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GAṆANAM (गणनम्)

HIGH PERFORMANCE *COMPUTING* NEWSLETTER

INSTITUTE FOR PLASMA RESEARCH, INDIA

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(3 Pages)

Simulation Study of Electromagnetic Launcher (EML) System Employing Double-Sided Linear Induction Motor (DLIM)

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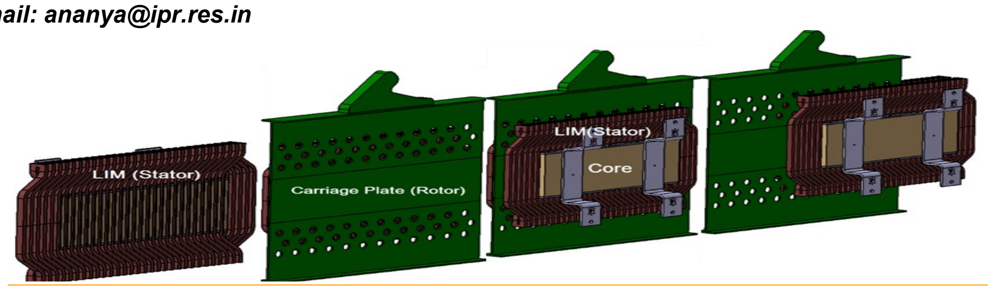


Figure 1: Schematic of the two vertically placed LIMs, each LIM having 30 copper coils system.

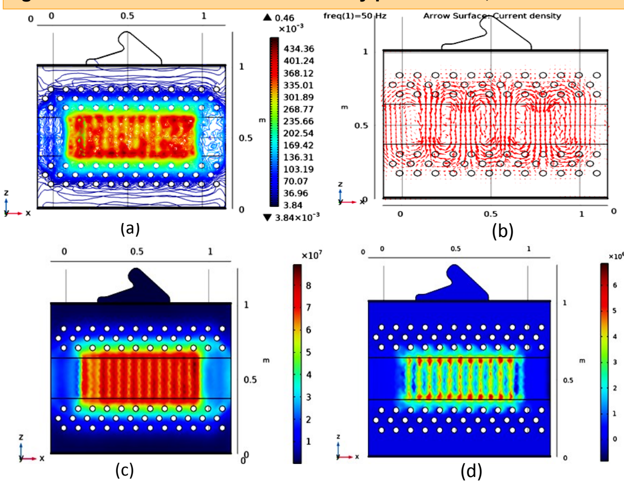


Figure 2: (a) Magnetic flux density magnitude, (b) induced current loops (c) induced current density magnitude and (d) longitudinal force density profile on the carriage plate

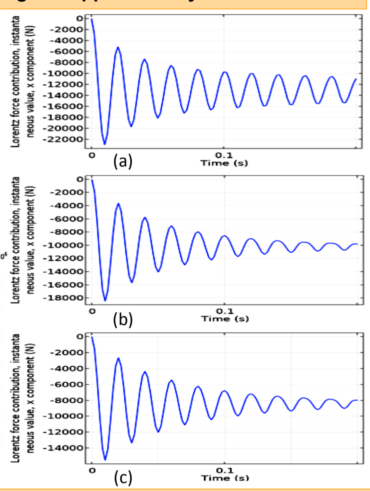


Figure 3: Instantaneous Lorentz force component along the length of carriage plate of (a) 8mm (b) 10mm, (c) 12mm thickness for 750 A RMS current

Linear induction motor (LIM) based technology is being utilized in widespread applications in various sectors namely in electromagnetic pumps, travelling cranes, metallic belt conveyers, linear accelerators, flywheel welders, aircraft technology, etc. LIM can be employed to meet the operational requirements to produce high force along with the high speed in a regulated manner [1-6]. A double sided LIM (DLIM) based electro-magnetic launching (EML) system employing 8 LIMs in series is being developed at IPR to produce 8 kN of thrust force on the carriage plate. DLIM is an efficient version of single sided LIM, where the rotor of the motor is positioned between two stators of the motor for more effective utilization of magnetic flux and thus produces higher thrust force. In order to have a ballpark estimation of the thrust experienced by the carriage plate, a 3D finite element model of the EML system is prepared and magnetic flux density, induced current density, and the linear thrust experienced by the rotor plate are estimated. The LIM operates on a similar principle to a squirrel cage induction motor; the only difference being the coils in the LIM, which act as the stator of the motor, are laid flat. In the case of DLIM, a non-magnetic metallic plate with considerable electrical conductivity is placed in between the air gap between two vertically placed LIMs. The metallic reaction plate acts as an equivalent rotor of the LIM assembly. When the stator i.e. the linear coil assembly of the two LIMs is connected with the three-phase power supply, a travelling flux is induced in the air gap which produces an eddy current in the rotor plate. The magnetic flux in interaction with the induced current in the rotor plate causes a linear thrust on the rotor plate. The linear coil assembly is placed in the slotted structure of the magnetic core which helps in concentrating the magnetic flux in the air gap region. Thus, in LIM whether single-sided or double-sided, the input electrical energy in the stator is transformed into mechanical energy in a non-contact manner through the linear thrust experienced by the rotor plate.

Based on the analytical calculation, an initial configuration of LIM with the geometrical and operational parameters is estimated. Accordingly, a 3D model assembly of two vertically placed LIMs, each LIM having 30 copper coils, is prepared using the finite element computational software package COMSOL Multi-physics (COMSOL 6.0 licensed version, license#1070169). The schematic of the system is shown in figure 1. An Aluminum carriage plate is placed in the air gap between two LIMs maintaining a 5 mm of clear air gap at each side. An air sphere modelled around the geometry acts as an infinite element domain. The individual coil is charged with 750 A RMS current as per the phase sequence. MUMPS (Multifrontal Massively Parallel Sparse Direct Solver) and PARDISO (Parallel Direct Solver), based on LU decomposition, are used for the computation. The analyses were carried out in ANTYA employing 40 cores. Several runs with varying simulation parameters like stator current, no of the current cycle, and thickness of carriage plate are executed in ANTYA.

> ***"The thrust characteristics obtained from the 3D finite element analyses of EML system on ANTYA will aid in designing the experiment facility at IPR"***

3D transient analyses and frequency domain analyses both are carried out for estimating linear thrust on the carriage plate of different thicknesses for 750 A stator current. The transient profile of the thrust is evaluated from time-dependent analyses and the time-averaged thrust value is determined from the frequency domain analyses. Transient analysis is carried out up to 200 ms. During the post-processing of the analyses, it is found that for the stator RMS current of 750 A, the volume integrated and time-averaged force acting on the carriage plate of highest thickness of 12 mm, the linear thrust of ~8 kN can be achieved. The linear thrust is even higher in the case of carriage plates having thicknesses of 10 mm and 8 mm. The time-averaged magnetic field, induced current density, and the force density as obtained from the analyses are shown in figure 2 whereas the instantaneous force profile on the 8 mm,10 mm, and 12 mm thick rotor plate are shown in figure 3. The velocity and acceleration profile of the carriage plate can be estimated using the moving mesh feature in the dynamic analyses.

References:

1. *Ananya Kundu, et al., 2022, Finite Element Analyses of Double sided LIM for EML IPR TR-681.*
2. *M.S. Manna, et al., 2011, Performance Optimization of Linear Induction Motor by Eddy Current and Flux Density Distribution Analyses Journal of Engineering Science and Technology 6 769-776.*
3. *Viktor Willow, 2014, Electromagnetical model of an Induction motor in COMSOL Multiphysics XR-EE-E2C:004.*
4. *S. E. Abdollahi, et al., 2015, Design and Analysis of a Double-Sided Linear Induction Motor for Transportation IEEE Transactions on Magnetics 51(7) 1-7.*
5. *Sarveswara Prasad Bhamidi, 2005, Thesis Master of Science Design of a Single Sided Linear Induction Motor (Slim) using a User Interactive Computer Program.*
6. *T. Yamaguchi, et al., 2001, 3-D finite element Analysis of a linear induction motor IEEE Transactions on Magnetics 37 (5) 3668 – 3671.*

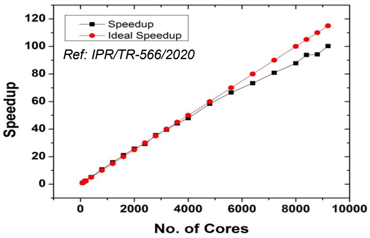
Selecting the Right Number of Compute Resources for Your Job

To make optimum use of the compute resources in ANTYA, the jobs must request cores/nodes which can be fully utilized in the code simulations to obtain results in the shortest possible time. For serial codes (single-core jobs), the selection of CPU cores is straightforward but for parallel codes (OpenMP/MPI), the selection will not only depend on the type of codes but the problem size as well.

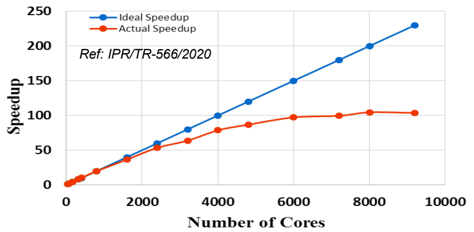
How to Decide No. of Cores for Parallel (OpenMP/MPI) Codes?

Asking more no. of cores will not automatically make your code run faster on ANTYA. For both OpenMP and MPI codes, a scaling study, with a small problem size for a limited no. of time steps needs to be performed. To perform a scaling study, one needs to start with fixed problem size and then run the same problem on increasing no. of cores. The execution time should reduce with increasing no. of cores. As an example, the scaling studies of two MPI codes, LAMMPS and PLUTO performed on ANTYA are shown below: (**Speedup = Walltime in 1core / Walltime in n cores**)

LAMMPS: Scaling Good, a job with large no. of cores would run fast.



PLUTO: Scales well till 4000 cores, beyond that, increasing the no. of cores would not reduce execution time.



How to know if all the requested resources are being utilized?

Once the parallel code job is submitted, check the usage of the requested resources using the following commands:

```
# Check your job Id and the node(s) on which your job is submitted
[user@login1 ~]$ qstat -an1
#Check the CPU utilization using scheduler, 1 core utilization is represented as 100%
[user@login1 ~]$ qstat -f jobID|grep resources_used.cpupercent
#If the scheduler reports 0% which may happen in some of the applications, check manually on the compute node(s) on which the job is running through top command and check the core % utilization for the job processes.
[user@login1 ~]$ ssh node_name
[user@node_name ~]$ top
```

Choosing the Right Queue?

Choosing the right queue will enable you to select compute resources and walltime limits which may shorten your job execution time. The details of ANTYA Job Queueing System are given in issue10 (page3). In ANTYA, all the queues available can be displayed along with their details with the following commands:

```
# Displaying available queues
[user@login1 ~]$qstat -q
# Details of available queues
[user@login1 ~]$qstat -Qf
```

Queue Selection Based on the Type of Codes

Code Types	Suggested Queues	Scheduler Parameters
Serial single CPU core code	serialq	-q serialq select=1:ncpus=1
Serial single GPU card code	serialq	-q serialq select=1:ncpus=1,ngpus=1
Multithreaded OpenMP code (with upto 10 cores)	serialq	-q serialq select=1:ncpus=10 export OMP_NUM_THREADS=10
Multithreaded OpenMP code (with upto 40 cores)	regularq	-q regularq select=1:ncpus=40 export OMP_NUM_THREADS=40
MPI code (with upto 40 cores)	regularq	-q regularq select=1:ncpus=40
MPI code (with upto 600 cores)	longq	-q longq select=15:ncpus=40
MPI code (with upto 1600 cores)	mediumq	-q mediumq select=40:ncpus=40
MPI GPU code (with more than 2 GPU cards)	(Based on walltime requirement select any one) longq, mediumq	-q longq select=2:ncpus=2,ngpus=2 -q mediumq select=2:ncpus=2,ngpus=2

ANTYA UPDATES AND NEWS

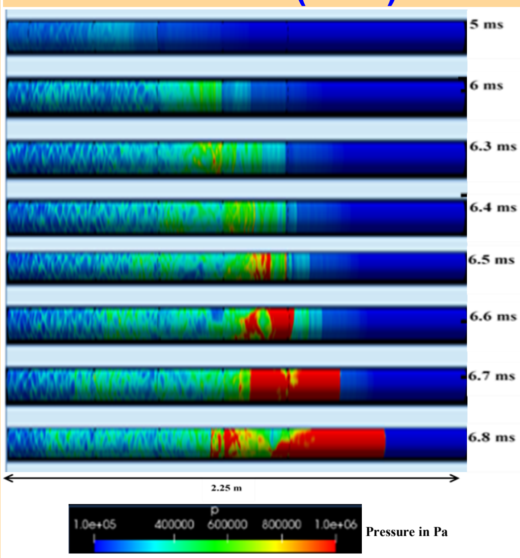
1. New Packages/Applications Installed

⇒ **The no. of Applications stays the same for this issue.**

⇒ **ANTYA Users /home data monthly backed up cycle completed.**

HPC PICTURE OF THE MONTH

Flame Acceleration and Shock Dynamics in Fuel-Air Mixtures (DDT)



Pic Credit: **K Tony Sandeep**

The figure shows the pressure timeline in 2.25 m long detonation tube with 10% blockage ratio in the 3D model filled with octane-air mixture. The time evolution of flame from slow deflagration (0-5 ms) in the initial stage to deflagration to detonation transition (DDT) (at 6.3 ms) and to detonation mode (after 6.5 ms) which then travels as a stable detonation wave.

This work is carried out in ANTYA by octFoam CFD solver which is developed in-house using OpenFoam framework for combustion applications. For the above simulation, 160 cores were utilized in ANTYA with walltime of ~4 hours.

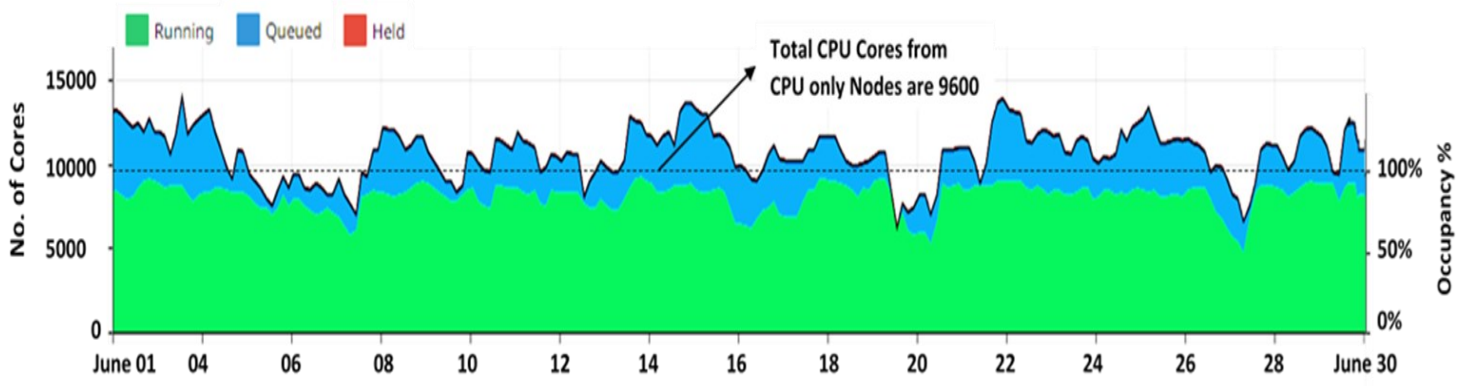
TIP OF THE MONTH

For accessing internet on the ANTYA login nodes through proxy you need to update your proxy credentials with new password you have set:

```
[user@login1 ~]$ export https_proxy="http://username:newpassword@10.20.1.222:3128"
export http_proxy="http://username:newpassword@10.20.1.222:3128"
export ftp_proxy="ftp://username:newpassword@10.20.1.222:3128"
```

ANTYA Utilization: JUNE 2022

ANTYA Daily Observed Workload



Other Recent Work on HPC (Available in IPR Library)

A novel quiescent quasi-steady toroidal electron cloud in a 3D toroidal trap with end-plugs	SWAPNALI KHAMARU
Accuracy of a pseudo-spectral MHD solver over a grid based solver: A Comparative Study between GMHD3D code & PLUTO 4.4 code	SHISHIR BISWAS
Effect of electrode biasing on radial particle and energy fluxes in the edge and SOL regions	VIJAY SHANKAR
Effect of turbulence on impurity transport in the edge and SOL region	SHRISH RAJ
Two-stage acceleration of electrons by intense laser-cluster interaction in strong magnetic environment	KALYANI SWAIN
Exploration of a Compact DEMO Reactor: Constrains on Shielding Materials and HTS Magnets from Parameter-Space Scans	SHISHIR P. DESHPANDE
Design and Development of LN2 cooled Cryopump for application in High Heat Flux Test Facility	SAMIRAN MUKHERJEE
Structural phase transition in a monodisperse 2D complex plasma	SWARNIMA SINGH
Re-entrant phase separation of a sparse collection of non-reciprocally aligning self-propelled disks	SOUMEN DE KARMAKAR
A feasibility study of radio-isotopes breeding in a compact fusion reactor	SHRICHAND JAKHAR

ANTYA HPC USERS' STATISTICS— JUNE 2022

- **Total Successful Jobs — 3833**
- **Top Users (Cumulative Resources):**
  - **CPU Cores** — Amit Singh
  - **GPU Cards** — Suruj Kalita
  - **Walltime** — Gayathri
  - **Jobs** — Arzoo Malwal

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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