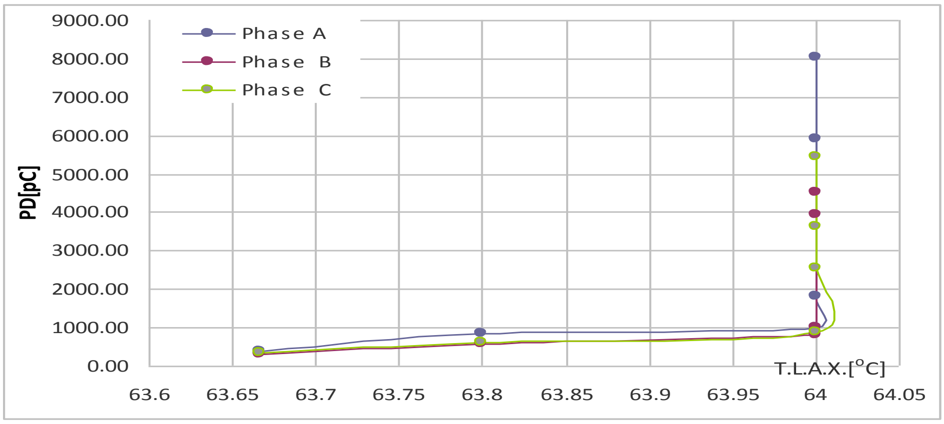

Figure 5. Axial bearing temperature

In Figure 6, the average value of the partial discharge levels is represented graphically on the three phases according to the inferior radial bearing temperature.

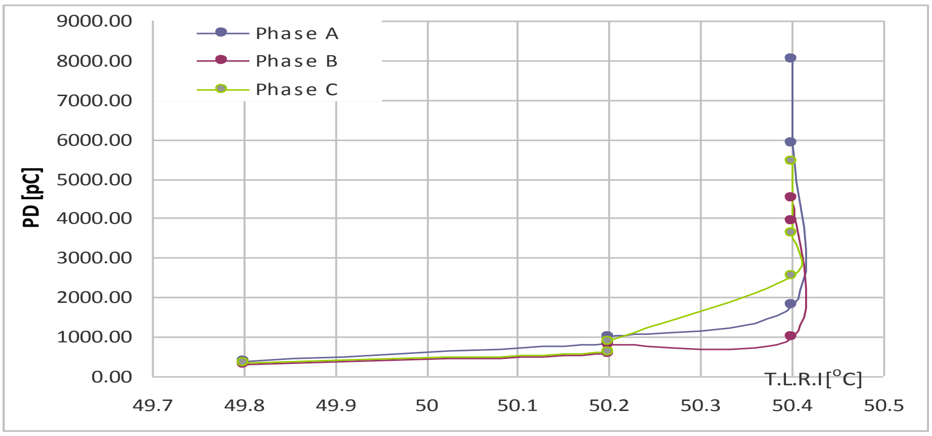

Figure 6. Inferior radial bearing temperature

In Figure 7, the average value of the partial discharge levels is represented graphically on the three phases according to the turbine bearing temperature.

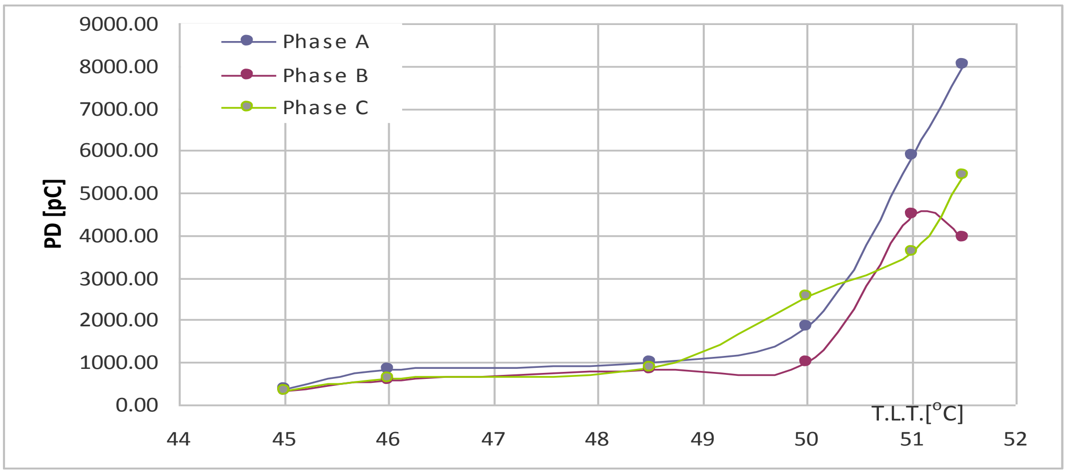

Figure 7. Turbine bearing temperature

To measure the ambient temperature, the sensor was mounted on a stem support at a height of 1.5 m in the generator fosse. In Figure 8, the average value of the partial discharge levels is represented graphically on the three phases according to the ambient temperature.

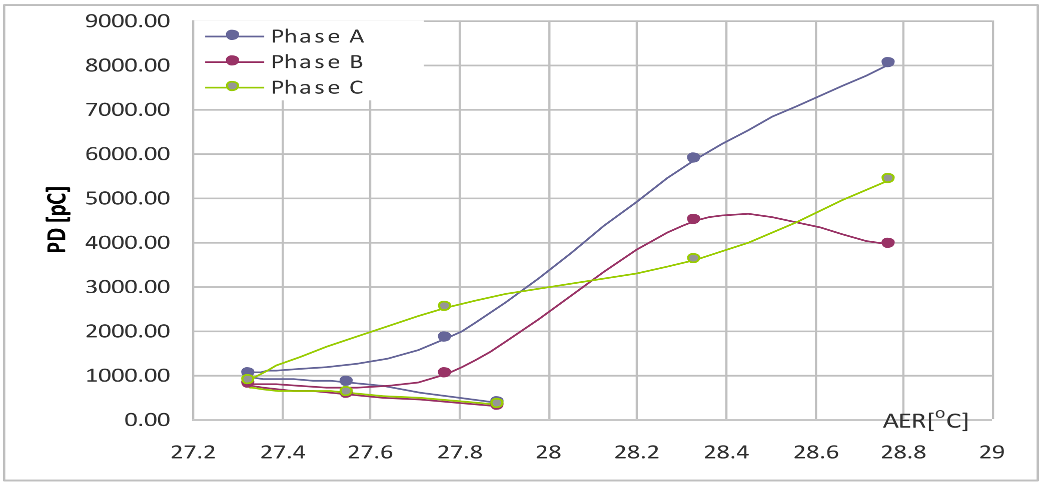

Figure 8. Ambient temperature

From Figure 8, it is observed that the average value of the partial discharge levels on the three phases increases approximately linearly, and the temperature variation is small.

From Figures 4,5,6 and 7, it is observed that the average value of the partial discharge levels on the three phases increases a lot, although the temperature variation on upper radial bearing, axial bearing, inferior radial bearing respectively turbine bearing is very low. This is because the voltage applied to the generator terminals is greater than 14 kV.

4. Conclusions

The Figure shows that for small values of line tension (up to 12,3kV), the partial discharges increase linearly with the temperature up to 1000 pC.

The Figure 3 shows that for high line tension (over 14 kV), the partial discharges increase sharply reaching a average value of 8026,56 pC. Note that although partial discharges have a sudden increase, the temperatures vary little.

One has observed, by measurement, that if the partial discharges increase linearly (for higher values of 1000 pC), depending on the temperature for different voltages, then the hydro- engine can be used safely.

It is noticed that the temperature in the cavity does not change, but there is a temperature gradient that increases with the partial discharge level, which means that the microcavity becomes a source of heat. Measurement of partial discharges found application as a test design, quality assurance test and condition evaluation test for high-voltage equipment.

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