GAṆANAM (गणनम्)

HIGH PERFORMANCE *COMPUTING* NEWSLETTER

INSTITUTE FOR PLASMA RESEARCH, INDIA

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Thermal and Structural Analysis of Large Cryopumping Test Facility (LCTF)

Hemang S Agravat (SA-D, Exhaust and Fuelling Technology Development Division, IPR)
Email: hsagravat@ipr.res.in

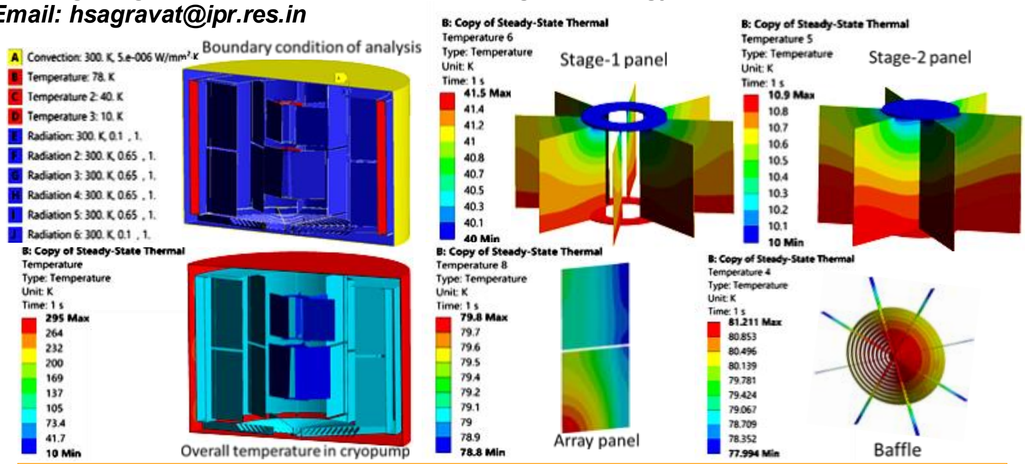


Figure 2: Thermal boundary condition and temperature gradient in cryopump and in its components.

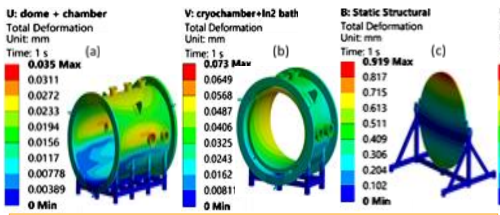


Figure 3: Total deformation in (a) test dome chamber, (b) Cryo-chamber, and (c) end flange with its support structure.

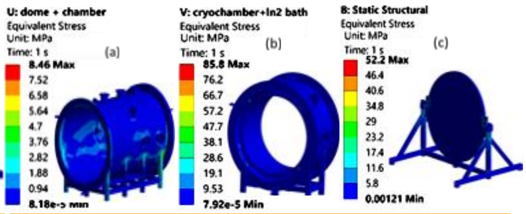


Figure 4: Equivalent stress in (a) test dome chamber, (b) Cryo-chamber, and (c) end flange with its support structure.

Vacuum chambers of large size are integral to various scientific applications, including space research, nuclear fusion, accelerator experiments, etc. These chambers operate within the High Vacuum (HV) to Ultra-High Vacuum (UHV) range, enabling specific scientific investigations. Notably, big experimental facilities [1-2] utilize large vacuum vessels for conducting precision experiments. To achieve the required vacuum levels in such large chambers, cryopumps offer an effective solution. A cryopump or a "cryogenic pump" is a vacuum pump that traps gases and vapors by condensing them on a cold surface. Cryopumps are capable of handling substantial gas loads consisting of air, water vapor, and small quantities of hydrogen and helium. Commercial cryopumps based on Gifford-McMahon (GM) Cryocoolers are widely used for various experimental and industrial purposes whereas for large cryo-pumping requirements, as seen in ITER [2], necessitate the use of liquid cryogen (liquid Nitrogen/liquid Helium) based cryopumps.

IPR developed various liquid nitrogen (LN_2) cooled cryo-sorption pumps for SST-1 tokamak and High Heat Flux Test facility at IPR and SAC-ISRO for the pumping of the water vapor and nitrogen/air [3-4]. However, they are not suitable for pumping hydrogen and helium gases. The pumping of these gases requires a sorbent coated panel temperature of ≤ 15 K for adsorption. To address this limitation, a new customized hybrid cryopump has been designed at IPR, combining liquid nitrogen cooling with a closed-cycle cryocooler to handle all gas loads. The cryopump, along with its American Vacuum Society (AVS) standard dome, is named as "Large Cryopumping Test Facility" (LCTF). Figure 1 provides a cross-sectional view of the LCTF. As compared to the liquid-helium-based-only cryopump used in ITER, LCTF is compact and has low running cost.

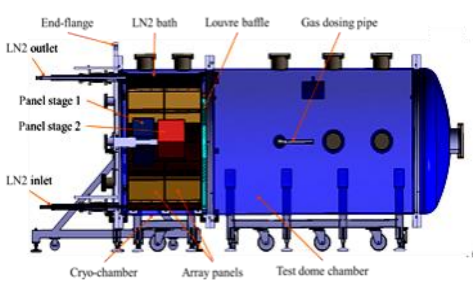


Figure 1: Cross-sectional view of the LCTF.

In this article, we discuss the thermal and structural analyses results performed for the optimization of the temperature, heat load, structural deformation, and stresses generated due to deformation of LCTF system using AnsysTM Workbench software (*Licensed version installed on ANTYA*). Steady-state thermal analyses were performed to estimate the heat loads. Figure 2 depicts boundary conditions, temperature gradient, and profiles in the components of LCTF. It can be seen that the temperature gradient is <1K for the array panels, and the edges facing the front baffle show a maximum temperature because of the transmitted radiation heat load through the baffle. The entire system is supported by three different stands, each consisting of square pipes measuring 70x70 mm^2 with a thickness of 5 mm.

> ***"Simulations on 2 HPC packs with 32 cores on ANTYA reduced the analysis time by over threefold compared to a regular workstation"***

Support pads will be welded to both the chamber and square pipes. Structural analysis was conducted to ensure the safe loading of the support stands. Figure 3 shows the total deformation, while Figure 4 displays the equivalent stress generated in the test dome chamber, cryo-chamber, and end flange system, respectively.

In summary, the article discusses the thermal and structural analysis of LCTF exploring the heat loads and stress limits for safe operation. The full published work can be accessed here [5].

References:

1. *A. Lahiri et. al. "Thermal Quality Assurance Aspects and a Strategy of Performance Evaluation of Thermal Soak of System Level Thermal Vacuum Test for Spacecraft" National Conference on Environmental Testing of Aerospace Systems – Advances & Future Trends (CETAS), October 11-12, 2019, Thiruvananthapuram, India.*
2. *"Vacuum Vessel," ITER; https://www.iter.org/mach/VacuumVessel*
3. *R. Gangradey et al. "Design and development of a liquid nitrogen cooled test cryopump for application in Steady-state Superconducting Tokamak-1", Vacuum 200 (2022) 110986.*
4. *S.S. Mukherjee et al. "Design and development of LN2 cooled cryopump for application in high heat flux test facility", Fusion Engineering and Design 184 (2022) 113315.*
5. *Hemang S Agravat, et al. "Thermo structural Analysis of Large Cryopumping Test Facility", FST ID: 2178252 DOI:10.1080/15361055.2023.2178252.*

The Need for Workflow Tools

Managing Large Scale Scientific Workloads in HPC

Workflows, essentially a series of interconnected tasks and processes, provide a systematic approach to orchestrate complex computations, data transfers, and dependencies in a streamlined manner in HPC environments. This article aims to shed light on the need for workflow tools for researchers in scaling their computational workloads to accelerate time-to-results and unlock new frontiers in scientific exploration.

What is a Workflow?

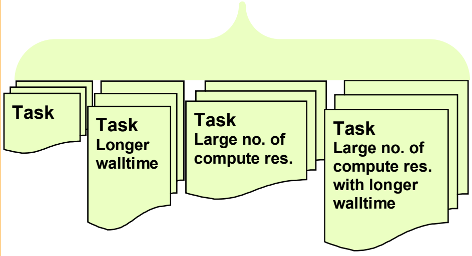
In the context of HPC, a workflow is simply a collection of computationally interconnected tasks to achieve the final result. Most HPC users use some type of workflow for their simulation work whether or not they call it that way.

What are Common Workflows?

Managing a Large Number of Tasks

⇒ Executing a large number of tasks

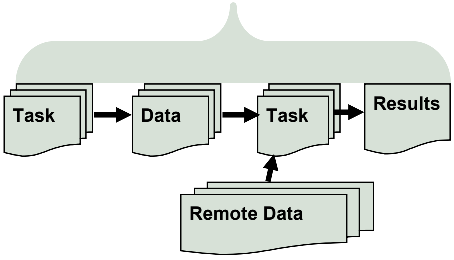
⇒ Tasks may have different resource need



Data Flow Integration Tasks

⇒ Tasks process and manipulate data

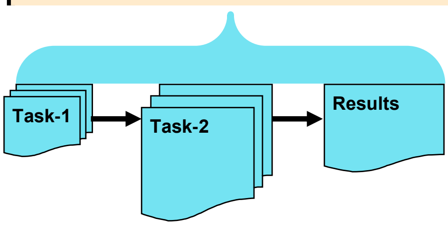
⇒ Tasks manage data remotely



Dependency Management Among Tasks

⇒ Interdependent tasks

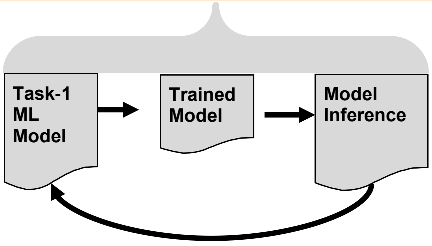
⇒ Tasks to be executed in appropriate order



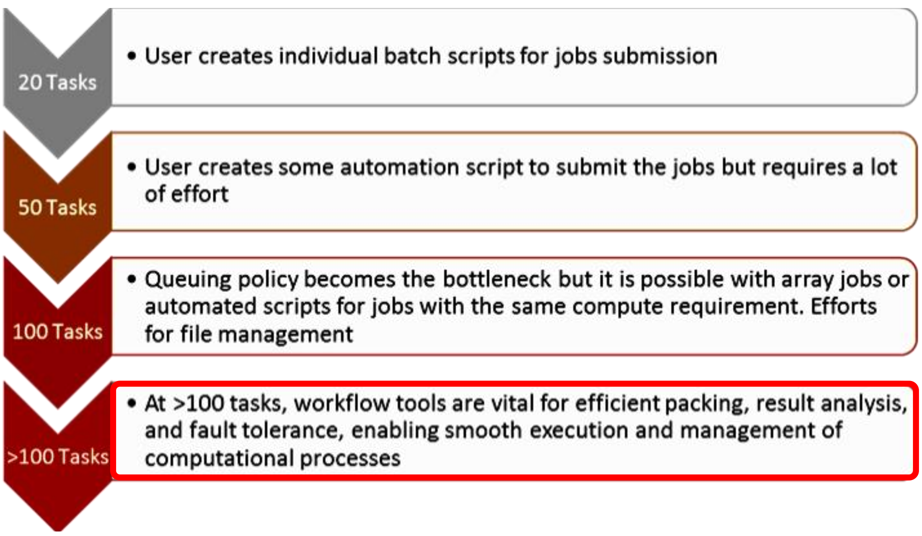
Dynamical Tasks Generation on Execution

⇒ Tasks generate new tasks dynamically

⇒ ML/AI tasks



When do Workflow Tools Become Necessary?



Popular workflow tools used in HPC environment will be covered in the next issue.

ANTYA UPDATES AND NEWS

1. New Packages/Applications Installed

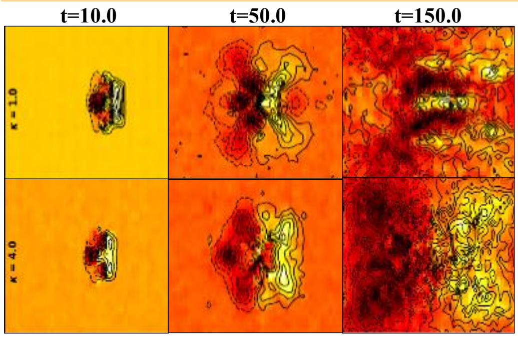
⇒ **Latest COMSOL Version**
COMSOL 6.1

⇒ **Modules compiled with gcc-11 version**
openmpi/gcc-11/4.0.1
hdf5/gcc-11.2/1.12.0

⇒ **XFIG Singularity image**
xfig.sig

HPC PICTURE OF THE MONTH

Time evolution of turbulent spot in a 3D Yukwa liquid



Pic Credit: **Suruj Kalita**

The figure shows the time evolution of a turbulent spot in a 3D Yukawa liquid on a horizontal plane at two different values of kappa (κ): 1 and 4. For κ = 1.0, the interaction range is larger compared to κ = 4.0. Initially (t = 10), the spot structures are similar, but as time progresses, streak-like structures surrounded by patch-like structures are observed for κ = 1.0, while only patch-like structures are observed for κ = 4.0. This difference arises because the system with κ = 1.0 is influenced by both large and small-scale flow dynamics, whereas the system with κ = 4.0 is governed solely by large-scale flow dynamics. The spot structure for κ = 1.0 closely resembles that obtained in hydrodynamics. For more information, refer to S Kalita, R Ganesh, Phys. Fluids 33, 095118 (2021).

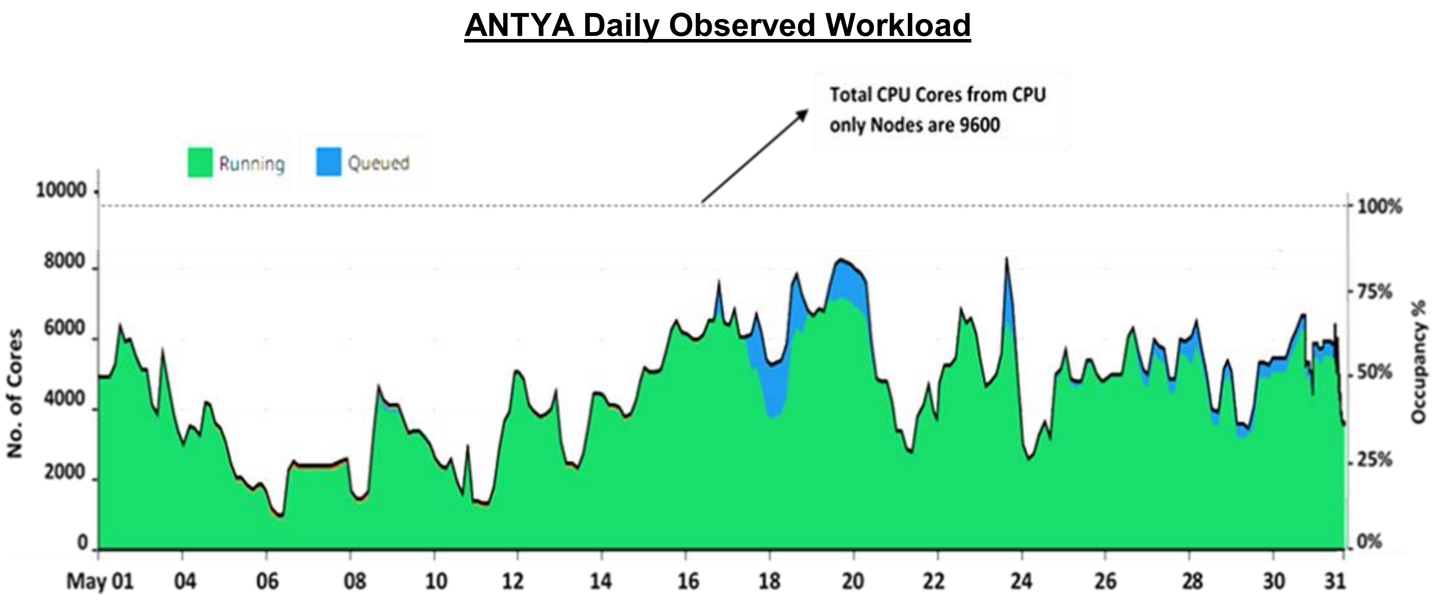
This figure is generated with the data obtained from MPMD-3D (inhouse code) simulation which took around 19 hours on 4 P100 GPU cards.

TIP OF THE MONTH

For transferring a file named "data.txt" from your local Linux machine to ANTYA home directory with username "user", rsync command will show the progress of the transfer percentage completed, data transferred, and estimated time of completion.

```
[user@login1 ~]$ rsync --progress data.txt user@antya.ipr.res.in:/home/user
```

ANTYA Utilization: MAY 2023



Other Recent Work on HPC (Available in IPR Library)

Effect of cluster size on the energy and angular distribution of electrons generated from laser-cluster interaction in an ambient magnetic field	Kalyani Swain
Trapping of wave in a flowing dusty plasma	Krishan Kumar
Breaking the Hexagonal Lattice Barrier: Experimental Achievement of Square Lattice Formation in 2D Dusty Plasma Crystal	Swarnima Singh
Safe disposal of different solid waste streams and energy recovery using thermal plasma technology	Sudhir Kumar Nema
Perturbed plane Couette flow in three-dimensional stably stratified Yukawa liquids	Suruj Jyoti Kalita
Role of translational noise on current reversals of active particles on ratchet	Anshika Chugh
Theory of plasma blob formation and its numerical and experimental validations	Nirmal K. Bisai
3D Computational Fluid Dynamics Analysis of PINI Ion Source Back Plate under high heat flux condition	Tejendrakumar Patel
Investigation of EDF evolution and charged particle transport in ExB plasma based negative ion sources using kinetic simulations	Dr. MIRAL ASHOKKUMAR SHAH

ANTYA HPC USERS' STATISTICS— MAY 2023

- Total Successful Jobs — **1950**
- Top Users (Cumulative Resources):
  - CPU Cores — Suruj Kalita
  - GPU Cards — Shishir Biswas
  - Walltime — Lucky Saikia
  - Jobs — Prince Kumar

Acknowledgement

The HPC Team, Computer Division IPR, would like to thank all Contributors for the current issue of *GAṆANAM*.

On Demand Online Tutorial Session on HPC Environment for New Users Available
Please send your request to ***hpcteam@ipr.res.in.***

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