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CSIR NEWS

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Team CSIR

Australian Air Show — Good market potential for NAL's *HANSA* in Australia

THE National Aerospace Laboratories (NAL), Bangalore's all composite 2-seater trainer *HANSA* aircraft (VT-HOD) took active part and successfully flew at the Australian International Air Show: 2007 at Avalon near Melbourne. The Air Show was held during 20-25 March 2007 and *HANSA* flew on all trade days exhibiting its skills in front of a global audience at the Avalon airport. This is the first time that the *HANSA* participated in an International Air show outside the country.

In addition to the static and flight display of *HANSA*, posters on NAL technologies, and models of NAL's *SARAS*, *HANSA* and the now — under development 4/5 seater General Aviation Aircraft were displayed at the joint NAL and RMIT (Royal Melbourne Institute of Technology) stall in the exhibition during the Air Show. Also on display was the composite Main Landing Gear for the *HANSA* developed by Sir Lawrence Wackett Aerospace Centre of RMIT University.

NAL's participation in the air show gave an opportunity to the concerned authorities and operators in Australia to see the aircraft and its flight performance. It also gave an opportunity to the concerned industries / customers to interact on possible manufacture and marketing of *HANSA* in Australia. The occasion was also utilised for a detailed discussion with CASA (Civil Aviation Safety Authority of Australia) on the steps towards possible certification of *HANSA* in Australia. An approach in this direction with a time plan of 6 months has been agreed to by both sides and action has been initiated.

The *HANSA* aircraft, which was exported in semi-knocked down condition, was re-assembled at Gippsland Aeronautics (GA). GA is an Australian Company located at Latrobe Valley in the state of Victoria, that is engaged in designing and manufacturing commercial aircraft from first principles. NAL's pilot AVM (Retd.) A.S. Lamba, a veteran Test Pilot for over 40 years, conducted the demonstration flights in the Air Show. The *HANSA* aircraft performed very well and was appreciated by all.

A number of pilots, who were given demonstration rides, appreciated the pleasant features of the aircraft. To name a few, Captain David Wheatland, Demonstration and Display Pilot, Gippsland Aeronautics, said, *"I personally enjoyed the opportunity to fly the HANSA-3 and explore its very pleasant handling characteristics during the period of the recent Australian International Air Show at Avalon in Victoria. The aircraft is very satisfying to fly in the circuit pattern and is positive to respond to proportionate control inputs. It is suitably equipped for VFR by night and day and exhibits excellent response and handling characteristics. It is forgiving of mishandling, has very good low speed ability and is rewarding to pilots who use appropriate and proportionate handling skills. He further added, "I am sure that there is a future for the HANSA-3 as a first-rate basic training aircraft to meet the challenges of India's anticipated demand for skilled aircrews in the coming years".*

Another pilot, Capt. Alan Campbell, Chief Flying Instructor, Gippsland Aeronautics, recorded, *"The HANSA-3 would be unusual as an ab initio trainer in Australia due to its turbo-charged Rotax and constant speed propeller. This is mainly because the majority of flight schools in Australia cater in some measure for private recreational pilots who look for simple aircraft*

systems. First impression from looking at the HANSA-3 is that the relatively high aspect ratio wing, tapering back to the tips, will give the aeroplane good performance from modest power output, and good glide performance, with nice handling as a bonus. Entry to the cockpit is easier than it may appear, and very comfortable once inside. Controls fall easily to hand. At close to MTOW the HANSA's take-off and climb performance, while modest, is certainly better than expected, and

NAL's *HANSA* in Australian Air Show

well within the norm for a trainer. Handling is a delight, with light and well co-ordinated controls, and it takes some discipline to remember that the aeroplane is not aerobatic. Visibility all round is excellent, and the Rotax is smooth and quiet, so that a day's work in the HANSA-3 would not be any too stressful. All round, a very pleasant and useful aircraft for training pilots."

Capt. Jerry, Flight Instructor and CFI of Latrobe Valley Regional Flying Club and quite a few other enthusiastic pilots had familiarization flights and expressed their satisfaction and happiness over the excellent features of the trainer aircraft.

The market survey indicates a good market potential for the two-seater trainer aircraft in Australia. Given that a number of Australian flying clubs and aviation enthusiasts are looking to buy aircraft of this class, NAL hopes to profitably market *HANSA* in Australia after its certification in that country. Priced at around 70 lakh, *HANSA* is significantly cheaper than any other aircraft of its class.

NAL's participation in the Air Show was facilitated and coordinated by Sir Lawrence Wackett Centre for Aerospace Design Technology, Royal Melbourne Institute of Technology (RMIT) University, Melbourne. In fact, the initiatives taken by Dr A.R. Upadhya, Director, NAL and Dr Arvind K. Sinha, Director, Sir Lawrence Wackett Centre, resulted in this participation. The extensive coordination on the Australian side by Dr Sinha and on the Indian side by Dr K. Yegna Narayan, Head, C-CADD, Mr R. Rangarajan, Project

Director (*HANSA*), Mr M.S. Chidananda, Project Director (*SARAS*), made this participation more fruitful.

An eight member technical team led by Shri R. Rangarajan from NAL ensured that the aircraft was always available in the ready-to-fly condition. The assembly and test flights of *HANSA* aircraft were carried out at M/s. Gippsland Aeronautics.

Among the VIPs who visited NAL stall were Shri P.P. Shukla, Indian High Commissioner in Australia; Capt. Sudharshan Shrikande (IN), Defence Advisor, High Commission of India in Canberra, Australia and Dr Belmonte, Chairman, Sir Lawrence Wackett Centre and Pro Vice-Chancellor, RMIT University. They evinced keen interest in NAL's aircraft programmes. A framework for agreement between NAL, RMIT and Mahindra Plexion Technologies Pvt. Ltd, to jointly work on Civil Aviation Programmes was exchanged in the presence of the High Commissioner. On the business side, there were a number of trade visitors who enquired about details of *HANSA* and *SARAS* aircraft.

In conclusion, Australian International Air Show: 2007 provided an excellent opportunity to showcase NAL's capabilities and its *HANSA* aircraft, and the discussions that NAL team had with various visitors indicate a considerable measure of confidence and expectations of tremendous growth in aerospace R&D in India contributing to international collaborations.

CSIR Network Project on Advanced Manufacturing Technology

THE CSIR project on developing capabilities in Advanced Manufacturing Technology embraces a clutch of component projects:

- Developing capabilities on applications of Virtual Reality Tools in Integrated Product Development
- Capability building on design and development of Autonomous Mobile Robot for manufaturing
- Near net shape manufacturing of Bio-implants and engineering components from advanced ceramics and metals
- Development of Near Net Shape Components of Al-Alloy by Squeeze Casting Process
- Development of Manufacturing Technology for Production of Wide Ferromagnetic Metallic Glass Ribbons
- Near-net-shape manufacturing technology through Austemperd Ductile Iron (ADI) route
- Standardization of process parameters of Metal Injection Mouldings for production of engineering components
- Development of near-net-shape manufacturing of ceramic particulate reinforced composites of Al-alloy by investment casting process (MMC)
- Development Of Robocasting (Mouldless Casting) Technology For advanced ceramic components
- Development of Rapid Tooling Methods for Injection Moldings and Pressure Die Casting.

The Central Mechanical Research Engineering Research Institute (CMERI), Durgapur, is the nodal institute of this project. The participating institutes include: Advanced Materials and Processes Research Institute (AMPRI), Bhopal; Central Glass & Ceramics Laboratory (CGCRI), Kolkata; Central Scientific Instruments Organisation (CSIO); Chandigarh; National Aerospace Laboratories (NAL), Bangalore; National Institute for Interdisciplinary Science and Technology (NIST), Thiruvananthapuram, and Structural Engineering Research Centre (SERC), Chennai.

Some of the achievements, according to the *CMERI Triennial Report 2003-06*, brought out recently, in the area are as follows:

- The Virtual Reality Laboratory has been established with facility for simulation & visualization in immersive environment
- First prototype of the 10 HP Tractor (christened ***KrishiShakti***) has been successfully developed and tested
- Navigational algorithms have been developed and tested on various platforms of Autonomous Mobile Robot
- Theoretical studies pertaining to Hexapod Robot have been concluded

- Technology for ultrasonic range finder has been established

MIM (Metal Injection Moulding) Technology

- Components of geometrical and manufacturing intricacies have been developed at the laboratory scale
- Simulation studies pertaining to Two Phase Mold Filling have been concluded
- Negotiations with Ordnance Factory Board and TVS are underway for the industrial application of MIM technology

Biomedical Implants

- Technology demonstration has been undertaken for the development of patient-specific biomedical implants
- Surgical demonstration has been undertaken for implantation of dental and orbital implants

Metal Matrix Composites

- MMC automotive components (rocker arm, cylinder head for engines) have been developed through Rapid Prototyping and Investment Casting route.

Robocasting

- Robocasting machine with 2½ axis simultaneous interpolation has been developed for layer-by-layer casting of ceramic parts
- Linkage with the GTRE, Bangalore is being established.

Rapid Tooling

- RT moulds have been developed through Direct Metal Laser Sintering and Rapid Prototyping-Investment Casting route.

Austempered Ductile Iron

- Technology for crankshafts & automotive components including Crankshafts for 35 HP tractor manufactured by ITL, Hoshiarpur, 5 HP Water Pump manufactured by KOEL, Pune, 14.5 HP Ambassador Car manufactured by Hindustan Motors have been successfully developed and tested.

Some of the initiatives undertaken under the network project are highlighted here:.

Autonomous Mobile Robotics

Some research work has been done on mobile robotics in different universities and research organizations in India.For example, Bhabha Atomic Research Center (BARC), Mumbai, has developed wheeled type of mobile robot in collaboration with IIT, Kanpur. The system has been designed for disposal of explosives. IIT, Bombay has developed one legged type mobile robot for BARC. R & DE (Engineers), Pune and CAIR, Bangalore are engaged in development of mobile robot but these are not autonomous type.

CMERI is engaged in R&D activities on Mobile Robotics for quite some time. It had developed a tele-operated mobile robot for Nuclear Power Corporation (NPC), Kalapakkam for mopping of spilled heavy water. It also developed an AGV, which follows fixed path using wire-guided navigation. The institute has also developed a Remotely Operated Vehicle (ROV) for Department of Ocean Development (DOD), Government of India. Recently, the institute has developed a mobile platform that navigates autonomously on the laboratory floor.

The institute has now undertaken the leading role, in association with CSIO, in developing R & D facilities and capabilities on Autonomous Mobile Robotics as a part of the CSIR network project on Advanced Manufacturing Technology. Initial efforts are directed towards the development of autonomous mobile robotic systems for indoor applications, specially for assisting manufacturing processes. For

Wheeled Robot at CMERI

experimentation, a mobile platform has been developed as test bed. Two driving wheels of the mobile platform are directly coupled with stepper motors, which are controlled independently. Two additional castor wheels are provided for balancing. The robotic vehicle carries a battery bank as power source and does not have any physical link or cable. An array of ultrasonic range finders is mounted in front of the robot. It has an on-board computer on it. The robot, as server is networked with a remote client computer by wireless LAN. The server transfers range information obtained by its range finders to the client. To incorporate intelligence, a Fuzzy Logic Controller (FLC) has been developed for dynamic path planning. The FLC resides in the client and it gives the deviation angle of the robot from sensor data. From this, control commands for motion of the robot is generated.

The sensors gather the position data of the obstacles at some sampling rate and feed these data into the fuzzy controller. The fuzzy controller processes the input data and takes fuzzy decision as to which path the robot should follow so that it can reach its goal position without colliding with any obstacle. The developed FLC is a two-input, one-output system. The inputs are (1) "Obstacle Distance" from the robot and (2) "Obstacle Angle", i.e., the angle of obstacle from the path of the robot. The fuzzy rule base consists of 25 rules.

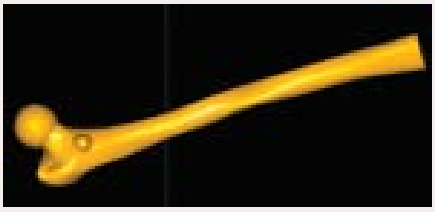
The software, developed in modular approach, consists of seven modules. The modules are distributed and shared by the client and the server. The sensors on the vehicle acquire the data by DAS module and the data are sent to the client by network. The FLC in the client processes the data and finds out the deviation angle for safe navigation of the robot. An algorithm has been developed and tested by simulation.

The robot avoided the obstacles and reached the target position safely. Two problems were faced: (1) The robot exhibited a left or right bias and (2) If the obstacles are spaced very closely the robot is unable to avoid all the obstacles. The problems arise owing to inherent weakness of FLC.

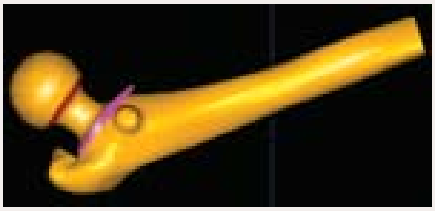
Presently, work is on to develop an upgraded version of mobile robot with much higher speed, equipped with a host of powerful sensors. Powerful sensor fusion algorithms will be developed for mapping the environment as accurately as possible. A manipulator will be mounted on the mobile robot for doing some specific tasks in manufacturing. The developed system will be used for material handling and transportation in the indoor environment. The vehicle will be driven by two DC motors and these motors will be controlled independently. It will be equipped with a number of sensors like ultrasonic range finder, laser range finder, camera, compass, proximity switch, etc. The environmental data acquired by the sensors will be processed by the on board computer. The navigational algorithm will reside in the on board computer. The operator will give the initial and final pose of the system through the GUI in the remote computer. The AMR will navigate to the indicated table and align itself with the table suitably such that the manipulator on the vehicle can collect the intended jobs from the table. To do this work, the manipulator will at first come over the jobs with some pose error. Then it will take the image of the jobs with the help of a camera fitted on the gripper. By image processing technique, the manipulator will align the gripper both for position and orientation error and properly grip the job.

Rapid Prototyping for Near Net Shape biomedical Implants

Rapid Prototyping (RP) can be defined as the fabrication of a physical, 3D part of freeform shapes directly from a numerical description, e.g. a computer-aided design (CAD) by a quick, highly automated and flexible process of manufacture. The size and shape of implants required for orthopaedic surgery differ from human to human. For this reason, tailor-made



CAD model of femur



CAD model of hip prosthesis implanted in femur

components are needed for replacement whenever damage of internal bones has taken place. CGCRI and CMERI have jointly taken up a project to develop various patient-specific Near Net Shape biomedical implants some of which have already developed following conventional routes.

With the development of Rapid Prototyping and Rapid Tooling (RT) and other relevant medical imaging software, it is proposed to establish the process of making tailor made artificial implants/limbs through the process of Medical Imaging – Solid Modeling – Selective Laser Sintering as well as Investment Casting route. If the process can be established, it will fulfill the demanding need of the society.

However, metallic implants made by investment casting generally contain porosity and thus are inferior in quality as far as strength is concerned compared to the corresponding forged and machined components. So the alternative routes to build the component may be vacuum casting or metal sintering and then sucking liquid metal into the voids of the part in vacuum. All these routes will be attempted in the present project.

A bright scope exists in India as well as elsewhere to develop the ideal implants like stents, load-bearing vertebral/bone-filling implants for spinal surgery and state-of-the-art dental and hip implants. Since these items are also in the research stage even in the most advanced countries, there would also have a very good export potential.

Near Net Shape Manufacturing of Component of Al based Particulate Metal Matrix Composites

As the demand for innovative light material in the manufacture of automotive components, such as cylinder blocks, cylinder heads, pistons and piston rings is increasing, several methods have been attempted to introduce new material for meeting the specific requirements Particle reinforced light metals are nowadays assuming increasing importance because of their potential as low cost, high modulus and strength and high wear resistance material. There are several ways to fabricate MMCs, e.g. powder metallurgy, molten metal mixing, sand casting, die casting, centrifugal casting, compocasting, pressure die casting, squeeze casting, investment casting, spray deposition, *in situ* reaction synthesis.

Under the CSIR network project, particulate reinforced composites based on aluminium matrix and SiC particles, as the reinforcing phase has been synthesized and prepared in investment casting process. The microstructure, fluidity index, hardness, mechanical properties have been investigated and compared to 356 Al-alloy without SiC reinforcement. Work is on to obtain better composite properties.

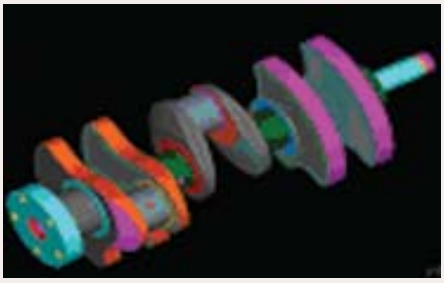
Metallic Glass

Extensive work on metallic glass has been carried out in India at Banaras Hindu University; Indian Institute of Science, Bangalore; IIT-Kharagpur & Kanpur; DMRL; etc

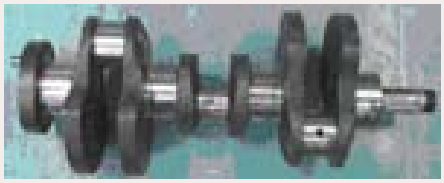
The majority of the work on metallic glass carried out at NML has been on the development of Fe-based alloy for magnetic application. The soft magnetic amorphous materials or synonymously called metallic glasses have replaced the conventional electrical steels in transformer cores due to their efficient power saving capacity.

Process Technology for Manufacturing of ADI Components

Austempered Ductile Iron (ADI) is a type of the cast iron with exceptional properties imparted through customized metallurgy. It is far superior to common cast irons. The austempering process is not new and has been utilized since 1930's on cast and wrought steels. It was first commercially applied on ductile iron in 1972 and by 1998 world wide production was approaching 100,000 tonnes



3D model of 35 HP engine crankshaft



ADI crankshaft of 35 HP, cylinder tractor engine crankshaft

annually. ADI material has strength equal to that of wrought steel with elongation up to 10%. It has an improved strength to weight ratio over steel and is potentially less expensive to produce near net shape in mass quantities. These characters along with superior mechanical properties that can be achieved with judicious alloying and controlled austempering, makes ADI competitive for many applications where wrought steel had dominated in the past.

Although the material has been produced commercially for several years, most notably in USA, it has not yet penetrated very far into the Indian market. Considering the advantages of ADI components over the conventional forged components, CMERI has taken up a project on " Development of ADI components through sand casting route" The objective of this project is to develop the manufacturing technology suitable for production of specific engineering components in NNS form. Crankshafts of different engines, which are currently being manufactured through forging and machining route, have been identified as target components.

Alloy chemistry was selected based upon the geometry and the end application of the selected components. Initial experiments were conducted on the cast and heat treated samples to optimise the process parameters to achieve the comparable mechanical properties of the forged component. 3D models of crankshaft were prepared from 2D drawings to run the computerised methodology.

Standardization of the process parameters for casting was done through computer simulation using AFS solidification software. Crankshafts were cast with the optimized alloy composition in sand moulds and machined (including straight & angular drills for lubrication) leaving the machining allowance required for heat treatment and final finishing operation. Subsequently the components were heat treated and machined to the final dimension. Heat treatment parameters mainly austenitising temperature and time, austempering temperature and time have direct influence on the mechanical properties of ADI. Laboratory experiments are being carried out on test samples to access the effects of above parameters on mechanical properties of different grades of ADI.

Since several factors like material property, geometry and manufacturing process, influence the fatigue life of crankshafts, fatigue testing of the crankshafts in laboratory is essential to assess the performance of the part.

Fatigue testing of 5 HP water pump crankshaft (SERC)

Fatigue testing of ADI crankshafts of 5 HP pump engine was carried out at SERC, Chennai, using computer controlled servo hydraulic UTM. The crankshafts were subjected to rigorous fatigue testing under cyclic bending up to 10 million cycles. Test results show that the fatigue performance of ADI is comparable to that of the forged steel crankshaft. After final machining and balancing operation, another ADI crankshaft was subjected to the extensive field trials for more than 100 hours. No abnormalities were noticed.

Subsequently the crankshaft of 4-cylinder car engine was fabricated. After completion of necessary DT & NDT, the crankshaft was fixed in the car and extensive field tests were carried out. Oil temperature and vibration of the engine were monitored and no abnormalities were noticed during 5000 km test run.

Metal Injection Moulding

Injection moulding is recognized as a high volume manufacturing method for small, complex shaped plastic components. On the other hand Powder Metallurgy process is the well-established route for production of small axis symmetry components from the material difficult to process by conventional route. Metal Injection Moulding (MIM) process has evolved by combining the above two processes and has become an attractive and growing manufacturing technology

in engineering sector.

Under the CSIR network project on Advanced Manufacturing Technology a project "Development of Metal Injection Molding Process for manufacturing of complex geometry components" has been initiated at CMERI. This is the first indigenous R&D effort to develop the complex geometry engineering component from feedstock as well as from metal powders . The primary objectives of the project are:

- Development of process route of MIM for manufacturing of engineering components from steel feedstock – 4140 and 316L.
- Optimisation of parameters related with preparation of feedstocks, moulding, debinding and sintering processes.
- Mathematical modeling and simulation for two phase die filling with feedstocks.

Squeeze Casting

Squeeze casting appears to be a very promising approach to cast sound castings of both ferrous and non-ferrous metals, because it adds special benefits of pressure die casting (high production and repeatability), and forging (finer grain size). In squeeze casting, the applied pressure plays a very important role.

Recently, researchers at the National Institute for Interdisciplinary Science and Technology (NIST), Thiruvananthapuram, have performed experimental studies on squeeze casting using Al-2124 (Al-4.4 Cu-1.5 Mg-0.6 Mn) alloy to understand the effect of applied pressure on microstructure. Square blocks of size 100x100x50 mm were produced using the facility available in the laboratory. The optimum processing parameter of squeeze casting such as the squeeze pressure, dwell time, temperature, etc. could be established for getting the product having refined microstructure and enhanced mechanical properties. A squeeze pressure of the order of 100 MPa is found to be necessary to produce a casting having a porosity level less than 0.1%. The microstructural features of the squeeze cast material showed a very fine Dendrite Arm Spacing (DAS) of the order of 20μm (a decrease of 27% compared to conventionally cast counterpart). The characterization of the squeeze cast material with respect to mechanical properties after proper T6 heat treatment revealed about 22-25% increase in the strength properties.

Some experimental work has been also done in the past in Advanced Materials and Processes Research Institute (AMPRI), Bhopal. It was felt that CSIR should take a major initiative in developing capability in this near net shape manufacturing technology since this will immensely benefit our auto-industry, which is becoming globally competitive.

The primary objective of squeeze casting task undertaken in "Developing Capabilities on Advanced Manufacturing Technologies" is to design and develop vertical type direct squeeze casting machine for aluminium alloy automotive parts. It is envisaged that the proposed system consist of auto transferring of metered molten metal into the die cavity. The hydraulic press of squeezing capacity of 300 tonnes could be capable of casting a component up to 3kg weight. Figure 10 shows the conceptual design of proposed system, which is expected to produce net shape casting in semi automatic mode.

Rapid Tooling for Injection Moulding

Competition is forcing a reduction in the lead-time to develop a mould for injection-moulded parts. Rapid tooling processes, based directly or indirectly on rapid prototyping technologies, are being explored for this purpose. However, these processes are still emerging and not very well understood, especially in terms of their influence on mold manufacturability (essentially quality and cost), and the quality of parts produced in such molds. Further, there is no single RT process that can produce mould, which can be used as an alternative to conventional mould making practices. This situation leads to three future research directions:

(1) Secondary treatment of existing RT moulds to enhance their performances in injection moulding,

(2) Process modeling and characterization to understand the process capabilities enabling appropriate RT process selection and mold design for manufacturability and

(3) RT application for EDM electrode, used in conventional mold making.

The major limitations of the present RT processes include, softer mould material, poor accuracy and surface finish, porosity leading to low mould strength and earlier mould failures and low thermal conductivity. Some of these limitations can be overcome through secondary treatments including post sintering, metal infiltration, hard metal coating, and through new alternative indirect RT routes to develop tool steel molds. Similarly, process modeling can enhance the performance of RT and it also facilitates RT process selection and mold design for easy manufacturability. The performance of RP based EDM electrodes can be enhanced by minimizing the porosities and increasing the conductivity of the material by infiltration and hard coatings, which are still not studied to a greater extent. These challenges have been taken up for investigation at CMERI under CSIR network project. on advanced manufacturing technologies.

The main goal of this investigation is to develop rapid tooling processes that can produce the moulds and or EDM electrodes to be used for rapid development of injection mouldings. In line with this the project objectives are delineated as below.

1. Improved RT Process for injection moulds and EDM electrodes
   a. RP integrated investment casting of mould inserts
   b. RP integrated gel casting and sintering
   c. Direct metal laser sintering direct mould
   d. SLA based direct mould
2. Investigations on effect of RT mould in injection moulding
3. Investigations on accuracy, RT mould failures analysis and mouldlife predictions
4. To generate mould design guidelines for RT manufacturability

The key results achieved include

1. Injection mould development through RP integrated investment casting
2. Investigations on effect of injection moulding parameters on part quality in DMLS moulds
3. Investigations of effect of geometry on accuracy in RT processes (SLA and DMLS)
4. Form governance (straightness, flatness and circularity) prediction in DMLS and SLA
5. Preliminary study on applications of DMLS models as EDM electrode

This research will be extended towards enhancing the performance of selected RT processes through hard coating and minimizing the porosity levels. Similar approaches would be extended for newer RT process to develop alternative methods, enabling easy RT process selection for specific requirements.

National Seminar on Gas Hydrates

A National Seminar on 'Gas Hydrates – A Potential Source of Energy' was held at the Indo-Russian Centre for Gas Hydrates at National Institute of Ocean Technology (NIOT) Campus, Chennai, during 4-5 February 2007. It was jointly organized by National Geophysical Research Institute (NGRI), Hyderabad, and NIOT, and sponsored by the Ministry of Earth Sciences. Scientists and researchers from several institutes (NGRI, NIO, NIOT and NCAOR), industries (ONGC and DGH) and universities [Osmania, Andhra, Pondichery, ISM, BHU and IIT (Kharagpur and Roorkee)] participated in this seminar. Academician I. Nigamutulin, Director, Shiroshov Institute of Oceanology, Moscow; Dr A. Paramanov, Director, EDBOE, Moscow; Dr Vladimir Stoyanov, Vice Director, EDBOE and Dr Sergey Sukonkin, Head, Underwater Robotics, EDBOE, participated from Russia. The seminar was aimed at bringing together scientists and technologists at a common platform to discuss and share knowledge on the ongoing activities and plan future strategies for exploration and exploitation of gas hydrates, which is considered as the future major energy resource of India. Apart from one Plenary Session, the seminar had three Technical Sessions on (i) Modeling of

Dr P.S. Goel delivering his presidential address at National Seminar on Gas Hydrates

Physical Parameters, (ii) Geochemical Analysis and (iii) Laboratory Studies & Exploitation of Gas Hydrates, and one Poster Session. Thirty-six technical papers were presented orally and 18 papers were displayed in the poster session.

Dr P.S. Goel, Secretary, Ministry of Earth Sciences, GOI, inaugurated the seminar and presided over the inauguration. Prof. Harsh Gupta, former Secretary, Department of Ocean Development and Raja Ramanna Fellow, NGRI, was the Chief Guest and Dr N. Satya Nandan, Secretary General, International Seabed Authority (ISBA), was the Guest of Honour. Dr S. Kathiroli, Director, NIOT, extended a warm welcome to the dignitaries, invitees, students and delegates. In his introductory remarks, Dr V.P. Dimri, Director, NGRI, gave an overview of the seminar and stressed the need of gas hydrates research in our country. In his keynote address, Prof. Harsh Gupta presented the energy scenario in the world and India, and high lighted the importance of gas hydrates. He outlined the various parameters such as bathymetry, seafloor temperature, sediment thickness, rate of sedimentation, TOC, etc. that indicate good prospects of gas hydrates in the vast offshore region of India. He opined that gas hydrates could meet the over-whelming demand of our energy requirement. He narrated the scientific work that is going on and future strategies that are to be followed for the exploration of gas hydrates within the Indian exclusive economic zone. He also showed the locations of gas hydrates reservoir that have been identified based on seismic experiment and later on validated by drilling under NGHP. Prof. Gupta laid emphasis on the development of extraction technology and was optimistic about the production of gas from gas hydrates by next decade or so.

Prof. Harsh Gupta delivering his key note address at National Seminar on Gas Hydrates

The abstract volume was released by Dr Satya Nandan, who in his address stressed the need of exploration and exploitation of gas hydrates.

Dr P.S. Goel in his inaugural address remarked that India should not be an energy-starved nation, as huge amount of gas deposits are available in the form of gas hydrates in the vast continental margins of India. He remarked that gas hydrates would have a special mention whenever non-conventional energy resources will be talked about. Finally, Dr Kalachand Sain, Scientist, NGRI and convener of the seminar, extended the vote of thanks to the dignitaries for sharing their vision on gas hydrates. He also expressed gratitude to the dignitaries for their unstinted support and valuable advice for organizing the seminar.

The 'Plenary Session' was chaired by Dr P.S. Goel in which eight lead papers based on research

work done by both national institutes and industry were presented. Dr Pushpendra Kumar of ONGC presented the preliminary results of Joides Resolution Drilling Ship, using which drilling/coring/LWD/MWD operations were carried out by NGHP in the Indian offshore, in collaboration with USGS. Recovery of gas hydrates samples established the presence of gas hydrates in the Krishna-Godavari, Mahanadi and Andaman basins, where gas hydrates were earlier recognized using seismic experiments by NGHP members (DGH, ONGC, GAIL, OIL, NIO, NIOT and NGRI). Dr V.P. Dimri presented details of the enhanced oil recovery procedure and pointed out that similar approach can be adopted for the extraction of gas from gas hydrates. Dr Kalachand Sain presented various seismic tools like traveltime tomography, waveform inversion, AVO inversion, AVO A-B crossplots, seismic attributes (blanking, reflection strength, instantaneous frequency etc.), quality factors and effective medium theory, and showed their application to marine seismic reflection data for the identification and quantification of gas hydrates. To better constrain the quantification of gas hydrates, he laid emphasis on studying both P- and S-wave seismic velocities and hence acquisition of large offset MCS and OBS data. Dr R.N. Singh of NGRI elucidated the theoretical aspects of thermo-mechanical modeling to understand the formation of gas hydrates deposits. Since gas hydrates are stable at high pressure and cool temperature, the system is to be considered as a dynamic multi phase. Prof. I. Nigamutulin, Director of Shiroshov Institute of Oceanology, Moscow, presented the gas hydrates activities in Russia and encouraged further cooperation between India and Russia on exploration and exploitation of gas hydrates. Dr N.K. Thakur of NGRI drew inferences based on vivid illustration of probable gas-hydrate models that might/might not produce BSR (marker for gas hydrates) on seismic section, which is a prerequisite for identification of gas hydrates. So the study is important as gas hydrates have been found by drilling without any BSR at many places around the world. Dr M.V. Ramana of NIO presented the NIO's gas hydrates activities along the continental margins of India. He suggested for high frequency sparker survey for seismic attenuation and collection of 40-60 m coring for geochemical studies for further investigation of gas hydrates. Dr I. Dutta of DGH presented the log data in Mallik well in Mackenzie Delta, Canada. The important result is that NMR log shows low porosity in hydrate formation, whereas the neutron and density porosity of gas-hydrate-laden sediment is similar to that of water bearing formations.

The next session on 'Modeling of Physical Parameters', chaired by Dr T. Ramprasad from NIO, was dedicated to the study of physical properties that govern the formation, identification and quantification of gas hydrates. It had nine technical presentations by scientists from NIO, NIOT and NGRI. Dr Ramprasad showed that BSR can be used to estimate geothermal gradient and heaflow without any heat probe in the marine environment. Dr Saurabh Verma of NGRI emphasized the need of marine electromagnetic methods for the delineation of gas hydrates, where seismic method cannot detect any BSR. Dr Kalachand Sain showed that AVO A-B crossplot can be used as an important tool to detect free-gas below gas hydrates, irrespective of saturation of overlying gas hydrates, and quantify the gas hydrates and free-gas. Dr N. Satyavani of NGRI pointed out that reflection strength and instantaneous frequency can aid in identifying gas hydrates and/or free-gas, where BSR becomes a suspect. Shri Maheswar Ojha of NGRI delineated 12% gas hydrates and 3.5% free-gas across a BSR in the Makran accretionary prism using a novel approach of estimating Vp/Vs ratios based on traveltime inversion followed by AVA modeling. Dr M.V. Ramana presented the utility of geophysical, geochemical and microbial proxies for identifying gas hydrates. Dr S. Ramesh of NIOT reported the results of winter expedition, carried out at the Lake Baikal in 2006 under ILTP between India's Institutes (NIOT, NGRI and NIO) and the Limnological Institute of Russia. The massive gas hydrates intermixed with clays were recovered by gravity corer at different location of the Malenki mud volcano in 1280-1320 m water depth. Shri D. Venkata Rao of NIOT presented the results of summer expedition, carried out at the Lake Baikal in 2005 under the ILTP between India's Institutes (NIOT,

NGRI and NIO) and the Russian Institutes (Limnological Institute and Sonic Group of VNIIOkeangeologia). The expedition recovered 160 cm long gravity core, of which first 40 cm contained the fine mud and remaining 120 cm was gas hydrates with intercalations of thin clay layers.

Dr Balesh Kumar of NGRI, who chaired third session on 'Geochemical Analysis', presented a paper relating to the molecular and isotopic composition of gases associated with gas hydrates to identify the biogenic or thermogenic origin of gas hydrates. Shri A Peketi of NIO showed evidence of methane gas in the shelf region off Goa and Mumbai between 15 - 30 m water depth. Shri Anil Kumar of ISM reported the synthesis of ethane gas hydrates in laboratory and observed that gas-hydrate always nucleated irrespective of temperature, pressure, rate of stirring and saturation rate of water at the interface. Dr Kocherla Muralidhar of NIO showed evidence of authigenic carbonates in the sediments collected from the water depths between 2665 and 3210 m in the Goa offshore. Dr Uma Shankar of NGRI showed various proxies such as venting through the seafloor, pockmarks, seafloor collapse, faults acting as migration path for fluid flow, transparent sediments due to gas-charged, reduction of amplitude strength, diaper, mud-volcano, VAMP, etc. for establishing gas hydrates in absence of BSR. On behalf of Ms Ranjana Ghosh of NGRI, who could not attend the seminar, Dr Sain presented a case study of estimating physical parameters like porosity, density, thermal conductivity, temperature, geothermal gradient, hydrates saturation, electrical resistivity and heat flow using the seismic velocity across a BSR in the Cascadia margin. Dr A. Majumdar of NIO highlighted the coupled process of anaerobic methane oxidation and sulfate reduction, forming the sulfate-methane interface (SMI), and demonstrated significant sulfate reduction within few meters of sediment cores in the Krishna-Godavari offshore, which indicates the probability of gas hydrates occurrences. Ms Judith Gonsalves of NIO presented the distributary patterns of physiological groups of bacteria in offshore Goa, and showed that the bacterial count in seep sediments was an order of magnitude higher than that in non-seep sediments.

Shri D. Venkat Rao chaired the session 'Laboratory studies and exploitation of gas hydrates' in which Dr P.S.R. Prasad of NGRI presented the results of molecular interactions and structural transition by studying the vibrational spectra (IR and Raman) of tetrahydrofuran hydrates and carbon-dioxide clathrates in natural quartz veins. Dr S. Ramesh reported that a submersible fitted with multi-beam sonar, and methane, oxygen, temperature and conductivity sensors, was being developed at NIOT in collaboration with EDBOE, Russia, that could be used for gas hydrates investigation. Dr A. Mandal of ISM showed the experimental results for the formation and decomposition of ethane hydrates. Dr P. Dewangan mentioned conditioning of MCS data before performing the AVO analysis of BSR and showed an example in the western margin of India. Dr Vikas Mahato of ISM reviewed possible methods of producing gas from gas hydrates by depressurization, thermal stimulation, inhibitor injection, carbon dioxide swapping or combination of these. Shri N. Vedachalam of NIOT described the power distribution and data telemetry control for submersible operation. Dr D.V. Borole of NIO discussed the importance of radiochemical and stable isotope studies, which can provide the age and dynamics of carbon pool and help to understand the genesis of gas hydrates. Shri M. Palaniappan of NIOT described in detail the design, capabilities and status of development of ROV. Shri Shivaprasad of NGRI described the investigation on the effect of low wt% of methanol on THF hydrates using Raman Spectroscopy and demonstrated that the methanol inhibits the hydrates formation at all concentrations but an increase in wt% shifts the dissociation of hydrates to lower temperature exponentially. Shri M. Selvakumar of NIOT presented the navigation scheme and manipulator operations for the submersible

Eighteen papers were displayed at the poster session, which was chaired by Dr Kalachand Sain. The poster of Shri Maheswar Ojha from NGRI was adjudged the best poster presenter award by a committee, and he was presented a certificate and a cash prize of Rs 5000/-.

Dr Pushpendra Kumar of ONGC, Drs. M.V. Ramana and Ramprasad of NIO, Drs. R.N. Singh, S. K. Verma, B. Kumar and Kalachand Sain of NGRI participated in the Panel Discussion, which was moderated by Dr S.K. Das, Adviser to the Ministry of Earth Sciences, GOI. In it emerged the need to develop scientific methods for the identification and quantitative assessment of gas hydrates along the continental margins of India, and for this, a large-offset multi-channel or ocean-bottom seismic data with suitable parameters may be acquired. It was decided to acquire high-frequency seismic data for attenuation studies and 40-60 m coring for geochemical studies with a view to detecting gas hydrates when BSR becomes suspicious. The reservoir properties should be thoroughly studied to understand the flow assurance problem. Depending on type of host rock, the technology for production has to be developed indigenously. Besides huge potential, the gas hydrates have implications as environmental hazard. The panel therefore also discussed precautionary measures while exploiting gas hydrates. Marine Electromagnetic survey, the panel observed, can be conducted in conjunction with seismic survey, as this will provide complementary information on the detection and quantification of gas hydrates. Laboratory studies should be encouraged to understand the nucleation, formation, composition and structure of gas hydrates. The multi-parametric ROV will play an important role in validating the ground truth. It was concluded that lot of scientific efforts (to understand the nature of distribution of gas hydrates and underlying free-gas) and technological developments (to tap gas hydrates from conventional or non-conventional reservoirs) are required.

Indo-Norwegian Workshop on Enhanced Recovery from Oilfields

Prof. Martin Landro, NTNU, Norway and Project Coordinator, Indo-Norwegian programme delivering a talk during the workshop

A two-day Indo-Norwegian workshop on "4-D seismic with special reference to Balol and Vasai Oil Fields: Enhanced Oil Recovery" was held at the National Geophysical Research Institute (NGRI), Hyderabad, from 17 March 2007. Norwegian Institute of Science and Technology (NTNU) and NGRI jointly sponsored the workshop. Shri Apurba Saha, Executive Director and Assest Manager, Mumbai High, ONGC Ltd, inaugurated and Shri P.L. Narayana, Chief, Monitoring Unit, Indo-Norwegian programme of International Cooperation Presided.

In his inaugural address, Shri Saha said that drilling involves huge expenditure and therefore , new wells must be drilled using more effective techniques and maximize the production. He pointed out that many oil fields have already crossed the maturity phase and entered the declining phase. He emphasized, "if you

have to sustain production, the only way is to find new fields in geologically complex areas and exploit the marginal fields already discovered through cost effective technologies and re-exploit the existing fields." He complimented NGRI for its efforts in undertaking a large number of hydrocarbon exploration programmes and assured that ONGC will provide funds for such programmes. He expressed that ONGC expects to work closely with NGRI and support its efforts towards 4-D seismic reservoir modeling for enhanced oil recovery from the abandoned wells.

Dr V.P. Dimri, Director, NGRI, in his welcome address outlined the Indo-Norwegian programme at NGRI. He said that at present two Norwegian programmes, one in groundwater pollution studies and the other on enhancing oil recovery from heavy oil fields are underway. Referring to the collaboration programmes, Dr Dimri said that under the Indo-Norwegian collaborative research programme the two-year project was taken up in February 2005 with the focus on enhancing secondary oil recovery from wells across the country. He pointed out that at present, with available technology, only 20-30% of oil can be extracted from reservoirs in India whereas in developed countries this rate is 50% or more. Norwey being a leading country in this field, a tripartite MoU has been signed between Institute of Petroleum and Geophysics, NTNU, NGRI, and ONGC Ltd. Under this programme a pilot study of Balol oil field in Cambay basin has been taken up jointly by these three organizations.

Shri P.L. Narayana said that India and Norway are maintaining cordial relations. Under the Indo-Norwegian co-operation there are 30 ongoing projects in various areas. Most of these projects will be over by June 2007. He further said India and Norway entered a bilateral co-operation five years back with a view to utilizing the S&T developments for the betterment of society. Dr A.K. Pandey, Scientist, NGRI proposed a vote of thanks.

During the workshop about 20 papers spread over five technical sessions were presented by NGRI, ONGC and NTNU scientists. The workshop provided an opportunity to discuss the latest developments in seismic and hydrocarbon exploration and production enhancement.

NEIST participation in exhibition

THE North - East Institute of Science and Technology (NEIST) (erstwhile Regional Research Laboratory), Jorhat, represented by Dr B. G. Unni and Shri S. B. Wann, Scientists and Ms Archana Bora, Project Assistant of the Biotechnology Division, participated in the Sericultural Exhibition held in connection with the *'Vanya Reshom Krishimela'* during 24-25 March, 2007. The exhibition was organised by the Central Muga & Eri Research & Training Institute, CSB, Lahdoigarh, Jorhat. The exhibition was inaugurated by Shri P Gogoi, Minister of Sericulture, Handloom and Textiles, Government of Assam.

In the exhibition, NEIST team demonstrated and released a medicinal plant based bioformulation called 'Muga Heal' developed by Dr Unni and his group to the muga farmers for field trials. In silkworms the diseases associated with pathogenic bacteria come under the general term called 'flacherie' which refers to the flaccid condition exhibited by infected silkworm owing to different ailments. As a result it affects large population of silkworms resulting in decrease in their silk producing capacity. Intensive research was carried out in NEIST during the last couple of years to find an antibacterial agent to control the disease. It was discovered that the dried fruits of *Terminalia chebula* (locally called Hilikha) is the most appropriate for controlling the flacherie diseases.

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