Industrialization process

Power couplers for XFEL project as an example

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Industrialization: Why?

Start: Prototypes (30 Couplers)

Industrialization process

End: Large series (1000 Couplers)

| Quality:       | - uneven                        |
|               | - random anomalies              |
| Manufacturing: | - long and difficult            |
|               | - lack of procedure             |
|               | - only a few people have the competence |
| High cost     |                               |

| Quality:       | - equal for all items          |
|               | - reliable                     |
| Manufacturing: | - regular process              |
|               | - written procedures           |
|               | - standard competence          |
| Lower cost     |                               |
Industrialization: What for?

Objectives:
1. To improve the quality
2. To define precisely:
   - all manufacturing processes
   - the control plan for quality assurance
   - the necessary equipment
   - the competences and the people
   - the manufacturing sequences
   - the schedule
   - the room space needed for all steps
   - the costs
   - the risks (technical, of procurement, financial)
3. To reduce the manufacturing costs
Before industrialization: specifications changes

- 4 diagnostics removed
- motorized tuning

TTF-3 Coupler

XFEL Coupler
Before industrialization: final design

Review drawings of each component in terms of tolerances
Analysis of each function results in:

- options for design
- options for material
- options for geometry
- options for components junctions

Each option has to be investigated in terms of:

- performance compatibility
- feasibility
- availability
- cost
→ Simplify concept

Example: Cold external conductor

Present design: bellows collars are machined + welded to standard bellows

Alternative: bellows including special collars are hydroformed together in 1 part
Industrialization: Topics of development -1-

→ Design for « manufacturability »

• Review existing design
• Identify the necessary functions
• Determine maximum acceptable tolerances
• Identify possible options for design
• Seek functional simplicity:
  • to minimise the number of parts
  • use standard products whenever possible
  • design for ease of assembly: several assembly solutions are possible, investigate and optimise
  • design for ease of control and test
  • design in view of packing and transport
Industrialization: Topics of development -2-

- Risk mitigation:
  - Assessment and re-design of areas at technical and process risk
  - Generation of product and process specifications
  - Update design

- Validation phase:
  - Modelling of component and process
  - Testing
  - Prototypes
  - Update design

- Other design topics to be considered:
  - reliability (of components, welds, coatings)
  - other risks (of procurement, logistics, financial)
  - MTBF, failure analysis (welds, windows, motions)
  - maintainability (easiness of replacement)
  - ergonomics (handling, assembly)
Industrialization: Check?

→ Iterative process after every change

Verification phase
Several possible new designs result from the functional analysis:

→ Verify that the desired specifications are fulfilled
→ Check the coherence of interfaces
→ Produce prototypes
→ Follow a test program
→ Analyze the results
→ Corrective actions if necessary
→ Decide on the final solution
→ Finalize Manufacturing Control Plan
For the XFEL power couplers, industrialization studies will be performed through “Definition contracts”:

- Essentially intellectual work (in dialog between the industry and our Lab):
  - Define all manufacturing processes (analysis and validation models)
  - Risk analysis (process, logistics)
  - Determine cost in series and justify
- Produce 2 prototypes (to be tested at LAL - Orsay)

**Particularities**

- 3 contracts will be awarded on the same subject: « Industrial studies »
- 2 teams will be selected after final evaluation
- contracts for manufacturing 2 series of 500 XFEL couplers will be awarded without a new call for tenders
- the 2 contracts may be awarded to a single company
Follow-up and evaluation of definition contracts

1. Continuous evaluation of performance
   - contracts will run simultaneously during 21 months
   - Regular progress reports
   - Continuous control of industry activity

2. Formal reviews are key points with delivery of documents, models and prototypes
   - SDR (System Design Review)
   - PDR (Preliminary Design Review)
   - CDR (Critical Design Review)
   - Final Review
Keypoints of the definition contracts

Contract Award:  $T_0$

Kickoff meeting:  soon after $T_0$

System Design Review:  $T_0 + 3$ months
  - functional analysis
  - identification of processes and proposal for models
  - preliminary development plan, management plan

Preliminary Design Review:  $T_0 + 8$ months
  - models for welding, brazing, specific materials, Cu coating
  - Quality assurance plan
  - development plan, management plan
  - Technical design review
  - preliminary risk analysis

Critical Design Review:  $T_0 + 14$ months
  - final models for validation of Cu coating
  - final justification design file
  - final risk analysis
  - preliminary cost analysis

Final Review:  $T_0 + 21$ months
  - delivery of 2 prototypes
  - plan for logistics of manufacturing and conditioning
  - final cost report
Deliverables for the definition contracts

1 - Technical reports: spread over 3 intermediate reviews (see time schedule)
- Conduct and comment all studies necessary for the fabrication of couplers, including TiN deposit
- Determine and explain the manufacturing processes, provide models for validation of each process
- Finalize and justify the mechanical design in view of lower cost in series and shorter time of assembly, evaluate risks
- Define and comment the sequences of assembly and conditioning of couplers, estimate time for assembly sequences
- Determine and comment the manufacturing logistics (in manpower, in building area) including conditioning, and evaluate difficulties and risks
- Establish a project management plan for the manufacturing in series:
  . PBS, WBS
  . interfaces
  . Cost control, time schedule control
  . Management of changes
  . Quality assurance
  . Risk management
  . Documentation control
- Establish a manufacturing schedule including conditioning and delivery

2 - Deliver validation models and 2 prototypes:
- models to validate each manufacturing process (welding, brazing, spinning, Cu coating, …)
- 2 prototypes assembled on test stand ready for conditioning:
  - already cleaned, baked, assembled, vacuum pumped and leak tested

3 - Financial report:
Objective: Commitment to a unit price in series, for 500 and for 1000 couplers
- Fill out a detailed price list including manufacturing, assembly and HF conditioning (Klystrons and modulators could be provided by the XFEL project), packing and transport on site
- Deliver a detailed report on price justification analysis