AUTOMATIC CLEANING MACHINE FOR RF POWER COUPLERS*

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Abstract

Couplers are technological devices that permit RF power matching between RF source and cavities. An high cleaning quality requirement especially for the coupler cold part directly linked to the cavity is needed. Even if the actual coupler preparation procedure at LAL works well, contamination risks remain due to the handling, no repeatability and a too long time duration (5 days) which is not acceptable for machines like ILC where around 16000 couplers would be prepared.

Our challenge is to suppress these weak points, in designing an automatic coupler cleaning machine which give us a lower contamination risk, a full repeatability of the cleaning and only 3 hours of process.

INTRODUCTION

Couplers are technological devices that permit RF power matching between RF source and cavities.

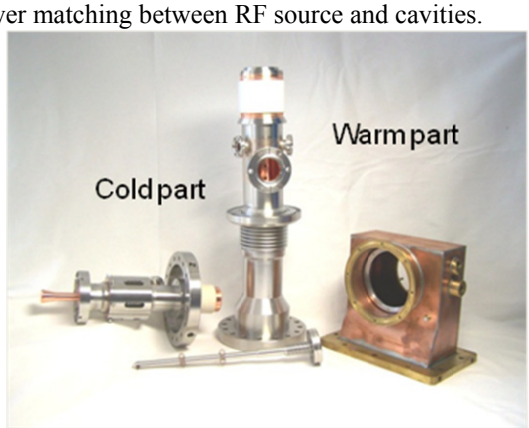

Figure 1: Coupler parts.

As couplers (Fig. 1) are directly plugged on cavities, they have a very high cleaning quality requirement in term of particles contamination. To satisfy this requirement, the following process [1] has been developed: ultrasonic bath in clean room class 1000 with detergent and warm (60°C) Ultra-Pure Water (UPW) for 15 minutes. Then pieces are rinsed by hand with a check of the rinsing water resistivity. After these 2 steps, the pieces are placed on a bench in the clean room class 10 for drying (a minimum of 72 hours of drying is needed). At the end, before mounting, a particle counting is done in order to certify the cleanness of the couplers.

The weak points of the actual cleaning procedure are:

- Contamination risks due to the handling
- No repeatability
- Too long time duration: 5 days

These points are not acceptable for coupler mass production (ILC) where around 16000 couplers would be prepared.

The solution is to use an automatic cleaning system with:

- No handling
- Full repeatability and control of each parameters
- Shorter time duration: 3 hours

Unfortunately, this kind of machine is not available in the industry. Our project is to make one in order to prove that it is possible to clean couplers automatically for mass production.

THE MACHINE

The Process

A cleaning cycle includes the following steps:

- Ultrasonic cleaning with hot UPW & detergent
- Rinsing and resistivity measurement
- Drying with filtered N2 and humidity measurement

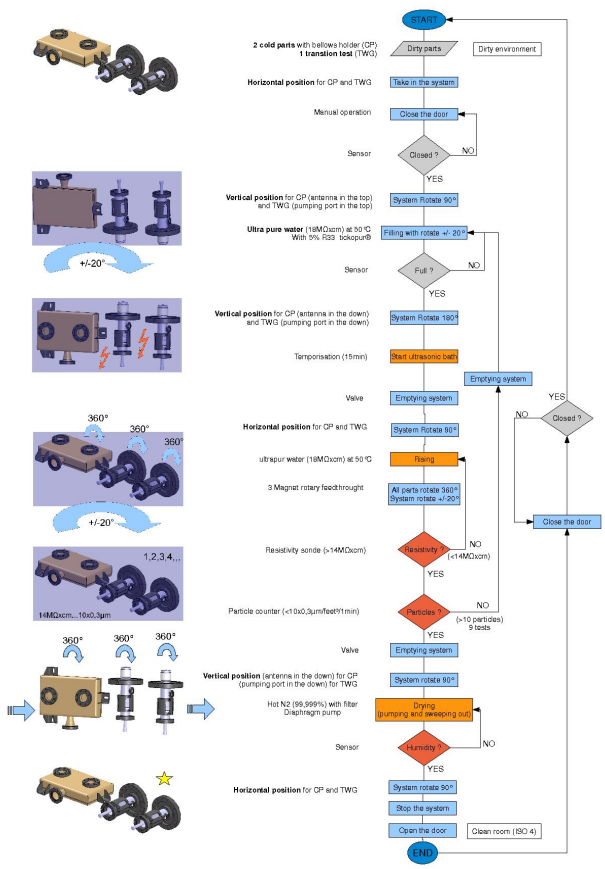

Figure 2: Cleaning steps overview.

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The Design

In order to avoid contamination of the clean parts and to waste time in getting the inside of the clean room, we decided to design a machine able to be loaded with dirty parts from outside and to be unloaded after cleaning from the ISO4 clean room.

Moreover, as shown on Figure 2, the process needs two rotations: one around the coupler axis and the other able to put the antenna up and down. As movements may induce some mechanical frictions that could generate particles. That's why, we decided to do the second movement in moving the entire machine avoiding any link. For the first motion, we decided to use a magnetic coupling without contact in addition to a special design and material to guide the rotation, as shown below (Fig. 3).

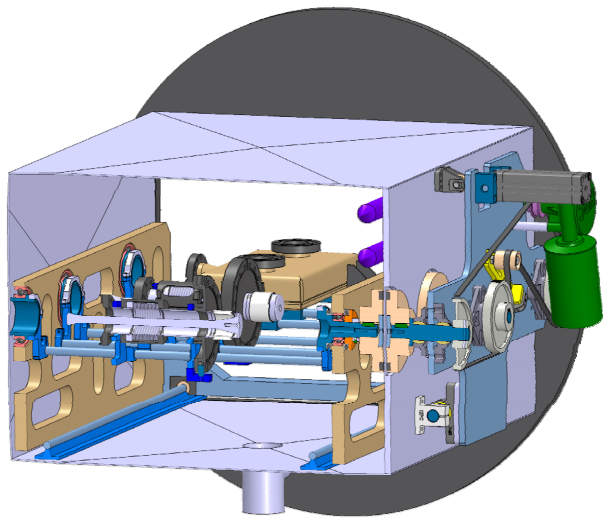

Figure 3: Machine overview.

The main challenge is to choose the right materials and to limit the contacts between the parts (ball bearing) to avoid system contamination (Fig. 4).

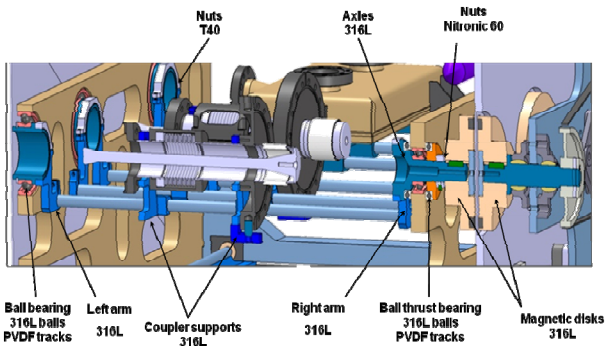

Figure 4: Rotating coupler holder overview.

Preliminary Tests for Validation

In order to measure the contamination due to the mechanical frictions during rotary holder motion, a test bench has been developed (Figs. 5 & 6). The test consists in a measurement of the number of particles before and after cleaning cycles.

The test conditions are the following:

- Ultrasonic bath: 2000 W , 40 kHz
- Water: UltraPureWater 18MΩ.cm² at 50°C
- Detergent: 5% Tickopur R33
- Time duration: 3 hours
- Acceptance criterion for coupler cold part: nb of particles <10 particles of 0.3µm per foot ³ during 1min

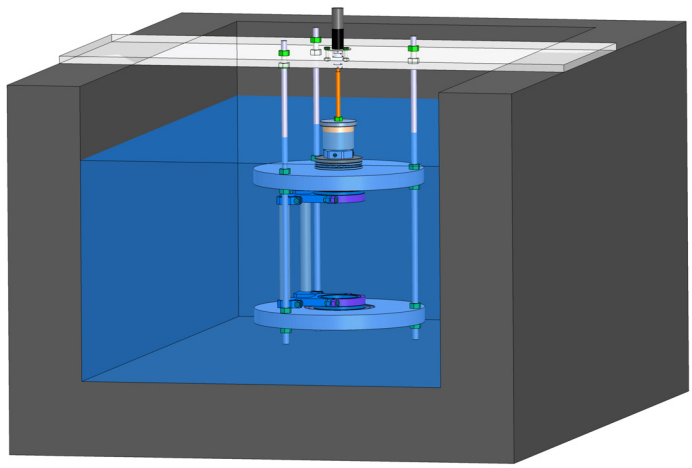

Figure 5: Design of the test bench in ultrasonic bath.

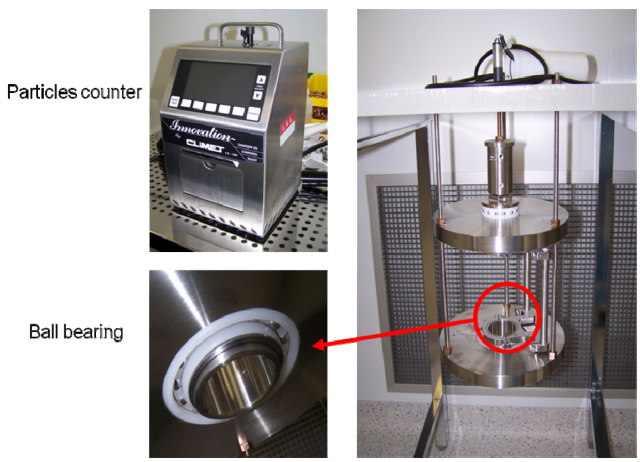

Figure 6: Test bench in ISO 4 clean room.

	ID= 1			COMPT.TOTAL		VOL ECHANT= 1.0 P3			
HEURE	> 0.3	> 0.5	> 1.0	> 5.0	>10.0	>25.0	HR	TEMP	DBIT
14:16:48	0	0	0	0	0	0	32.8	20.6	0.99
	ID= 2			COMPT.TOTAL		VOL ECHANT= 1.0 P3			
HEURE	> 0.3	> 0.5	> 1.0	> 5.0	>10.0	>25.0	HR	TEMP	DBIT
14:19:00	6	2	1	1	0	0	32.4	20.6	0.99
	ID= 3			COMPT.TOTAL		VOL ECHANT= 1.0 P3			
HEURE	> 0.3	> 0.5	> 1.0	> 5.0	>10.0	>25.0	HR	TEMP	DBIT
14:21:11	6	3	0	0	0	0	32.0	20.8	0.99
	ID= 4			COMPT.TOTAL		VOL ECHANT= 1.0 P3			
HEURE	> 0.3	> 0.5	> 1.0	> 5.0	>10.0	>25.0	HR	TEMP	DBIT
14:23:20	5	2	0	0	0	0	31.6	21.0	0.99

Figure 7: 4 Tests before cleaning phase.

	ID= 1			COMPT.TOTAL		VOL ECHANT= 1.0 P3			
HEURE	> 0.3	> 0.5	> 1.0	> 5.0	>10.0	>25.0	HR	TEMP	DBIT
14:34:41	1	1	1	0	0	0	32.0	21.4	0.99
	ID= 2			COMPT.TOTAL		VOL ECHANT= 1.0 P3			
HEURE	> 0.3	> 0.5	> 1.0	> 5.0	>10.0	>25.0	HR	TEMP	DBIT
14:36:51	4	1	1	0	0	0	31.6	21.4	0.99
	ID= 3			COMPT.TOTAL		VOL ECHANT= 1.0 P3			
HEURE	> 0.3	> 0.5	> 1.0	> 5.0	>10.0	>25.0	HR	TEMP	DBIT
14:41:03	12	3	1	0	0	0	30.8	21.7	0.99
	ID= 4			COMPT.TOTAL		VOL ECHANT= 1.0 P3			
HEURE	> 0.3	> 0.5	> 1.0	> 5.0	>10.0	>25.0	HR	TEMP	DBIT
14:44:17	0	0	0	0	0	0	30.4	21.7	0.99

Figure 8: 4 Tests after cleaning phase.

As shown in Figures 7 & 8, the test results (before and after the cleaning cycle) are promising, only a measure was just over 10 particles. Further tests are planned to get reliable statistics and to insure that the system will not pollute couplers.

These tests are determinant for the project, because they are the last before the manufacturing of the full machine.

CONCLUSIONS AND OUTLOOKS

The Automatic Cleaning Machine will permit the preparation steps improvement and the decrease of their time duration. Preliminary tests shown that in despite of mechanical frictions, the amount of generated particles should be below to the acceptance value (<10 particles of 0.3µm per foot ^{3} during 1min). If the further tests are successful, the entire machine would be manufactured by the end of the year.

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REFERENCES

[1] L. Grandsire, 'List of Preparation and Assembly Operations for two TTF3 Couplers on their Test Bench' May 2005.