Technology Systems Programme

4.) FERRO-FLUIDS R&D PROGRAMME – NEW INITIATIVES

In the quest for novel domains of S&T exploration, FERROFLUIDS is found to be an exciting area of scientific and technological pursuit with excellent academic interests, research opportunities, developmental challenges, application avenues, device innovation prospects, and business openings etc. In the global scene, monumental work is done in Ferrofluids, their Flow Behavior, Magneto Rheological Fluids, Magneto Rheological Finishing, Electro Rheological Fluids, Magneto-Hydro Dynamics, Magnetic Ionic Liquids and many associated areas of ferrofluids in terms of synthesis, characterization, application areas, device innovation and development. May patents have been filed and good number of commercial activity is also in progress, using the fruits of S&T pursuits in this area.

In India, a number of groups (in academia, R&D laboratories, industry) have been active in R&D in different aspects of ferro-fluids and have done pioneering work. However, for achieving major breakthroughs, it is necessary to combine the expertise of various groups in a harmonious manner to achieve challenging goals. Hence, to optimize the benefits of the R&D groups pursuing the areas of ferrofluids, Department of Science & Technology (DST), Government of India has conducted Brain-Storming Session “FERRO FLUIDS: S&T & APPLICATIONS” at the CSIR-Central Scientific Instruments Organisation, Chandigarh. The aims were: a) to identify R&D groups keen to participate in a national coordinated program b) to identify specific areas to be pursued and d) to formulate a road map for this Ferro-Fluid R&D Programme in the country.

About FORTY FOUR delegates have participated in this session, with SIXTEEN Concept Papers submitted, presented & discussion. Based on the deliberations at the session, it was decided that R&D work should be carried out in the following areas: 1) Materials: Synthesis & Characterization; 2) Ferro Fluids: Applications for Energy Sector and 3) Ferro Fluids for Strategic Applications.

Accordingly, project proposals were prepared by the identified groups and forwarded for a preliminary scrutiny by a select committee headed by Prof. Krishan Lal, followed by the groups’ interaction with the committee. The project proposals were suitably refined as per suggestions of this interaction and were submitted to DST for funding. DST has scrutinized these project proposals and has sanctioned the following R&D Projects with respective details. In each project, the investigating teams have identified clearly their respective Collaborators, User Agencies, Other Beneficiaries and the Industries involved and finally following projects were supported:

A) Materials: Synthesis & Characterization:

- Ferro Fluids: Science & Technology Application at Charotar University of Science & Technology-CHARUSAT, Gujarat
- Preparation & Characterization of Ferro-Fluids for Energy Conversion Application at CSIR-National Physical Laboratory, New Delhi
B) Ferro Fluids: Applications for Energy Sector:

- Development of solar power generator using rare-earth magnets & ferro-fluids at Amity University, Noida

C) Ferro Fluids for Strategic Applications:

- Exploration of ferro-fluids for strategic applications: Athermalization in advanced optical systems at CSIR-Central Scientific Instruments Organisation, Chandigarh & Bhavnagar University, Gujarat;
- Design and Development of CNC Magneto-Rheological Finishing (MRF) system at Indian Institute of Technology, Delhi
- Exploration of ferro-fluids for magneto-rheological finishing in advanced optical systems with strategic applications at CSIR-Central Scientific Instruments Organisation, Chandigarh & Bhavnagar University, Gujarat.
A) Ferro Fluid

Magnetorheological Abrasive Flow Finishing (MRAFF) Process
DEVELOPMENT OF SOLAR POWER GENERATOR USING RARE-EARTH MAGNETS AND FERRO FLUIDS

Objectives: - To develop solar power generators using Ferro-Fluids and Rare-Earth Magnets.

Methodology: - To design, fabrication and optimisation of various parameters of solar power generators.

Deliverables: - A prototype Solar Power Generator using Solar Thermal Energy, Ferro-Fluid and Rare-Earth magnets. This is the new concept and it will provide the different type of power generators using solar energy. The work will also produce the trained manpower in the area of Ferro-Fluids.

In this project, the principal of rotation of the magnets with the help of Ferro-fluid is used. Using Ferro-fluid, the friction between magnet and the walls of the generator circular tube will become extremely less. Due to the very small friction, the magnets rotate at very high speed with a small pressure of air. The continuous rotation of these magnets will be generated with the help of expansion of the air due to solar thermal energy. The continuous motion of the rare-earth magnets inside the coil will produce electric power.

![Diagram of Solar Power Generator Using Rare-Earth Magnets and Ferro Fluids]

Features of proposed Ferro-Fluid power generator:
- Clean Energy
- Efficient
- Safe
- Portable
- Cost Effective

Project Investigator: - Dr. Abhilash Venkat, Assistant Professor and Dr. V. A. Jain, Professor, Amity Institute of Renewable and Alternative Energy (AIRAE), Amity University, Noida 201 309, Uttar Pradesh.
B.) FERRO FLUIDS: S&T & APPLICATIONS: Up-scaling of tailor made magnetic fluids & its characterization for different applications: Coolant, Damper, Seal, etc. by Dr. R V Upadhyay, CHARUSAT University, Changa, Gujarat.

The adoption of magnetic fluid for various applications like damper, coolant, etc. are far from being optimized due to the variable performance of magnetic nanoparticles systems especially during large scale production. Herein, we aim to tune a reproducible and potentially scalable magnetic fluid for damper and coolant applications.
i5-P CNC MRF

Redefining Finishing Through 5-axis CNC MRF System

Indigenous design and development of World’s 1st CNC Ball and Magnetorheological Finishing (MRF) system for 3D surface finishing.

Nano-finish Materials

- Hi-Cr Steel
- Stainless Steel
- Copper
- Aluminium
- Polycarbonate
- Glass
- Silicon

Funding under "Technology System Development (TSD)" scheme on Ferro-fluids by DST

Department of Mechanical Engineering, I.I.T. Delhi

Email: sundeep@mech.iitd.ac.in
DST - National Network Program on Ferrofluid

Ferrofluid-Nanotechnology: colloidal dispersion of magnetic nanoparticles size 10-20 nm.
Ferrofluid Activity
CSIR- National Physical Laboratory
DST National Network Project Programme

Preparation and Characterization of Ferrofluids for Energy Conversion Application

AIM: 1. Ferrofluid Preparation and Characterization
      2. To Provide ferrofluid & Characterization facilities to other network projects
      3. Development of Energy conversion devices: μW-mW power generator;
         Sensors: Temperature, Vibration & Optical.

Technology Development and Transfer (TDT) Division
Department of Science & Technology (DST)
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CSIR-NPL [www.nplindia.org]
Ferrofluid Network Project
CSIR-National Physical Laboratory

- Ferrofluid - Synthesis and Characterization
- Energy conversion devices - sensors and power generator

Chain formation of ferrofluid particles with magnetic field works as a liquid bearing of very low coefficient friction for various applications.

We at NPL have developed varieties of ferrofluids and tailored the properties suitable for application. Utilizing these unique properties we at NPL have developed a portable ferrofluid electric power generator and also sensors.
- **Functionalised CNT based Ferrofluid** (Filed US Patent 16/73 DEL 2014)

- **Ferrofluid based electric power generator**

- **Milli watt power generator**

Device made at NPL
Ferrofluid Facilities at NPL

XRD

PSA

Magneto-rheometer

Nano MOKE -3

Electron Paramagnetic Resonance

E.)
EXPLORATION OF FERRO-FLUIDS FOR STRATEGIC APPLICATIONS:
ATHERMALIZATION IN ADVANCED OPTICAL SYSTEMS

Ferro Fluid Based Liquid Cooling System

Ferrofluid based Smart Miniature Cooling System is a cooling device which utilizes heat and magnetic field to dissipate heat from the circuit or heat source. Traditional devices have certain limitations in terms of heat diffusion, noise and at the same time they require power from working system to dissipate heat. This proposed work discusses a novel technique which is truly 100% passive without conventional cooling components and thereby enhancing the reliability. The invention makes use of high heat transfer coefficient and natural circulation caused by the magnetic pump of ferrofluids so as to constitute a high performance cooling device. The heat transfer can be scaled depending upon the heat load and space constraints. The invention of Ferrofluids based Smart miniature cooling system, adapted for dissipation of heat generated from heat source (electronic devices), which comprises, microsorption for high heat requirements mounted directly on the cooling source.

Funding under “Technology System Development (TSD)” Scheme on Ferro-Fluids by DST, New Delhi
Optical Devices & Systems, CSR-Central Scientific Instruments Organisation, Sec 30C, Chandigarh, Email: harry.garg@csiroes.in

EXPLORATION OF FERRO-FLUIDS FOR STRATEGIC APPLICATIONS:
ATHERMALIZATION IN ADVANCED OPTICAL SYSTEMS

Features

- Removal of heat using heat transfer coefficient & thermal conductivity of fluid
- Team 100% passive cooling system
- Virtual magnetic pump (Magnetic engine)
- Efficient for Miniatured Systems or Microsystems
- Customized Horizontal & Vertical Systems
- Less weight and aesthetics issues
- Less components

Specifications

- Working range (Flow): 50-100 W/cm²
- Operating temperature: 40-90°C
- Heat Transfer Coefficient: 1000 W/m²K
- Size (customized): 61.6x63.5x25.4 mm
- Material: Copper and Aluminum
- Weight: 400-500g
- Flow rate: 100-150ml/min
- Magnet: Perm anet

Applications

- Electronic passive cooling
- Computer passive cooling
- Customized Miniature cooling

Industrial Interactions

- Participated in the Bangalore International Exhibition 2014
- Actively talking to ISRO for application in Miniatured Systems
- Already held discussions & presentations at ISRO
- Active talks with Thermotron, Bangalore for Technology Transfer
- Talks are going on with NGOs of Indian Companies for solution & application to their Technology.

Optical Devices & Systems, CSR-Central Scientific Instruments Organisation, Sec 30C, Chandigarh, Email: harry.garg@csiroes.in