

# LESSON LEARNED ON THE MANUFACTURING OF FUNDAMENTAL POWER COUPLERS FOR THE EUROPEAN XFEL ACCELERATOR

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## Abstract

In this paper, we described lessons learned during the production of Fundamental Power Coupler (FPC) for the European XFEL accelerator and different steps necessary to obtain a rate of 8 couplers a week, from the manufacturing of individual components up to the RF conditioning. This document also proposes some possible ways to be optimized for a future mass production of such components. With comparison of processes and adaptation which could benefit to an increase rate or a more secure program. Some of them, which could be studied from the coupler definition to the manufacturing process in order to obtain a stable and possible increase rate or lower cost of production by decreasing risks on programs. This analysis is based on a current production of more than 500 couplers, see Fig. 1.

## INTRODUCTION

For the European XFEL accelerator, 670 fundamental power couplers are under manufacturing by Thales and RI Research Instruments[1].

These couplers are RF conditioned by LAL in Orsay before being sent to Saclay for Cryomodule integration[2].

The main metallic sub-assemblies of a coupler are the Warm External Conductor (WEC), Warm Internal Conductor (WIC), The Cold External Conductor (CEC) and the antenna, as illustrated on Fig. 2.

The two other critical components are the two cylindrical ceramics.

For the fundamental power coupler production a weekly rate of 10 couplers a week has been demonstrated over few months.

A current production of more than 500 couplers delivered to LAL (Laboratoire de l'Accélérateur Linéaire) has been achieved.

Ramp up for such a rate is a fundamental parameter to be considered by experience on the XFEL FPC program.

This ramp up period is needed in order to solve the following issues:

- Common understanding and sharing on visual acceptance criteria for each individual production phase.
- Stability of manufacturing process.

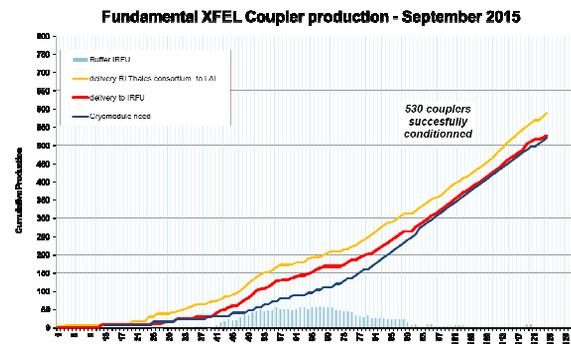


Figure 1: FPC production status.

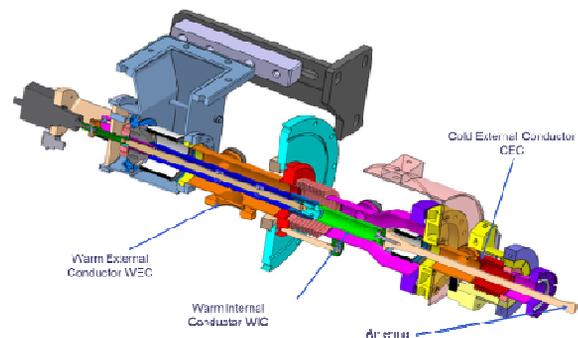


Figure 2: Coupler general layout.

## VISUAL INSPECTION CRITERIA

Visual inspection criteria process shared with all participants of such a program is one of the major lessons learned during the XFEL FPC production.

Objective and measurable criteria are to be shared between all parties involved in the production program.

Often some of the visual acceptance criteria given in specifications are difficult to be understood commonly. As example of such criteria if copper coating quality is defined as “special attention to the aspect”, this criterion is not measurable and could be interpreted differently by operators.

This is the reason why it is of the most importance to define commonly such criteria. For the XFEL FPC

production such documentation has been established which define:

- Magnification of the optical used for inspection
- Table of measurable elements which can be accepted or not
- Pictures illustrating these elements.

As an example, Table 1 and Figure 3 illustrate such documentation for peeling on one of the flange of the coupler.

This kind of illustration has been implemented for all kind of non-measurable visual aspect and/or defect on copper coating.

It is also very important to have the same sharing analysis independently of the operator.

Table 1: Example on Table for the Definition

1	Copper coating edge peeling on CF100 flange	acceptable	If peeling is removed and no transfer with adhesive tape is observed. (copper coating remaining under CF100 gasket circumference)
		Not acceptable	Peeling not removed or copper coating outside CF100 gasket circumference.

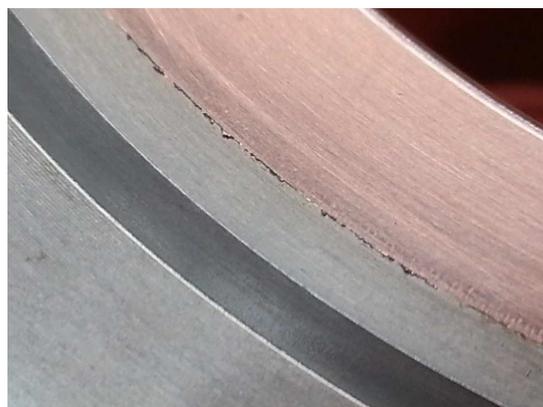


Figure 3: Illustration of the defect.

## MANUFACTURING IMPROVEMENTS

### Sub-Assemblies Preparation

For metallic sub-assemblies like WEC, WIC and CEC, brazed technology is used. This choice has been done for the following advantages respect to welding process:

- No operator dependence on the process
- Repeatability of the manufacturing
- Possibility to do this kind of assembly by batches improving the overall capability on production.

This process needs a longer preparation and validation before starting full production.

### Copper Coating

In order to obtain copper coating with a repetition quality enough for each piece a strong validation phase of automatic coating and process have been established. Even with a strict control of parameters and tooling, yields of production need to be improved.

### Dispersion on Parameters

For a mass production we learned that final parameter could still have some dispersion, even with a strict control on all parameters.

For example on a sample measurements and real pieces measurement a significant dispersion on measurement for the RRR value has been observed, as in Fig. 4.

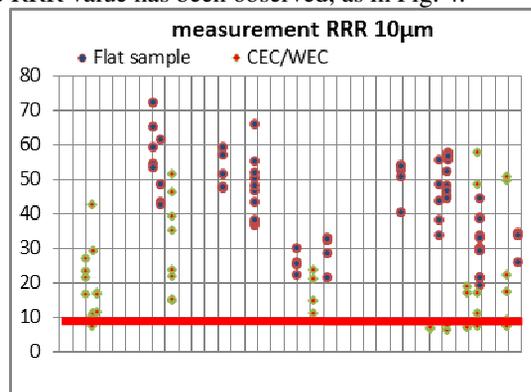


Figure 4: RRR measurement on samples.

Such dispersion is still unclear, not only between sample and real pieces, but also dispersion is observed within the same sub assembly.

## POSSIBLE WAYS TO INCREASE RATE

For an increase rate of production some possible improved parameters could be studies:

Remaining processes which are still operator dependant could be replaced by automatic sequences.

Among these welded ports or EBW are the ones which could be improved for coupler manufacturing.

- Influence on TiN coating, thickness, diffusion and stoichiometric, for a brazing process, other material than TiN[3].
- Chemical process for a copper plating which could maintain a RRR value after brazing

Some more studies could be done in order to have a clear understanding on remaining parameters dispersion or their measurements.

Another way could be done also by a simplification of the design or by relaxing some parameters specification. As an example, thickness of copper coating could be relaxed in some parts of couplers.

### CONCLUSION

Thales and RI Research Instruments have demonstrated the capability to have a production rate of 10 couplers a week for the European XFEL accelerator. Several key manufacturing processes and control have been refined during the production.

Several ways for an improve rate of production could still be foreseen.

### ACKNOWLEDGEMENT

We want to acknowledge all the operators involved in the current manufacturing process of FPC for the European XFEL accelerator.

We want also to acknowledge W.Kaabi, A.Gallas from LAL and D.Kostin, W.D.Moeller from DESY for their fruitful collaboration and advices in the manufacturing process

### REFERENCES

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