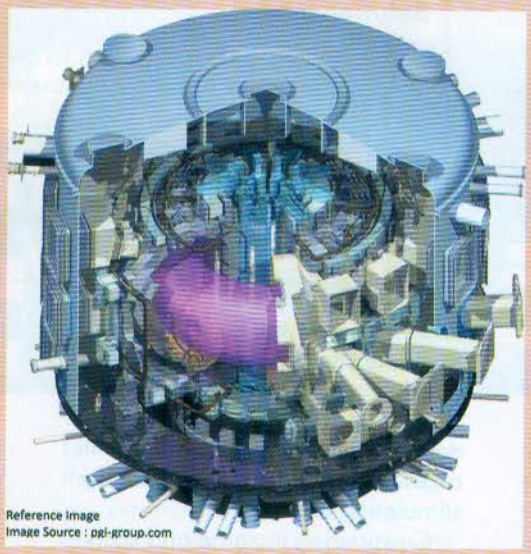
Innovative design thinking for nuclear fusion reactor

DesignTech works as a 'Mech-in-India' partner to the world's first nuclear fusion reactor. The company has had an opportunity to make valuable contributions in an internationally recognised multi-countries collaborative project of building world's first nuclear fusion reactor.

ITER (International Thermonuclear Experimental Reactor) is an international Body that comprises of 7 countries coming together to build one of its kind experimental nuclear fusion reactor.



Reference Image
Image Source : pri-group.com

India's involvement

The Government of India nominated and funded an Indian agency, Institute of Plasma Research, Ahmedabad, to manage and oversee the execution of part of the project that was assigned to India. This state funded agency, formed a separate subordinate organization, ITER-India to dedicatedly assign, manage, and review the tasks through the network of services partner vendors. ITER-India selected DesignTech as one of the partner vendors to work in the field of and furnish mechanical designs, and conduct Virtual validation of various systems and subsystems. DesignTech also had to extend the required manufacturing support and guidance to the systems manufacturing Partner in India. These sub-systems were to be designed and manufactured in India and structurally integrated into the main reactor to be installed in France.

Having been consigned with the responsibility of 'design-for-manufacturing', DesignTech had to evaluate manufacturing feasibility of the parts of the sub-systems designed, and work with the manufacturing partner accordingly to support and guide them in manufacturing planning and execution.

Scope of work

Some of the challenges involved were:

- **Lack of reference material:** Being the first of its kind project, there was no past reference material that could be used to understand and strategize the execution of such a vast and ambitious assignment. This being the world's first experimental nuclear fusion reactor, lot of studies had to be conducted, numerous 'what-if' and worst case scenarios had to be considered to anticipate and plan for the imminent challenges that could be encountered while executing this mammoth engineering venture.
- **Extensive collaboration:** It wouldn't be an exaggeration to say that this could very much be one of the biggest concurrent engineering assignments in the world; requiring extensive collaboration and collective efforts with the organizations in other countries and IO (International Office), in terms of apprising other partners with updates on tasks progressions, regular knowledge and data sharing about key insights, learnings, findings, deviations if any, and discussing consequent improvisation of execution plans and strategies.
- **Project management:** Concurrent engineering, manufacturing execution and reactor erection would require perfectly congruous tasks progression. Seamless implementation of the project entailed breaking down of big tasks to the tiniest of details and minutest of action items with frequent monitoring and inspection.

Parameters for selecting DesignTech

DesignTech was chosen through a bidding process and after conducting detailed technical capabilities evaluation.

Tasks delegated to DesignTech

DesignTech was selected as a mechanical design and engineering partner charged with the responsibility of working on detailed product engineering including design, virtual validation and design-for-manufacturing of various sub-systems.

This required DesignTech to contribute in design and development, analysis and simulation, geometric dimensioning and tolerances analysis, design-for-manufacturing and meeting compliances standards.

Design and development

DesignTech was given the task of ideation and conceptual designs of certain parts and components.

It was also responsible for preparation of detailed parametric and engineering designs through the

reference data provided by the Principal Body – keeping in mind design guidelines, packaging and manufacturing aspects, product performance objectives, and logistics consideration to transport the manufactured parts to France to be integrated in the mainframe of the Reactor

Analysis and simulation
It tasked with conducting detailed product design and engineering analysis through virtual tests and simulations to identify design fallacies or errors if any, evaluate systems functioning to predict failures and enhance performance.

Performing structural analysis and design optimisation was crucial to maintaining the overall structural integrity of the sub-systems so as to ensure and prevent any adverse causal compounding impact to the overall structure.

Design optimisation facilitated in streamlining agile and lean manufacturing processes through diligent use of resources thus helping to achieve greater operational efficiency.

The team of engineers had to use their expertise in the fields of advanced CAE applications such as electromagnetic analysis, thermal analysis, structural analysis (including static, modal and vibration analysis), piping simulations, and design-for-manufacturing for ensuring desired results and required quality output.

Geometric dimensioning and tolerances analysis
The team had to work within extremely strict tolerances that limited the scope of deflection or warpage to be contained within the specified target in few millimetres. To ensure this level of high precision and accuracy, the team had to work on critical geometric dimensioning. This required the team to design the special fixtures that would be fabricated into the sub-system to withstand the anticipated forces and loads under all conditions and circumstances. Manufacturing processes, assembly mechanisms, and design constraints with respect to the peripheral structure had to be meticulously deliberated while working on these fixture designs. The structure had to be considered in its entirety while working on one of its aspects, making it an intellectually stimulating exercise.

Considering the time and costs involved in reiterative designs and analysis processes, the team had to work on getting the designs right the first time, as the cost of error would be humongous.

Design-for-manufacturing
Optimal manufacturing processes had to be configured after careful study of product designs. Effects of manufacturing on the material properties of the products had to be also duly analysed to prevent design deviations. In case of anomalies, manufacturing process had to be revisited, and redefined to achieve the desired output.

Detailed manufacturing drawings had to be prepared and submitted to the other partner from India appointed by ITER-India that was tasked with the manufacturing responsibility. DesignTech worked closely with this Manufacturing partner to duly execute manufacturing operations based on the 'design-for-manufacturing' specifications of the sub-systems and fixtures that were worked out in conjunction with them.

Meeting compliances standards
The team had to abide by all the requisite and stringent international and nuclear design codes, norms and standards such ASME and EJMA.

Project duration
The team has worked on and supported this project for over 10 years. At any given point in time, a maximum of about 40 engineers were dedicatedly working on this pioneer project of international scrutiny

Feedback
DesignTech's contribution in this paradigm shifting engineering project was well appreciated by the Principal international body and associated industry fraternity. The success of this reactor would imply end to the world's energy crisis.

In a nutshell
DesignTech's involvement panned across and expanded beyond the stipulated sub-systems engineering design and advance CAE validation; traversing into the specialised areas of geometric tolerances studies, digital mock-up studies, manufacturing feasibility studies, and fixtures design for achieving greater structural robustness. IPF

PROJECT HIGHLIGHTS

Industry Type: Nuclear Power
Project Duration: 10 years
Engineers Involved: 40

Challenges:

- To design a large unique structure and validate it for untried nuclear grade material
- Deliver conceptual and manufacturable designs

Solutions:

- Use innovative design thinking for Structural Design
- Optimize product design using expertise in simulation suites to ensure absence of errors
- Use 'Design-for-Manufacturing' concept for flawless product installation and performance

Software: CATIA, HYPERMESH, ANSYS, Nastran, CFX FLUENT, Phanthom, and ECS