JANUARY, 2023 | VOL. 1

MECHAZINE

DEPARTMENT OF MECHANICAL ENGINEERING

Proudly presented by

FLAMES & FLARES

Fulfilling Aspirations of Mechanical Engineering Students
Fulfilling Aspirations of Robotics Engineering Students

MECHAZINE |

Official Newsletter of Department of Mechanical Engineering

THIS ISSUE >

Henry Ford is famous for the Model T car, but it was his contribution to manufacturing that was truly groundbreaking. In 1913, Henry Ford installed the first moving assembly line.

This new process lowered the price of the car from $850 in 1908 to $300 in 1925. The moving assembly line meant that, for the first time, average Americans could afford an automobile. More than 15 million Model T cars were produced between 1913 and 1927.

ABOUT THE DEPARTMENT |

Department of Mechanical Engineering

DEPARTMENT ★

1

- The Department of Mechanical Engineering was started in the year 2007, since then it has been produced graduates who are excelling in the industries, entrepreneurship and higher studies. Department has been implementing Outcome Based Education (OBE) with Continuous Quality Improvement (CQI) for holistic development of the students, which is an essential model for any institute which aspires to be leader in the field of education. Batchelor of Engineering program in the Department of Mechanical Engineering has been accredited by National Board of Accreditation (NBA) and also from Institute of Engineers (India).

★ DEPARTMENT VISION

2

- To be the centre of excellence in education ,innovation and incubataion in the field of Mechanical Engineering to cater contemporary technological changes for sustainable development.

DEPARTMENT MISSION ★

3

- Create an ambience for holistic learning by imparting quality education through practicing professional ethics to cater social needs.
- Inculcate industrial practices through industry-institute interaction by providing skill and leadership qualities.
- Foster creative and innovative thinking skills among the faculty and the students by establishing state-of-the-art facilities to encourage life long learning and promote Entrepreneurship.

★ VALUES

4

- Excellence, Research, Innovation, Incubation, Integrity, Leadership, Diversity, Commitment and Empowerment

ABOUT THE DEPARTMENT II

Department of Mechanical Engineering

5 DEPARTMENT GOALS

- Creating 50 leaders every year in the field of Technology, Social enterprise.
- 25 Interdisciplinary Projects related to Sustainable Development Goals(SDGs)
- 5 Community Industry Partnership per individual programs.
- 25 Research Publications, 2 Entrepreneurs, 10 Innovations on SGDs for individual programs.
- Obtaining Academic Autonomy from Regulatory bodies.
- Digitalization of Campus.
- NIRF Ranking better than 180

6 PROGRAMME EDUCATIONAL OUTCOMES

- To design, develop and manage the industrial and social projects by applying modern tools in multidisciplinary environment
- To practice lifelong learning, professional ethics and apply engineering principles to achieve sustainable development.
- To demonstrate the leadership qualities and team building to take up innovation and Entrepreneurship.

7 PROGRAMME SPECIFIC OUTCOMES

- Solve complex engineering problems through innovative techniques in competitive environment to design mechanical systems.
- Apply the knowledge and competence in the field of manufacturing engineering.
- Apply the knowledge and skills to formulate sustainable solutions in the field of thermofluid and energy engineering.

Editor's Note

Dear Students,
I wholeheartedly welcome you to the Department of Mechanical Engineering at Sahyadri College of Engineering and Management. Our department comprises focused, research-oriented, ambitious, creative, and vibrant students, faculty members, and non-teaching staff who constantly challenge themselves by setting goals and ambitions of high standards.
The Department of Mechanical Engineering hosts UG and Ph.D. programs in two main fields - MECHANICAL ENGINEERING and ROBOTICS & AUTOMATION. Our students and faculty are incredibly ambitious to do research and design projects focusing on these two domains and their allied interdisciplinary areas such as Cyber-physical systems, Artificial Intelligence in mechanical systems, adaptive control systems, soft-robotics, robotic welding, metal-polymer composites, and electric vehicles. Our students and staff continuously strive to work on emerging technologies through "no-borders" collaborations with neighboring universities abroad. We also have partnerships with medical hospitals in the areas such as prosthetics and medical device design.

-RATHISHCHANDRA GATTI
Editor-in-Chief

OFFICE BEARERS

Flames & Flares

FLAMES & FLARES

PROF. RATHISHCHANDRA GATTI
Head of Department Mechanical Engineering
PRESIDENT

MR. KIRAN PRAKASH A
Asst. Professor Mechanical Engineering
STAFF ADVISOR

SANJAN B
VICE PRESIDENT

SHARVIK SHETTY
COORDINATOR- SPORTS & CULTURAL

SHOBITH R KAVA
COORDINATOR- EDITORIAL BOARD

AMAN
COORDINATOR- SOCIAL MEDIA AND BRANDING

EXECUTIVE COMITTEE MEMBERS

Flames & Flares

SANJAN B	SATHVIK M BEKAL
BIPIN SHETTY	U K ZAMIL AHMED
SHARVIK SHETTY	VASUNDARA
SAGAR G	ANKITH MARLA
SHOBITH R KAVA	ROSHAN S B
SHREERAJ	NAVEEZ AHMED
AMAN	JEEVAN S
ASHISH THALEKAR	SHRIDEVI V RAO
HARSHITH J K	DISHA N

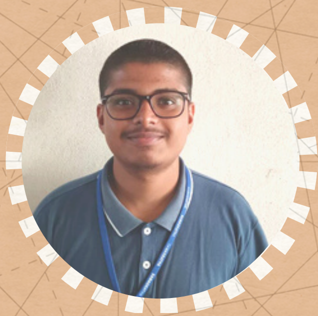
EDITORIAL MEMBERS

Flames & Flares

FLAMES & FLARES

PROF. RATHISHCHANDRA GATTI
Head of Department Mechanical Engineering
PRESIDENT

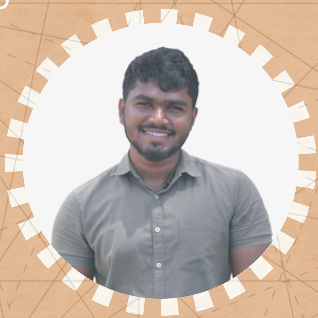
MR. KIRAN PRAKASH A
Asst. Professor Mechanical Engineering
STAFF ADVISOR



SHOBITH R KAVA
COORDINATOR- EDITORIAL BOARD

PRATHVICHANDRA K
TEAM MEMBER

SHREERAJ
TEAM MEMBER



BRAJESH
TEAM MEMBER

MAHAMMED ANAN
TEAM MEMBER

INAUGURATION OF FLAMES & FLARES -PILI PAJJE

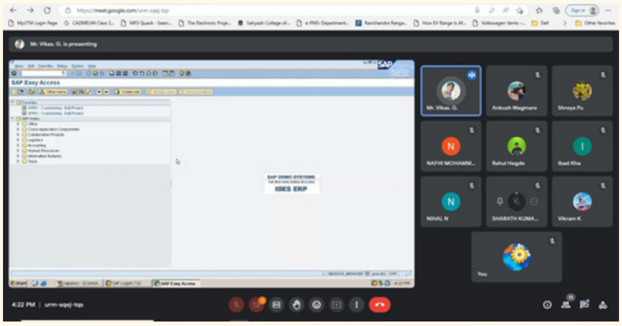
Department of Mechanical Engineering in association with ISTE, IIC, IEI, FLAMES & FLARES conducted Inaugural program of FLAMES & FLARES- an Association of Mechanical Engineering Students - "PILI PAJJE" for the academic year 2022-23.

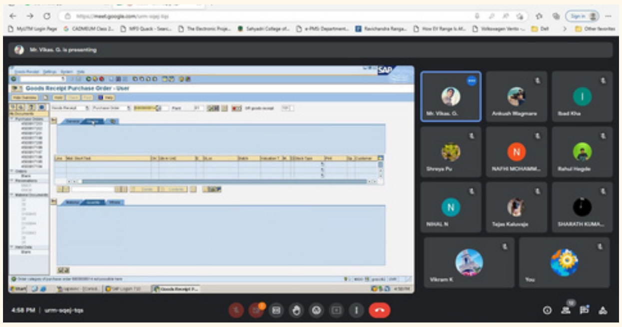
FLAMES & FLARES- association of Mechanical, Robotics & Automation Engineering students: Its inauguration was held on 16th December 2022, Friday at 10.00 am in Netravathi Auditorium. Mr. Adarsh G A, GM, Maintenance Planning, MRPL, Mr.Vismay Vinayak, Actor and Mr. Patla Satish Shetty, Yakshagana Bhagavata, were invited as the chief guests for the event.

Mr. Adarsh G A addressed the gathering and briefed about the scope for mechanical engineering students in various industries, skills to be required and importance of professional behaviour. He addressed the gathering and motivated the students to take part in various academic, extra and co-curricular activities. Also stressed on the importance of academics and basic fundamentals which builds platform for the job opportunities and carrier growth.Mr.Vismay Vinayak, shared hisexpierience of his studentlife and mentioned about how importance it is be get educated in society.He entertained the students with few movie dialogues.Mr. Patla Satish Shetty appreciated the student's effort on decorating the stage with full of traditional based theme and explained about the importance of traditional culture for the current generation and also for the future generation. He sung a famous yakshagana song for the students and gathering. Rathishcahnadra R GattiHead of the Department gave the introductory remarks about the association. Prof. S.S. Balakrishana, Vice Principal, motivated and encouraged the students to actively involve with the academic and other related activities.Dr.Rajesha S, Principal delivered the presidential address and mentioned the importance of mechanical engineering courses along with the multidisciplinary approach. Academic achievers, students who excelled in various project activities were felicitated by the chief guests.

A new logo for FLAMES was revealed by the guest which was prepared by Robotics & Automation student as a part of logo design competition.Mr.Kiran Prakash, Assistant professor coordinated the event as the faculty in-charge of FLAMES & FLARES. Formal functioned followed by fun games and cultural programs at the noon session. Students exhibited their talent through the platform provided by the association.

FLAMES-Fulfilling the aspirations of Mechanical Engineering students, a student's association of mechanical engineering department was formed in the year 2007. This association provides a platform for the students to showcase their technical, cultural, sports and academic talents at the department level. The association also provides opportunity to have industry interaction, academia expertise interaction, hosting many more technical events such as CATAPULT, OFF ROAD ROBO, MECH MANIA, MATTARAME so on. FLARES- Fulfilling the aspirations of Robotics and Automation Engineering students, an association of Robotics and Automation commences from this year academic 2022-23.

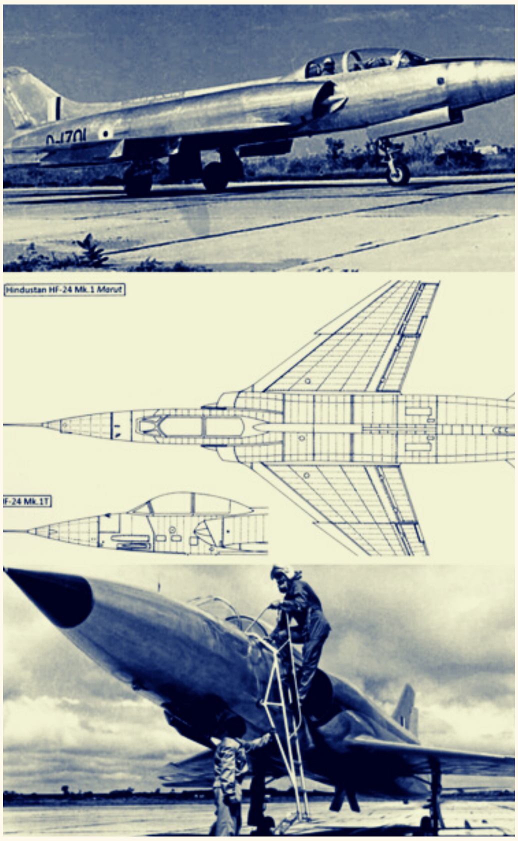




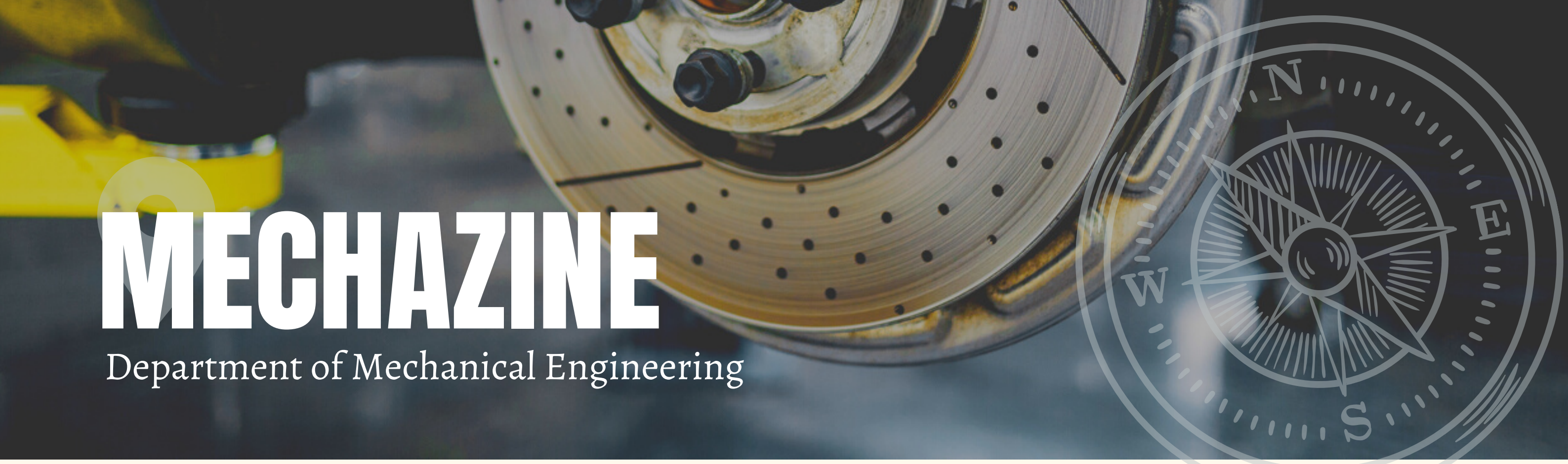
TALK ON 'SAP P2P CYCLE'

Department of Mechanical Engineering in association with ISTE,IIC,IEI,FLAMES & FLARES conducted a Tech Talk on ‘SAP P2P Cycle’ on 30th Jan, 2023 for Second Year Mechanical Engineering students. The Resource Person was Prof. Vikas G, Dept. of Mechanical Engineering (ME). The objective of this tech talk was to introduce the students to the ERP software- SAP to those interested to pursue career in SAP. The tech talk focused on SAP P2P (Procure-to-Pay), Materials Management, creation of Purchase Requisition, Request for Quotation, Maintain Quotation, Deciding a vendor, Purchase Order, Goods Receipt and Invoice Receipt. Dr. Rathishcandra Gatti, HOD, Dept. of Mechanical Engineering was also present during the session and encouraged the students to take up this session.

The key takeaways of this Tech Talk were:
How any ERP software like SAP is used in an industry for procurement of materials? By having a good understanding of the SAP P2P cycle, one can ensure that procurement processes are efficient and cost-effective, and how the suppliers (vendor) are paid in a timely manner.



It was India’s first home-grown fighter jet. Developed by Hindustan Aircraft Limited (HAL), with Kurt Tank as lead designer..HAL itself lacked the experience needed to develop frontline military fighters, so enlisted the help of Kurt Tank. The aim was to have an aircraft that was capable of speeds of between Mach 1.4 and 1.5, and that the aircraft would have a twin-engine configuration. The aircraft would go on to have a pair of British engines powering it, and on June 24th 1961 the first prototype of the Marut conducted its maiden flight. This was a big step for India’s aircraft industry.Powered by two Bristol Siddeley Orpheus 703 turbojets, HAL was of course delighted that its latest creation was now airborne. But it wasn’t long before problems started to arise. The Orpheus engines were only originally intended as interim before more powerful engines were then fitted. However, HAL decided to fit the production versions of the Marut with those same, unreheated Orpheus 703s. Not only did this reduce the speed from Mach 2 for the Marut, it meant it couldn’t even attain a top speed of Mach 1. But it would not become plain sailing, it served as a very solid foundation for the future of Indian aviation, one that has ultimately led to the much more advanced Tejas.



MECHAZINE

Department of Mechanical Engineering

DEMO DAY OF START-UPS DEVELOPED – ROBOTIC WELDING

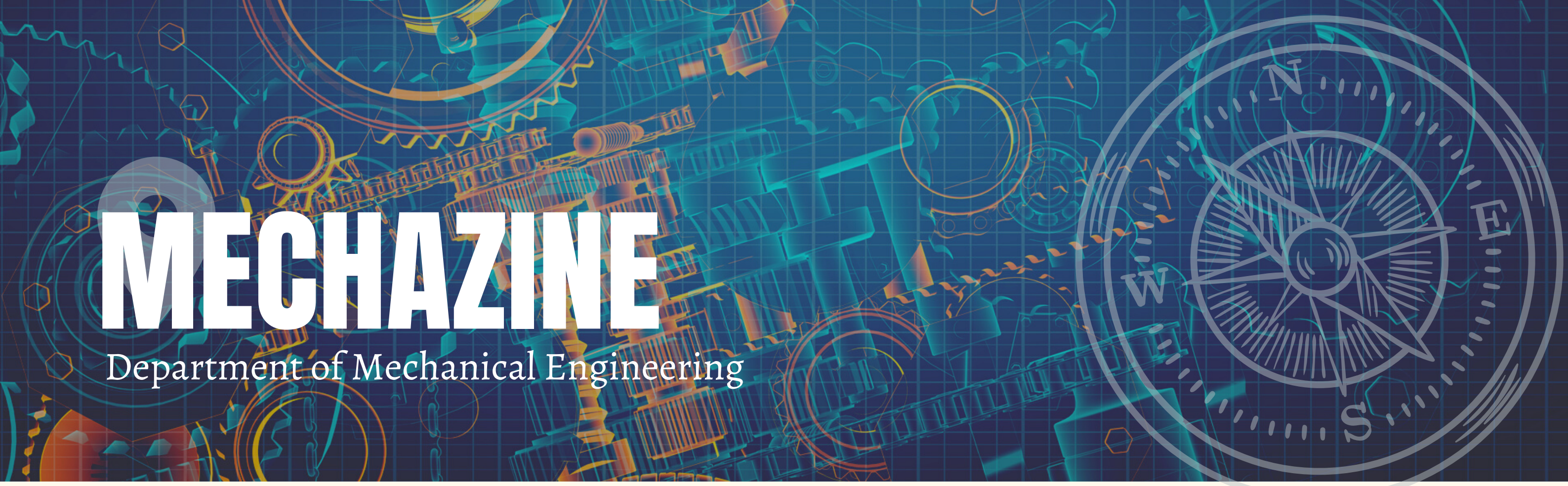
Dept. of Mechanical Engineering, SCEM in association with Caliper Engineering Pvt. Ltd, Mangaluru, Indian Society of Mechanical Engineers (ISME), Sahyadri Institute Innovation Council (IIC). IEI and FLAMES-Mechanical Engineering Students Association organised an "Demo Day by start-up developed -Robotic welding" at in house industry Caliper Engineering & Lab Pvt. Ltd. for the first-year students of engineering discipline students under the IIC calendar activity of "Demo Day of start-ups developed" for the academic year 2021-22 on 19.08.2022 at 10.00am.

Prof.Adesh P, Assistant Professor, was the resource person. On this demo day, he explained about the requirement of welding, need for robotic welding, its applications.

Demonstration on MIG Robotic welding was shown by explaining about the various types of codes and coordinate systems used. Various components of welding set up was explained such as power source, transformers, work table, method of mounting the work parts, selection of filler material, use of gases for the welding purpose, selection of current parameters, welding speed. For the robotic setup, he explained about degree of freedom, various types of joints, types of movements etc.,

Two batches of students were explained at different sessions. Total 40 students took the benefit of the session.

The Racemo was India's first sports car which was built by Tata Motors under the badge of its sub-brand Tamo. It has a 190 PS engine that can go up to 100km/hr in 6 seconds. It was unveiled at the 87th Geneva Model Show. The Racemo was a sub-4 meter car. As a result, in Indian soils it was eligible for a huge tax-benefit, something which compact-SUVs are famous for. Tata Motors promised to launch the road-legal two-seater race car at the price of Rs.25 lakh. One of the main benefits of this small car was its exquisite performance. For such a small machine, Tata Motors was planning to provide the Tata Nexon's 1.2L turbocharged petrol engine which easily powers a much heavier SUV. Being an engine of a regular car, it also had the advantage of a respectable and practical fuel economy. The Racemo was thought to be built in two different models. One was based on roadways and the other one was for the track ready. The final limited number of models that were estimated to be made was around 250 units. However, due to cost issues, the model was halted.



: "EMERGENT 2022"- FLAMES STUDENTS SYMPOSIUM

Dept. of Mechanical Engineering, SCEM in association with Sahyadri Institute Innovation Council (IIC). IEI and FLAMES-Mechanical Engineering Students Association organised an "EMERGENT 2022"- FLAMES STUDENTS SYMPOSIUM for the Final year students of Mechanical Engineering under the IIC calendar activity for the academic year 2021-22 on 15.07.2022 at 9.00am.

Our students were presented about 74 Original Research and Review papers on the latest trends in Mechanical engineering and their allied fields. The abstracts of the accepted papers will be part of the Proceedings of the EMERGENT 2022 symposium. Selected papers will be published (subject to authors' approval) in Peer-reviewed reviewed journals and books of SCOPUS recognized publishers (Nova Science, Scrivener-Wiley, IGI Global, and Bentham Science)

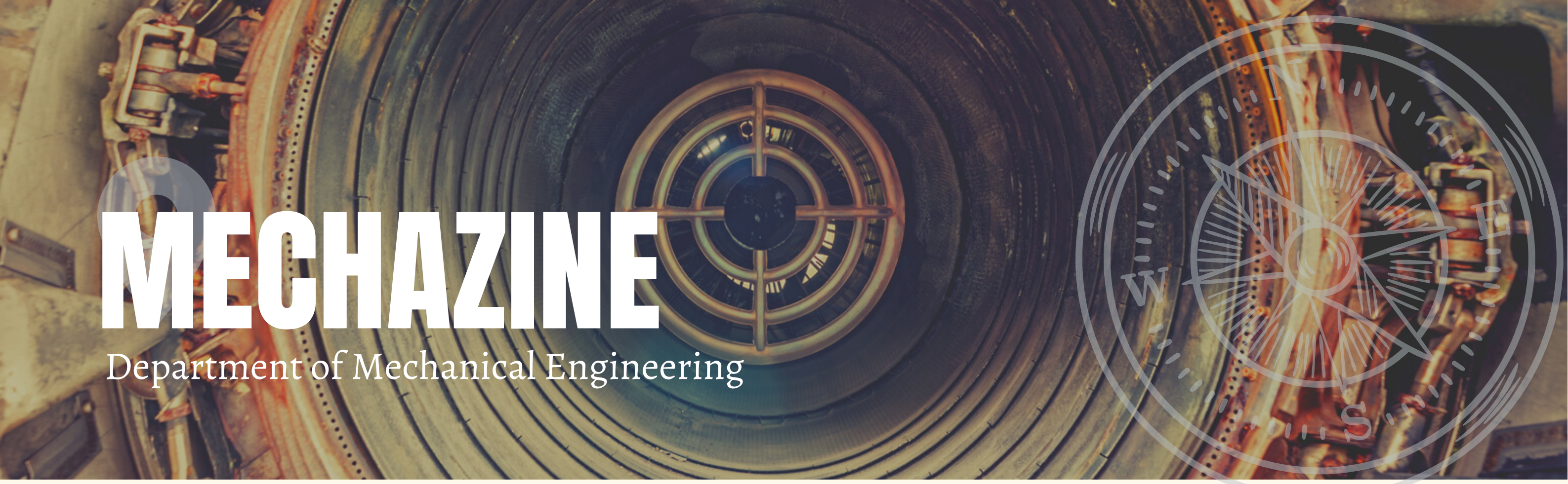
Themes

1. Robotics & Cyber-physical Systems -20 research papers
2. Alternative Energy and Fuels -20 research papers
3. Advanced Material Science -14 research papers
4. Advanced Thermal & Fluid Systems -2 research papers
5. Intelligent Transportation Systems & Electric Vehicles -18 research papers

Dr. S.Manjappa,Director-Research, Dr.Rajesh S, Principal were the chief guest and inaugurated the symposium and appreciated the departmental effort on conducting such technical event. Dr.Rathishchandra R Gatti, Head of Mechanical Engineering briefed about the importance of journal on career development. Prof.Kiran Prakasha A was coordinated the event.

The **HSTDV** is an unmanned scramjet demonstration aircraft for hypersonic speed flight. It is being developed as a carrier vehicle for hypersonic and long-range cruise missiles, and will have multiple civilian applications including the launching of small satellites at low cost. The HSTDV program is being run by the Defence Research and Development Organisation (DRDO).The 1-metric-ton, 5.6-meter-long (18 ft) air vehicle under construction features a flattened octagonal cross section with mid-body stub-wings and raked tail fins and a 3.7-meter rectangular section air intake. The scramjet engine is located under the mid-body, with the aftbody serving as part of the exhaust nozzle. Development work on the engine is also in progress. Two parallel fences in the forebody are meant to reduce spillage and increase thrust. Part span flaps are provided at the trailing edge of the wings for roll control. A deflectable nozzle cowl at the combustor end can deflect up to 25° to ensure satisfactory performance during power-off and power-on phases. Surfaces of the airframe's bottom, wings and tail are made of titanium alloy, while aluminum alloy comprises the top surface. The inner surface of the double-wall engine is niobium alloy and the outer surface is nimonic alloy.

On Sepetember 7 at 1103 hours India successfully tested HSTDV from Dr APJ Abdul Kalam Launch Complex at Wheeler Island.



MECHAZINE

Department of Mechanical Engineering

HANDS ON SESSION ON PRODUCT MARKET FIT

Department of Mechanical Engineering in association with ISTE,IIC,IEI,FLAMES & FLARES conducted a Workshop on "Interactive Dashboard using MS Excel - Hands on session on Product Market Fit" on 17th Jan, 2023 (1:15 PM -3:15 PM) at Aptitude Lab (1st Floor, Main Block) for Second Year Mechanical Engineering Automation students. The Resource Person was Prof. Gagan Shetty, Dept. of Mechanical Engineering (ME). The Workshop focused on Introduction to Interactive Dashboard and how it is being implemented in the business market analysis. Basic tools used in MS excel was introduced to the students. Later, hands on session were conducted by taking the real-world examples of implementing interactive dashboard for E- Commerce to analyze the sales and profit of different sectors in the domain.

Reusable Launch Vehicle – Technology Demonstrator (RLV-TD) is one of the most technologically challenging endeavors of ISRO towards developing essential technologies for a fully reusable launch vehicle to enable low cost access to space. The configuration of RLV-TD is similar to that of an aircraft and combines the complexity of both launch vehicles and aircraft. The winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies, namely, hypersonic flight, autonomous landing and powered cruise flight. In future, this vehicle will be scaled up to become the first stage of India's reusable two stage orbital launch vehicle

RLV-TD consists of a fuselage (body), a nose cap, double delta wings and twin vertical tails. It also features symmetrically placed active control surfaces called Elevons and Rudder. This technology demonstrator was boosted to Mach no: 5 by a conventional solid booster (HS9) designed for low burn rate. The selection of materials like special alloys, composites and insulation materials for developing an RLV-TD and the crafting of its parts is very complex and demands highly skilled manpower.

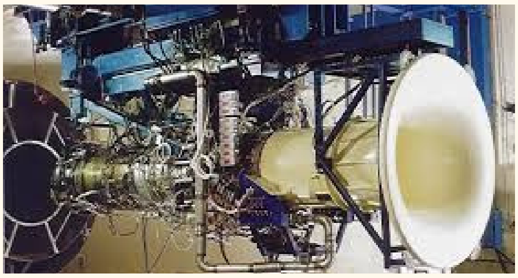
'HANDS-ON RESEARCH PAPER BOOT CAMP USING MENDELEY'

Dept. of Mechanical Engineering conducted a 'Hands-on Research Paper Boot Camp using Mendeley' for final year Mechanical Engineering students during 26th to 29th Sep '2022 at CAED Lab. The objective of this workshop was to make students conduct and disseminate their innovative research using publications as the tool. In this boot camp, reference manager -Mendeley from Elsevier was used.
Dr. Rajesha S, Principal, gave insights on the importance of research through examples that motivated students towards their career on R&D sectors.
Dr. Rathishchandra R Gatti, Professor and Head, Dept. of Mechanical Engineering, gave students the envision on Registering individual students on Elsevier, creating collaborative research groups, boolean search on google scholar, creating references, importing references and collaboratively writing a research paper with collected references. At the end of the bootcamp, students were able to create a project group and were collaboratively writing research papers using Mendeley cloud.
Dr. Shankara Murthy H M, trained the students on how to read a research paper and the generic structure of a research paper. Students were enlightened with the idea of writing and understanding the research paper. He also spoke about publications and how important it is for their career.
Prof. Vinay B U, Dept. of Mechanical Engineering trained the students on using Mendeley software to collate information for writing research papers

The James Webb Space Telescope (JWST) is a space telescope currently conducting infrared astronomy.As the largest optical telescope in space, it is equipped with high-resolution and high-sensitivity instruments, allowing it to view objects too old, distant, or faint for the Hubble Space Telescope.The mass of the James Webb Space Telescope is about half that of the Hubble Space Telescope. The JWST has a 6.5 m (21 ft)-diameter gold-coated beryllium primary mirror made up of 18 separate hexagonal mirrors. The mirror has a polished area of 26.3 m2 (283 sq ft), of which 0.9 m2 (9.7 sq ft) is obscured by the secondary support struts,[14] giving a total collecting area of 25.4 m2 (273 sq ft). This is over six times larger than the collecting area of Hubble's 2.4 m (7.9 ft) diameter mirror, which has a collecting area of 4.0 m2 (43 sq ft). JWST is designed primarily for near-infrared astronomy, but can also see orange and red visible light, as well as the mid-infrared region, depending on the instrument.[9][10] It can detect objects up to 100 times fainter than Hubble can, and objects much earlier in the history of the universe, back to redshift z≈20 (about 180 million years cosmic time after the Big Bang).[16] For comparison, the earliest stars are thought to have formed between z≈30 and z≈20 (100–180 million years cosmic time),[17] and the first galaxies may have formed around redshift z≈15 (about 270 million years cosmic time).

HOW TO SELF-PUBLISH A BOOK ON AMAZON & KINDLE

Department of Mechanical Engineering in association with ISTE,IIC,IEI,FLAMES & FLARES conducted a Workshop on "How to Self-Publish a book on Amazon & Kindle" on 16th Jan, 2023 (3:30 PM -5:30 PM) at CIM lab (2nd Floor, Mech Block) for Second Year Mechanical and Robotics & Automation students. The Resource Person was Prof. K Sudheendra Nayak, Dept. of Mechanical Engineering (ME). The Workshop focused on Book writing, Manuscript creation, Self-publishing procedure, Launch and Marketing tips. Dr. Rathishcandra R Gatti, HOD, Dept. of ME also addressed the students on key takeaways from this workshop and also on importance of learning new skills.



The GTRE GTX-35VS Kaveri is an afterburning turbofan project developed by the Gas Turbine Research Establishment (GTRE), a lab under the Defence Research and Development Organisation (DRDO) in Bengaluru, India.On 3 May 2010, about 1880 hours of engine test had been completed on various prototypes of Kaveri Engine. A total of eight Kaveri Engines and four core engines have been manufactured, assembled and tested. High Altitude testing on core engine has been completed successfully.In June 2010, the Kaveri engine based on Snecma's new core, an uprated derivative of the M88-2 engine that powers the French Rafale fighter, providing 19,000–19,000 lbf (83–85 kN) of maximum thrust is being considered an option by DRDOOn 3 May 2010, about 1880 hours of engine test had been completed on various prototypes of Kaveri Engine. A total of eight Kaveri Engines and four core engines have been manufactured, assembled and tested. High Altitude testing on core engine has been completed successfully.In June 2010, the Kaveri engine based on Snecma's new core, an uprated derivative of the M88-2 engine that powers the French Rafale fighter, providing 19,000–19,000 lbf (83–85 kN) of maximum thrust is being considered an option by DRDO.A Non-afetrburner varient will be used in India's stealth UCAV AURA.

RIDE AWARENESS PROGRAM"

Sahyadri College of Engineering and Management, Department of Mechanical Engineering in association with ISTE,IIC,IEI,FLAMES & FLARES conducted "Ride Awareness Program" for the students inside the campus followed by a session on "Safety Tips for driving and demonstrating how to drive safely" organised by Road Safety Club@Sahyadri in association with Radio Mirchi and Bajaj Auto Ltd on 14.12.2022, 3.00pm at Sahyadri Food Court Arena.
“Ride Awareness Program" and session on "Safety Tips for driving and demonstrating how to drive safely" was based on the importance of safety during the driving and safety precautions. The key points were discussed in the session about Tips for Safe Driving are as follows,
·Do not drink and drive
·Keep a safe distance from vehicles
·Buckle up before you drive
·Do not drive on the wrong side
·Always wear a helmet
·Always give an indicator while changing lanes
·Drive within the speed limits
·Don't use mobile phones while driving.
·Do not jay walk. Cross the road safely and use the zebra crossing
·Be patient while driving
·Do not honk unnecessarily
Also, in the session stressed about the following points,
·Focus on driving
Ignoring distractions while driving and maintaining focus on the road is key to driving safely. In order to keep focused while driving, you should follow these steps:
·Keep 100% of your attention on driving at all times – no multi-tasking.
·Don’t use your phone or any other electronic device while driving.
·Slow down. Speeding gives you less time to react and increases the severity of an accident.
·Defensive driving

·Be aware of what other drivers around you are doing, and expect the unexpected.
·Assume other motorists will do something crazy, and always be prepared to avoid it.
·Keep a 2-second cushion between you and the car in front of you.
·Have items needed within easy reach – such as toll fees, toll cards and garage passes.
·Always wear your seat belt and drive sober and drug-free.

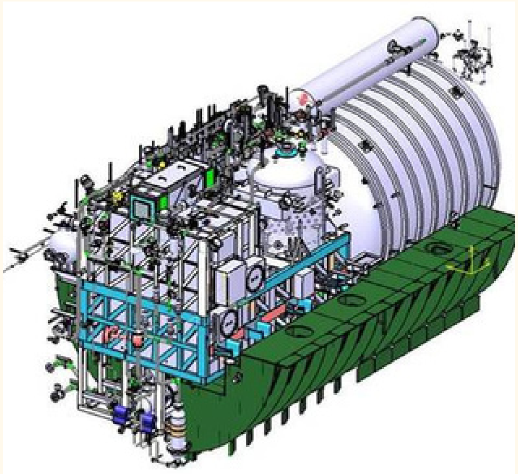
Mr.Devdas Hegde, Trustee, Bhandary foundation, Prof.S.S Balakrishna, Vice Principal, Dr.Prashantha S, HoD ,Basic Science, Dr.Joyline DSa, Associate Dean were present on the occasion. After the session, various two wheel vehicles from Bajaj Auto Ltd where exhibited. Stunt on the Bajaj vehicles by the experts were entertained the gathering. A total of 300 students were the part of session and awareness program. Prof. Kiran Prakasha A. and Prof. Gagan Shetty, Assistant professors were the coordinators for the event.

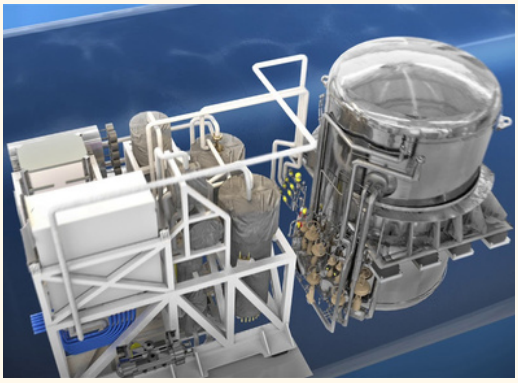
ATTRACTIVE CAREER IN MERCHANT NAVY

Department of Mechanical Engineering in association with Sahyadri Institution's Innovation Council (IIC), FLAMES, ISTE, IEI, ISME organized an awareness program on "Attractive career options in Merchant Navy" for the mechanical engineering students on 20th October 2022, Friday at 10.00am.
Prof.Raj Mohan M., Dean Marine Engineer from R.L. Institute of Nautical Science, Madurai, Tamil Nadu was the resource person.
The key topics were discussed,

- Merchant Navy as an attractive career option
- Career prospectus at sea
- Travel the world with a career
- Various Courses offered

Prof. Raj Mohan Briefly explained about the Graduate marine Engineering (GME) Course, duration of the course, academic activities, placement opportunities and road map towards the course completion. He encouraged the students for opting the mechanical engineering course and also highlighted on the importance of academics along with the extracurricular activities to be adopted. He also mentioned about the assistance offered by RLINS in Registration of INDOS, Seafarers Profile Registration, Continuous Discharge Certificate (CDC), Technical training in our ship-in-Campus etc., Total 150 students from sixth semester mechanical engineering were took the benefit of the session.



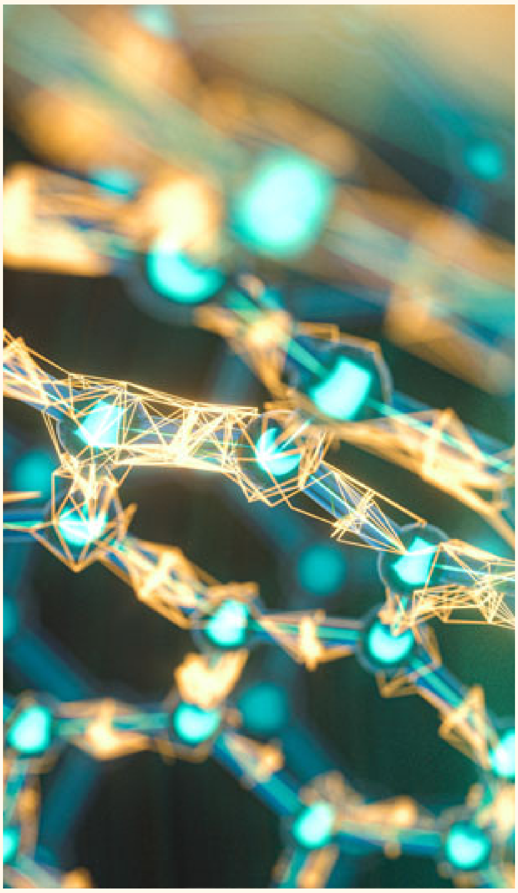


Air-independent Propulsion is a recent innovation in propulsion technologies for conventional submarines.This technology allows a submarine to recharge it's batteries underwater and to operate without the need to surface or use a snorkel to access atmospheric oxygen.A non-nuclear alternative to the conventional diesel-electric propulsion system,the AIP enhances the endurance of a conventional submarine, enabling it to remain underwater for up to two weeks,as compared to the conventional two days.This gives it an enormous advantage over the conventional submarines of adversaries.The DRDO's NMRL is developing an indigenous AIP system for all future conventional submarines of the Indian Navy.This AIP system is based on indigenously developed PAFC(Phosphoric Acid Fuel Cell) based technology.Hydrogen and oxygen are supplied to fuel cells to produce power.Hydrogen is generated on-board by a hydrogen generation plant and oxygen is supplied through liquid oxygen stored in the cryogenic tank.

DESIGN INNOVATION FOR SUCCESSFUL CAREER IN THE FIELD OF AERONAUTICS,SPACE AND DEFENCE

Department of Mechanical Engineering organized webinar a on "Design Innovation for Successful Career in the Field of Aeronautics, Space and Defence for Mechanical Engineers"

Dept. of Mechanical Engineering in association with Sahyadri Institution’s Innovation Council (IIC), FLAMES, ISTE, IEI, ISME organized a webinar on "Design Innovation for Successful Career in the Field of Aeronautics, Space and Defence for Mechanical Engineers" facilitated by Mr. Dhanish Abdul Khader, Space System Engineer (Analytics), SS Technologies, Bengaluru on 20th April, 2022 in Seminar Hall, Mechanical Block. The Webinar was about the software tool used in space research, aeronautics and defence. The resource person also discussed the challenges faced by Mechanical Engineers in procuring a job and he guided them towards the selection of the right direction in upgrading their skills and making them industry ready. The webinar was carried out in the view to create an awareness among the graduating students and shaping their career.



Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering. It’s hard to imagine just how small nanotechnology is. One nanometer is a billionth of a meter, or 10-9 of a meter. Here are a few illustrative examples:

- There are 25,400,000 nanometers in an inch
- A sheet of newspaper is about 100,000 nanometers thick
- On a comparative scale, if a marble were a nanometer, then one meter would be the size of the Earth

Scientists currently debate the future implications of nanotechnology. Nanotechnology may be able to create many new materials and devices with a vast range of applications, such as in nanomedicine, nanoelectronics, biomaterials energy production, and consumer products. Nanomaterials may also offer new opportunities for the reduction of environmental pollution.

Tejas: The Design Evolution Of An Indian Fighter

Source: Delhi Defence Review |@delhidefence|

It is no overstatement to say that the Tejas Light Combat Aircraft (LCA) program has made significant progress of late with the Mk1 variant being officially granted Final Operational Clearance (FOC) on February 20, 2019 and its production picking up pace at Hindustan Aeronautics Limited (HAL). Seven of the thirteen Initial Operational Clearance (IOC) standard Tejas Mk1 already in service with No. 45 squadron or the Flying Daggers of the Indian Air Force (IAF) were handed over in the last 11 months alone. The remaining three IOC-standard single-seater aircraft meant for the Flying Daggers are slated to join the squadron by the end of April 2019. The Tejas MK1 is now also a regular at IAF air exercises, raking up high range scores and generally winning the confidence of its users. As such, the focus has now shifted to the development and production of the Tejas Mk1A variant since India's Defence Acquisition Council has accorded approval for the acquisition of 83 units of the type by the IAF. Before we turn to analyzing developments related to the Mk1A and further evolution of the Tejas platform, it is important to profile the current capabilities of the baseline Mk1 itself.

LCA TEJAS MK1

Tejas Mk1 is a 'fourth-generation lightweight, single-engine, multi-role, tactical fighter aircraft. It employs an unstable tailless compound delta-wing configuration, optimized primarily for maneuverability and agility'. Over 90 percent of its surface, and over 45 percent of its airframe by weight is made of composite structures. This is one of the highest usage of composites in an aircraft of any kind, anywhere in the world. This extensive use of composites has lowered the aircraft's weight by 21 percent and reduced its part count by 40 percent, as opposed to what would have been the case had it been of all-metal construction.

The aircraft has intentionally been made longitudinally unstable to enhance maneuverability. In fact, its static margin, i.e. a measure of its instability (and hence maneuverability) is also one of the highest for any modern fighter aircraft [18]. To recover stability and provide good handling qualities, it is equipped with a fully redundant quadruplex digital fly-by-wire flight control system (FCS). This FCS is one of the biggest accomplishments of the LCA program. Its robustness has ensured an accident-free test record of over 4,300 test flights. The aircraft has also been equipped with advanced autopilot capabilities like auto-level (in case of pilot disorientation), safe altitude recovery (which automatically pulls up the aircraft if it comes too close to the ground) and auto navigation modes.

In-service aircraft are certified to fly from -3.5 to +8.0 Gs, up to an altitude of 50,000 feet, a top speed of Mach 1.6, and an angle of attack (AoA) of up to 24 degrees. The test pilots have stretched the prototypes even further, up to 8.5 Gs, and 26 degrees AoA. At the 2016 Bahrain Air Show, the Mk1 had even demonstrated a low speed pass at 110 knots. The FCS has now been updated to lower the minimum speed to 100 knots, at which point auto recovery is initiated. The 2016 demonstration at Bahrain also showcased another important feature: Following the above-mentioned low speed pass the aircraft immediately proceeded to accomplish a vertical climb. The ability to accelerate while in a climb is a virtue that only fighters with a thrust to weight ratio (TWR) of above 1.0 possess. At Bahrain, the Mk1 also showcased an instantaneous turn rate (ITR) of near 30 degrees per second and a sustained turn rate (STR) of between 15 to 16 degrees per second. A minimum radius turn of 350 metres (m) radius was also exhibited. All of these are extremely respectable numbers for air to air (A2A) combat roles.

The Mk1 is equipped with a powerful MultiMode Radar (MMR) which has A2A, air to sea, and air to ground (A2G) target detection modes.

ARTICLES

Getting to know about the jewels of our nation

Tejas: The Design Evolution Of An Indian Fighter

Source: Delhi Defence Review |@delhidefence|

In A2A, the Tejas Mk1 is currently capable of firing R-73 close combat missiles (CCMs) and Derby beyond visual range A2A missiles (BVRAAMs). In the future, the Mk1 is likely to be integrated with India's Astra BVRAAM as well. Together, with state-of-the-art helmet mounted display and sight (HMDS) and hands on throttle-and-stick (HOTAS) controls, and coupled with navigation aides like Very High-Frequency (VHF) Omnidirectional Range (VOR) / Instrument Landing System (ILS) and tactical air navigation system (TACAN), Tejas Mk1 allows the pilot to concentrate on "head-down" mission-critical requirements rather than worry about basic flying.

One of the Tejas's greatest strengths is its A2G weapon delivery accuracy. In all flight tests and air exercises so far, the Mk1 has consistently garnered some of the highest range scores of all the aircraft in the IAF's inventory. Not only can it carry 250 kg and 450 kg dumb bombs, but also laser guided bombs (LGBs) which are guided to their targets using a Litening laser designation pod (LDP). A single LGB can be carried on either the center-fuselage, wing-inboard or midboard weapon stations. For dumb bombs, two can be carried in tandem in the wing-inboard pylons, whereas one each can be carried in the center-fuselage and wing-midboard locations.

The Mk1's all-weather and day/night capability has been proven in various extreme hot and cold weather trials, from Jaisalmer to Leh. For example, in Leh, the aircraft was successfully started after a cold soak of 42 hours where the temperature reached near -20°C . In each of the three attempts, the aircraft started effortlessly even on a partially drained battery. The reader might be reminded that a few Multi-Medium Role Combat Aircraft (MMRCA) contestants had actually failed this test during trials for that tender. Similarly, in hot and high trials, the aircraft took off with 1.9 tons (50 percent) of its max payload, which is an astounding feet given its highly swept delta wings.

The Tejas Mk1 has a total of five 'wet' points: one underneath the fuselage and two underneath each wing. The hardpoint underneath the fuselage can carry a 725 litre (L) subsonic drop tank or a 710 L supersonic tank (still under development). The wing inboard pylon can carry a subsonic drop tank of 1200 L while the midboard can carry a drop tank of 800 L. Although the MK-1's developer, the Aeronautical Development Agency (ADA) publishes a conservative ferry range of 1750 km, ferry flights of ranges of nearly 2100 km have

been completed in the past. The FOC version of the Tejas MK-1 has also been fitted with a fixed refueling probe which can be used to refill all of it internal and external fuel tanks, effectively doubling its range and endurance.

ENTER TEJAS MK1A

Now even while ADA was developing the Tejas Mk2 for the IAF, HAL proposed a simpler interim upgrade. Thus emerged the Tejas Mk1A which will be equipped with an ELTA EL/M- 2052 active electronic scanned array (AESA) radar along with a compatible electronic warfare suite, which would include a self protection jammer (SPJ) pod carried on the outboard wing pylon. This position was found to derive maximum performance out of the pod. On the the outboard pylon, two CCMs would be carried on a dual-rack pylon as shown in Figure 1. This configuration was found to have lowest drag penalties among a variety of studied configurations.

In addition to the above changes, HAL would upgrade some line replacement units (LRUs) to cater to obsolescence management, weight reduction, ease of manufacture and maintenance. The aircraft would also be fitted with an Onboard Oxygen Generation System (OBOGS) which would allow pilots to

Tejas: The Design Evolution Of An Indian Fighter

Source: Delhi Defence Review |@delhidefence|

undertake long endurance flights. The turnaround time of the aircraft has also been reduced by means of hot refueling, a feature that SAAB wanted to showcase on its Gripen fighter during the MMRCA competition. At the time, the permission was denied by the IAF since it did not have a standard operational procedure (SOP) set up for the same. This hot refueling capability has now been showcased on a Tejas test aircraft.

One of the Tejas's greatest strengths is its A2G weapon delivery accuracy. In all flight tests and air exercises so far, the Mk1 has consistently garnered some of the highest range scores of all the aircraft in the IAF's inventory. Not only can it carry 250 kg and 450 kg dumb bombs, but also laser guided bombs (LGBs) which are guided to their targets using a Litening laser designation pod (LDP). A single LGB can be carried on either the center-fuselage, wing-inboard or midboard weapon stations. For dumb bombs, two can be carried in tandem in the wing-inboard pylons, whereas one each can be carried in the center-fuselage and wing-midboard locations.

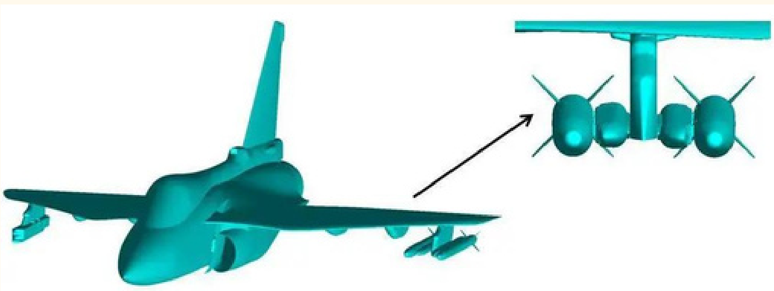
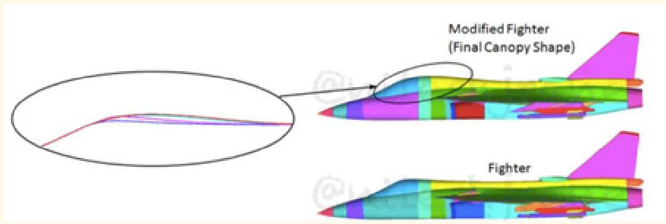


Figure 1: One jammer and a twin-assembly of two CCMs at the O/B stations of the aircraft

THE INITIAL ROAD TO MK2

However, to meet the IAF's stringent air staff qualitative requirements (ASQR) for the LCA project, ADA knew that substantial changes to the basic Mk1/Mk1A airframe were required and that is where the genesis of the Tejas Mk2 development program lies.There were two primary concerns: the IAF wanted a fighter that had faster transonic acceleration and a higher STR of about 18 degrees persecond. As late as Aero India 2017, ADA displayed scale models that aimed to achieve this by extending the Mk1 with a 0.5 m fuselage plug and fitting a more powerful F414 engine with a maximum rated thrust of 98kN.The plug was to be inserted just behind the canopy where the area curve had the highest discontinuity (see Area curve in Figure 1). In addition to the plug, ADA studied a bulged canopy to improve area ruling even further. The combined effect was 6 percent lower supersonic drag, which in turn led to a 20 percent improvement in transonic acceleration and 2 percent improvement in maximum speed [4]. The fuselage plug and bulged spine would also provide space for more internal fuel and LRUs.



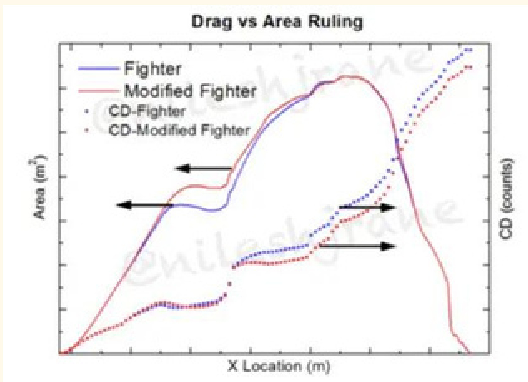


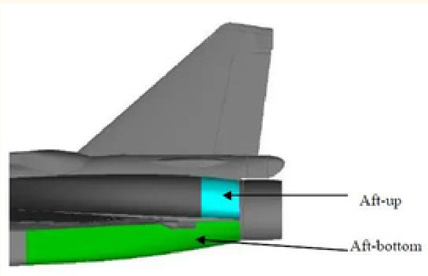
Figure 2: Canopy optimization study shows a bulged canopy improving the area ruling results in 6% reduction in drag, 20% increase in transonic acceleration and 2% increase in max speed

Similarly, it was observed that there was a sudden kink in the aft bottom of the fuselage in Mk1 as shown in Figure 2. By eliminating this kink and identifying an optimized smoothened aft fuselage, an

Tejas: The Design Evolution Of An Indian Fighter

Source: Delhi Defence Review |@delhidefence|

improvement of 4.9 percent was predicted in the supersonic drag on the aft body region.



Besides clean configurations, studies were also conducted to decrease the drag of loaded configurations. For example, it was realized early that by replacing the current 'blunt' pylons on Mk1 with more aerodynamically shaped pylons, significant drag reduction could be affected in supersonic regimes[18]. Figure 3 shows the inboard pylons before and after the reshaping. These new pylons have already been realized and are expected to even become a part of the MK1/1A platforms. One such pylon for the center fuselage has been put on display in Aero India 2019.

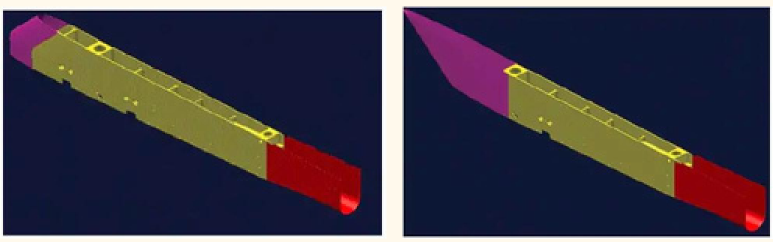


Figure 3: wing inboard pylon: before and after reshaping for better supersonic drag

Similarly, computation fluid dynamics (CFD) studies on a variety of drop tanks have yielded fuel tank geometries which could carry more fuel at marginal to no extra cost in drag. For example, Figure 4 shows the modified supersonic drop tank arrived by choosing optimal lengths for the conical nose and tail sections. The final shape allowed the carriage of 58 percent more fuel (710 L against the current 450 L) at only two counts greater supersonic drag. This provided a significant increase of about 11 percent in flight mission time. This tank can also be seen at Aero India 2019.

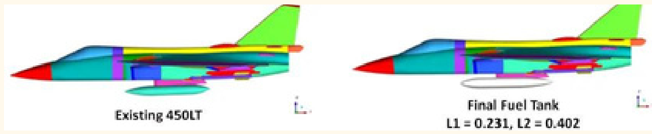


Figure 4: Modified supersonic drop tank with 58% more fuel carrying capacity and 2 counts increase in supersonic drag.

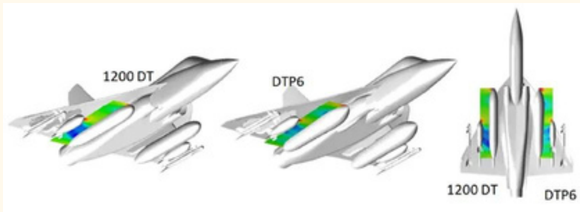


Figure 6: Effect of drop tanks, original and modified on airlfow around nearby bombs. The modified drop tanks has negligible destabilizing effect, 11% more fuel carrying capacity and lower drag penalty.

Besides the supersonic tanks, it was found that the presence of the current 1200 L subsonic fuel tank generates a suction on the surface of a bomb placed on its nearby station. This asymmetric force led to the destabilization of the bomb, and deviation from its ideal separation trajectory. Therefore, a variety of alternate geometries were studied which could mitigate this problem. The resultant fuel tank not only had a trivial destabilizing moment as shown in Figure 5 but could carry 11 percent more fuel at a lower drag penalty. These reshaped tanks are estimated to provide a 15-18 percent improvement in mission performance.

Tejas: The Design Evolution Of An Indian Fighter

Source: Delhi Defence Review |@delhidefence|

Detailed studies were carried out on the aerodynamic characteristics of CCM carriage at wing tip stations rather than the underwing station, as in the Mk1. The CFD studies found that carrying a CCM at the wingtip station increased lift-to-drag (L/D ratio) in subsonic, transonic and supersonic regions. Additionally, the fighter with the wingtip stations exhibited better Cnβ characteristics which would aid in the higher AoA flight regimes.

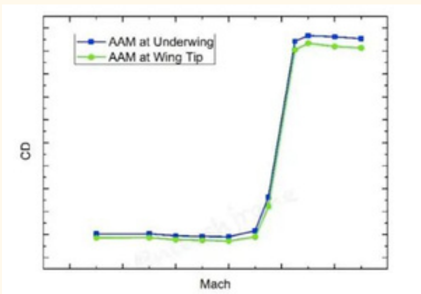
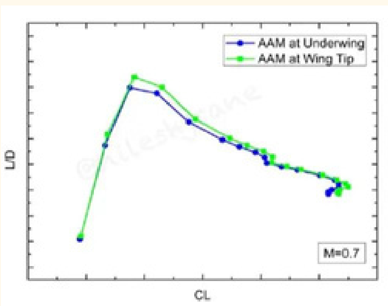
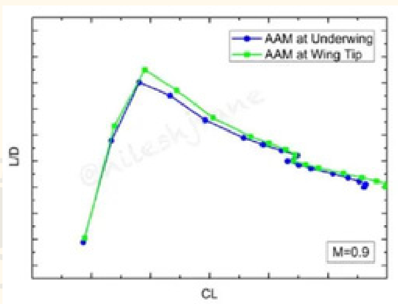


Figure 6: Assessment of Wintip mounted vs underwing CCM pylon. CFD study shows significant improvement in Zero-Lift drag at all speeds, especially the supersonic regime





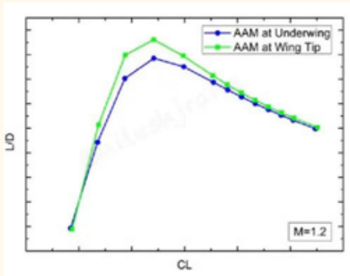
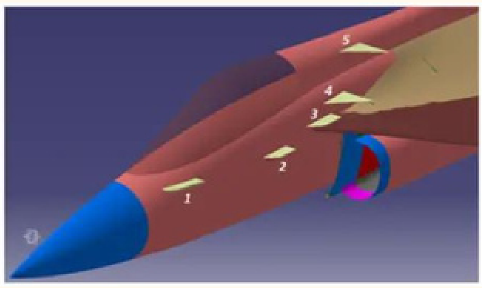


Figure 7: Wingtip mounted CCM pylon improved aerodynamic efficiency (L/D ration) of the wing significantly at all speeds and especially at the supersonic speeds

Other means of increasing directional stability at higher AoA included studies of body strakes of different geometries at different fuselage locations. Various geometries were found which could improve the yaw moment coefficient (Cnβ) by energizing the wing vortex, but at the cost of pitching characteristics. Therefore, subsequent studies were carried out using a chine (nose strake) to improve Cnβ with a focus on its influence on undesired pitching characteristics. The best chine gave a marked improvement in Cnβ by anchoring the nose vortex flow with only a marginal effect on pitching coefficient



Tejas: The Design Evolution Of An Indian Fighter

Source: Delhi Defence Review |@delhidefence|

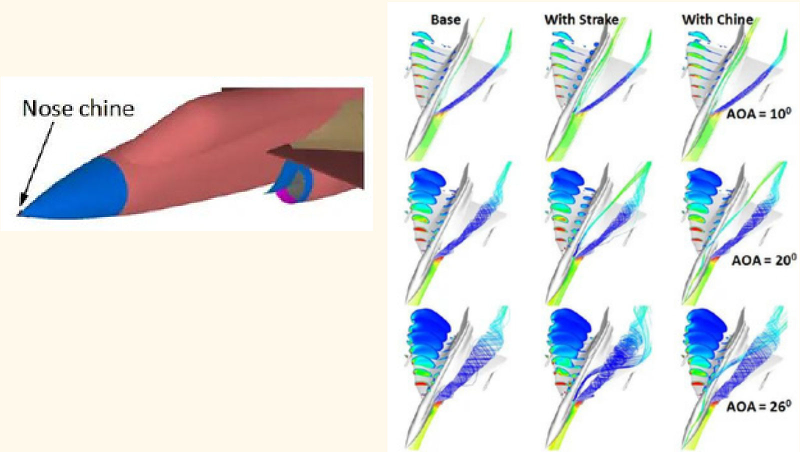


Figure 7: Fuselage and nose strakes (chine) studied for improvements in Cnβ

A substantial amount of effort was directed towards optimizing the air intakes. The impact of changes in lip and cowl geometries, contractions ratio (i.e. the ratio of air intake to the minimum area of the intake duct) and performance of a newly proposed 3-door auxiliary intake were studied. The goal of these studies was to improve pressure recovery at low speeds without adversely impacting spillage drag at high speeds. It was found that the lip geometry and variation in contraction ratio of these features have minor improvements in low speed regimes, but their attendant side effect on high speed performance was deemed to be too high.On the other hand, cowl geometry optimization showed good improvement in pressure recovery due to its positive impact on the local flow field near the inlet plane. The 3-door design further enhances the gains in pressure recovery. It's also expected to facilitate improved flow rates through the auxiliary intakes during the low speed, high AoA regimes. The combination of optimized cowl geometry and 3-door design results in a 3 percent improvement in pressure recovery, which should lead to an equivalent improvement in engine performance [11]. The 3-door design can already be seen on LCA Navy Mk1 prototypes.

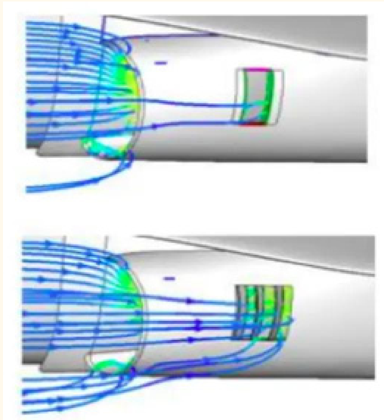


Figure 8: Streamlines showing airflow through Auxiliary Air Intake Doors (AAID) at low speeds. Top image represents existing design on LCA MK1. Bottom design is proposed 3-door design for improved airflow at low speed

With the above-mentioned changes, the Tejas Mk2 was predicted to have significantly lower transonic and supersonic drag, even with a slight increase in weight. Coupled with a more powerful engine, this variant would have much improved transonic and supersonic performance. The higher thrust engine also accorded a higher TWR which when combined with the better L/D, meant the fighter would have a better turn rate and a higher climb rate. The fuselage plug ensured additional space for more internal fuel and an internal SPJ.This, in turn, would lead to higher endurance and range. All in all, ADA was suggesting changes which could have been designed, built, flight tested and certified within a relatively short period of time.

However, on account of the IAF's growing requirements, ADA is now engrossed in the creation of a substantially more capable and larger Mk2 design, which has since been dubbed the Medium Weight Fighter (MWF)

ARTICLES

Getting to know about the jewels of our nation

Recent Indian Developments in Thermal Barrier Coatings For Jet Engines

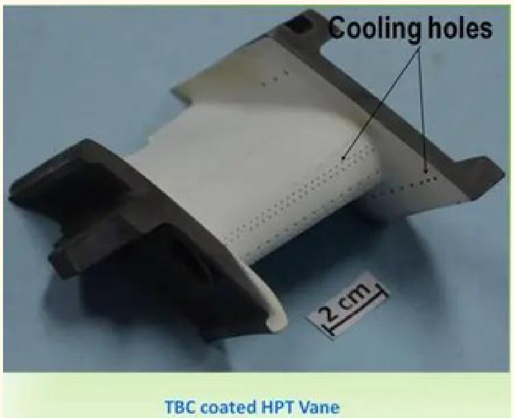
Source: Delhi Defence Review |@delhidefence|

It has been couple of decades since India embarked on a project to build a modern low-bypass turbofan jet engine compatible with the Light Combat Aircraft (Tejas) at the Gas Turbine Establishment (GTRE) of the Defence Research & Development Organization (DRDO). The engine under development, named Kaveri, has faced multiple hurdles both technological and bureaucratic over the years. Nonetheless, the Defence Metallurgical Research Lab (DMRL), a lab under DRDO, has produced and proven a new thermal barrier coating (TBC) material that has a maximum surface temperature capability of 1200°C. This development, as we shall see, provides a useful baseline for the progression of jet engine technology in India.

A Brief on the Significance of Thermal Barrier Coatings

A jet engine produces thrust not unlike an internal combustion engine. Air is drawn in and compressed by the compressor section. Fuel is then mixed with this compressed air and ignited producing a great amount of gases which are then used to rotate a turbine to extract work. The turbine and the compressor are connected via a common shaft such that fuel ignition is utilized to drive the compressor and continue engine operation. Military as well as modern civilian use place a great premium on weight, specific fuel consumption, maximum thrust as well as low maintenance requirements and long life of components.

One of the primary limiting factors that limit thrust and fuel consumption in a jet engine is the temperature of exhaust gases. Titanium, a metal widely used in aerospace applications, readily undergoes oxidation below temperatures of exhaust gases. Hence, Nickel alloys are used for 'hot section' components of the jet engine. Today, even the high pressure compressor turbine blades of the Kaveri engine utilise indigenous Ni alloy SUPERNI718A due to the high temperatures. Ni-alloys by themselves however are not robust enough to prevent heat and aero-mechanical stress related deterioration of turbine blades. Extended exposure to high temperature and mechanical stress results in creep-fatigue that causes failure of turbine blades. Reducing thermal exposure of the turbines therefore is vital to extend their life. Layers of oxidised material called TBCs are applied to high temperature sections of the engine such as turbine blades and vanes for this purpose. Air cooling vents are also used to provide a barrier on top of the blades and vanes to lower heat transfer.



Picture Courtesy : ARCI, Hyderabad.

Yttria Stabilised Zirconia (YSZ) has been the gold standard of thermal barrier coatings (TBC) for many years. The need for increasing exhaust gas temperature, Turbine Entry Temperature (TeT), is one of the ways to extract greater work from fuel. A stoichiometric air-fuel ratio would produce the maximum temperature. However such a temperature would also produce the greatest thermal stresses on the turbines and vanes in the engine. TeT is therefore limited to the extent of a designer's target of component life. Therefore any TBC that can enable higher gas temperature operation would be greatly valued.

Rare Earth pyrochlores ($Re_2Zr_2O_7$, Re = La, Gd) are very stable materials. La and Gd zirconates remain structurally stable under reducing atmosphere of $Ar(g)/3\%H_2(g)$ at 1400 °C. The zirconates with pyrochlore structure, are predominantly cubic and ionic. They also allow a variety of atomic substitutions at the A, B and O sites when the ionic radius and charge neutrality conditions are met. Since Gadolinium is heavier and earmarked for strategic applications,

Recent Indian Developments in Thermal Barrier Coatings For Jet Engines

Source: Delhi Defence Review |@delhidefence|

Lanthanum was chosen for TBC purpose. Also, Lanthanum has a higher ionic radius which helps mixing it with Zirconium to produce Lanthanum Zirconate

Among the pyrochlores, $La_2Zr_2O_7$ (LZ) seems to have great potential as a TBC material due to its excellent bulk properties vis a vis YSZ. But it has a lower coefficient of thermal expansion and slightly higher specific gravity compared to YSZ. Though nano LZ can mitigate the problem to a certain extent, it can not be applied directly on the MCrAlY bond coat. A double-layer coating with $La_2Zr_2O_7$ as top coat was adopted since it is reported that such a bi-layer coating enhanced the temperature capability of the coating by >100K. Therefore LZ is applied as a top coat material over YSZ for enhanced coating life. A nano-structured bi-layer is also expected to reflect certain amount of radiations thus providing a more effective TBC. LZ has good chemical compatibility with YSZ at least up to 1250C. LZ remains stable in a large La/ Zr molar ratio range, from 0.87 to 1.15 and remains so even when the La_2O_3 composition changes ±10 per cent from the stoichiometry. This is significant since in the absence of cooling or heat losses the substrate temperature equals that of the environment eventually. The synthesis and impurities in TBC materials also influence the stability and life of the coating.

IR radiation which has wavelength in the 700 nm –1100 nm range results in heating of the surface if absorbed. To achieve the highest Near-IR reflectivity, particle size needs to be more than half the heat wavelength that is to be reflected. A comparison of the NIR reflectance of nano and their micro crystalline forms show that the nano-crystalline metal oxides are about 15 per cent – 20 per cent more reflective. A decrease in mean particle size usually increases the reflectance. Particle size also dictates diffuse reflectance. The reduction in particle size increases the inter particle boundaries and therefore the number of reflections at the boundaries increases.

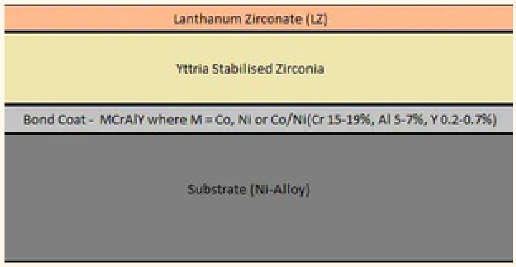
Nano- and mesostructured zirconia ceramics combine many desirable properties like low thermal conductivity (k), high refractive index, high chemical and thermal stability. The wavelength of the reflected light is directly proportional to the particle diameter. Hence TBCs require micro-particles of the order of 1-3 μm to reflect heat in the near IR spectrum. In the medium and far IR bands, larger particles are relevant. Particle size reduction also stabilizes the high-temperature phases at room temperature. The nano-material always has a larger thermal expansion coefficient and higher toughness than its micro counterpart. The thermal cycling life of nano LZ is reported to be six times that of micro LZ coatings. The indentation toughness of the nanocrystalline SPPS 7YSZ TBC was found to be five times that of corresponding APS TBC in the most critical in-plane orientation. Due to the lower in-plane tensile stress and higher fracture toughness of the nano-composite TBCs, they have higher thermal shock resistance than the conventional TBCs. It is reported that the yield stress (τ) and micro-hardness (Hv) of nano-crystalline materials are 2–10 times that of the coarse-grained counterparts of the same composition. Particle size reduction also reduces the flaw sizes in the coating. Therefore the fracture resistance in nano-ceramics is higher compared to conventional micron-sized materials. Grain boundary scattering, an extrinsic mechanism limiting the thermal conductivity decreases in nanocrystalline materials. Mean free path of the point defects in YSZ is significantly smaller than even the smallest grain size attainable in nano-crystalline YSZ. Nano-structured TBCs often exhibit excellent performance compared with conventional TBCs such as adhesive strength, thermal shock resistance, thermal insulation, corrosion resistance and so on. Since Phonons play a major role in heat transport in ceramics, spatial confinement of Phonons in nanostructures can strongly affect the phonon spectrum and thus the thermal properties at nanoscale. The superior thermal shock resistance and thermal cycling capability than conventional TBCs is attributed to the formation of a large number of micro-cracks, uniformly distributed tiny pores and a large area of nanostructured region with high stress relief capability.

Recent Indian Developments in Thermal Barrier Coatings For Jet Engines

Source: Delhi Defence Review |@delhidefence|

Crystallite size of approximately 10 nm, could be synthesized employing the stearic acid and co-precipitation routes. For uniform particle size, care was taken to produce fine particles with lower dispersity. LZ powders with excellent phase and compositional control via co-precipitation method was obtained and the absence of other precursor ions was validated by ICP-MS. Lower the impurity content (namely oxides), higher the stability of YSZ powder. Silica, even at <1 wt. % in YSZ coating, adversely affects the thermal cycling life of the coating. It was found that silica gets segregated especially at grain boundaries triple points where it may lead to local instability. For preparation of LZ, zirconium oxy-chloride is the key starting material produced from Zircon, a natural combination of Zirconia (ZrO_2) and Silica (SiO_2). It is also found concentrated with other heavy minerals e.g., Ilmenite, Rutile, Garnet, Sillimanite, Monazite and Xenotime in beach sand. Newly synthesized YSZ powder showed maximum amount of 'tetragonal'- t' phase compared to the other two powder variants. This is due to complete intermixing of species in the atomic scale and the fact that particle size reduction stabilizes the high-temperature modifications. It is this t' structure in YSZ, that is responsible for thermal stability and endurance of the coating.

The TBC material was then applied to a component by first by grit-blasting with synthetic alumina of 120-140 grit sizes. Calcined and screened TBC powder was air plasma sprayed on to cast Ni-base super alloy substrates and components preliminarily coated with MCrAlY bond coat (Cr 15-19%, Al 5-7%, Y 0.2-0.7%) and less than 50 μm size) and YSZ top coat (thickness 100 μm). LZ was applied (thickness 50 μm – 60 μm) over and above the YSZ to produce a bi-layer TBC. The interruption between YSZ and LZ coatings was kept as low as practicable for better adhesion. The total maximum thickness was kept well below 250 μm. To check the adhesion and quality of the coating on the specimens (70 mm x 20 mm x 2.5 mm), production bend tests on 10 mm diameter mandrels were done. No visible spalling/ delamination was observed up to 60°. The bend test was also used to optimise the process parameters. On more ductile substrates, no delamination/spalling was observed up to 90° bending.



After coating, the stoichiometric ratio of ZrO_2/La_2O_3 differed from initial composition of the powder due to the evaporation of La_2O_3 in high temperature reducing environment of plasma. This was expected and monitored. Higher current plasma spray was employed to prepare a coating with significant resistance to high velocity gas erosion. The bi-layer YSZ-LZ coated flaps were assembled and tested in an aero-engine which was under accelerated mission testing for long endurance. The coating withstood rapid thermal transients, supersonic flow of combustion products along with vibratory loads of about 4 'g'. The coating sustained 1000 h equivalent of engine operation and more than 30000 nozzle actuations. No chipping off or spallation of the coating was observed. It was also evident that the two flap with indigenous nanostructured bilayer coating were hardly tarnished compared to the other flaps which were coated with commercial YSZ grade. Also the two flap had lesser warpage compared to others which could be due to higher insulation effectiveness of bi-layer coating. This could be realized right first time due to the application of multiple strategies like nanostructures, bi-layer thermal barrier, high purity materials and a thermally stable sinter resistant coating as the top coat among others.

SAHYADRI COLLEGE OF ENGINEERING AND MANAGEMENT,
MANGALURU - 575007