SPECTRO-MECH

· A MAGAZINE ON MECHANICAL ENGINEERING

·TECHNIQUE POLYTECHNIC INSTITUTE

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SOLAR CAR

MAGNETIC LEVITATION TRAIN
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Editorial

Greetings and a warm welcome to our third issue of Mechanical Engineering Technical magazine **'SPECTRO MECH'** in 2017.We are excited to report that our department continues to grow in response to the global need for engineers. Mechanical engineering is the large enrolled department in the college, with more than 220 Undergraduate Students. Over the last few years, we have made significant improvements in our education programs. Mechanical Engineering department work that shows potential to enhance and improve our world. Many of these initiatives are only possible thanks to the generous contributions of alumni, friends, faculties and staffs.

I would like to express my considerable appreciation to all authors of the articles in this issue of the Magazine. It is their generous contributions of time and effort that made this issue possible. Our goal is to create a new forum for exchange of information on few aspects of mechanical engineering. We are honored to share the work of so many committed and thoughtful people. The success of **'SPECTRO MECH'** depends on your response. I would appreciate your feedback and offer any suggestion for improvement.

Soumyendra Nath Basu

Executive Director
Technique Polytechnic Institute

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POWER GENERATION BY SOLAR THERMAL IN INDIA – AN OVERVIEW

.... Soumyendra Nath Basu,
Executive Director, Technique Polytechnic Institute

The sun can be one of the most powerful renewable energy sources possible. Capturing and using just the sunlight which hits the earth in one day could provide enough energy for the entire world all year. There is no environmental damage or pollution involved, and an enormous amount of power can be generated using solar panels. These panels can be installed on almost any structure, and can greatly reduce the dependence on fossil fuels which harm the world.

Solar power has the immense capacity to bring in stability to the fluctuating electricity tariffs in India as it is cheaper than thermal and domestic coal. States have realized that solar sector is positive as most solar radiation in the worst part of India is better than the best part of Europe.

Furthermore if we magnify our focus as it deserves to be, from the point of rational scientific researcher on the problems like global warming, ecological disturbance, decreased rain fall etc then power generation by " SOLAR THERMAL" will be justified in the sub-conscious level of our mind .Under the space of this subtitle I will try my best to do it.

Often the economic growth of a country like India is measured in terms of GDP. But on the concept of "GREEN ECONOMY" economist are saying to measure economic growth only in terms of GDP is not appropriate. The proper way is to take the cumulative effect of GDP and human development index (HDI) is to be taken. If we take cumulative effect then we cannot see a satisfactory economic growth.

According to International Energy Agency (IEA), solar energy (solar photovoltaic and solar thermal) could meet most of the global demand of electrical energy by 2060. Carbon dioxide emissions from the energy sector would fall to about 3 Giga-tons per year compared to 30 Giga-tons at current levels.

In India, till 2012, no commercial solar thermal power plant generating bulk electricity has been installed. There is ample scope in India to meet the energy problems through solar thermal technologies which will help to protect the global climate by reducing GHG and CO_2 emissions for sustainable economic and social development of the country.

The main features of the radiation climatology of India are as follows:

i) About 3300 to 3700 hours of bright sunshine are available in a year in the northwest and West Central regions of the sub-continent and 2900 hours over Central peninsula except Assam, Kerala and Kashmir where it is appreciably lower.

ii) About 7.5 Kwh/m^2/day of solar energy is received over the country as a whole, for the major portion of the year, of which the maximum about 210 Kwh/m^2/month is received during cloud free winter months and pre-monsoon months and the minimum 140 Kwh/m^2/month is received during monsoon seasons.

iii) During winter, the lowest radiation is received in North India and the highest in the South India. During summer, a reversal occurs with high values in North and low in South.

iv) Diffused solar radiation is a minimum 740 KWh/m^2 over Rajasthan increasing eastwards to 840 KWh/m^2 in Assam and to 920 KWh/m^2 in extreme south of the peninsula.

v) The total solar energy received by this subcontinent is over 60 x 10^{13} MW-h. There are between 250 to 300 days of usual sunshine per year in most parts of the country.

Solar energy thus emerges as a positive alternative with certain unique advantages for the Indian condition. The industrialized nations are requesting India to take the leadership in the development of solar energy in the Third World.

Within 2035, the world's renewable energy sources could grow by at least 60 percent and could even double. And by 2060, renewable energy could supply up to four times more energy than today. Solar energy could be the world's largest primary energy source by 2060.

Solar thermal energy is finite energy resources to meet up long term global energy crisis. The recent energy crisis and environmental burden are becoming increasingly urgent and drawing enormous attention to solar-energy utilization. This thesis is intended to present a thorough review on recent advances in developing the solar-thermal technologies for direct solar thermal power generation. Both the fundamental issues and latest application research are illustrated and critical issues are discussed as far as possible.

Our country India is blessed with plenty of sun-shine. About 5-7 Kwh / m^2 /day of solar energy is received daily over India as a whole for a major portion of the year. About 210 Kwh/m^2 /month is received during cloud- free winter and pre monsoon months. Diffused solar radiation is 740 to 920 KWh/m^2.Approximately 5 x 10^{15} KWh of energy per annum from the sun is received in India. The quantum of energy is so huge that the state of Rajasthan alone is sufficient to meet annual energy demand of the world. The National Action Plan on climate change also pointed out that India is a tropical country, where sunshine is available for longer hours per day with great intensity. The country is currently the seventh largest producer of solar photovoltaic (PV) cells and ninth largest producer of solar thermal energy. This huge potential of global solar radiation and diffused solar radiation over India is yet to be harnessed in full. Among the most promising areas of the world are the South-Western United States, Central and South America, North and Southern Africa, the Mediterranean countries of Europe, the Middle East, Iran, and the desert plains of India, Pakistan, the former Soviet Union, China and Australia. In many regions of the world, one square kilometer of land is enough to generate as much as 100 -120 Giga-watt hours (GW-h) of electricity per year using solar thermal technology. This is equivalent to the annual production of a 50 MW conventional coal or gas-fired mid-load power plant. Most developing countries including India located in the tropical latitudes of 30^0 N and 30^0 S in arid and semi-arid regions of the world are endowed with plentiful and almost uninterrupted supply of sunshine throughout the year. The mean monthly values of the intensity of direct solar radiation at noon in India vary from 0.5 to 1.05 KW/m^2 depending on latitude, altitude of the station as well as the season.

A projection in the 12^{th}. Plan document of the Planning Commission indicates that total domestic energy production of 669.6 million tons of oil equivalent (MTOE) will be reached by 2016-17 and 844 MTOE by 2021-22. This will meet around 71 per cent and 69 per cent of expected energy consumption, with the balance to be met from imports, projected to be about 267.8 MTOE by 2016-17 and 375.6 MTOE by 2021-22.

The total potential for renewable power generation in the country as on 31.03.12 is estimated at 89774 MW. This includes wind power potential of 49130 MW (54.73%), SHP (small-hydro power) potential of 15399 MW (17.15%), Biomass power potential of 17,538 MW (19.54%) and 5000 MW (5.57%) from bagasse-based cogeneration.

Solar thermal power generation technologies

Solar thermal technology is not the same as solar panel, or photovoltaic, technology. Solar thermal power currently leads the way as the most cost-effective solar technology on a large scale. Solar thermal electric energy generation concentrates the light from the sun to create heat, and that heat is used to run a heat engine, which turns a generator to make electricity. The working fluid that is heated by the concentrated sunlight can be a liquid or a gas. Different working fluids include water, oil, salts, air, nitrogen, helium, etc. Different engine types include steam engines, gas turbines, Stirling engines, etc. All of these engines

can be quite efficient, often between 30% and 40%, and are capable of producing 10's to 100's of MW of power. Storage of heat energy in solar thermal is a far easier and efficient method, which is what makes solar thermal so attractive for large-scale energy production. Heat can be stored during the day and then converted into electricity at night. Solar thermal plants that have storage capacities can drastically improve both the economics and the dispatch ability of solar electricity.
Spain and Australia are the current leading countries in solar thermal energy production.

Solar energy collectors are basically of three types;

a) Parabolic trough system: at the receiver can reach 400° C and produce steam generating electricity.
b) Power tower system: The reflected rays of the sun are always aimed at the receiver, where temperatures well above 1000° C can be reached.
c) Parabolic dish systems: Parabolic dish systems can reach 1000° C at the receiver, and achieve the highest efficiencies for converting solar energy to electricity.

Growth Potential

As per the Economic Survey 2009-10, the 11th Five Year Plan envisaged an additional capacity of 78,700 MW of which 19.9 per cent was hydro, 75.8 per cent thermal and the rest was nuclear.
The Centre has targeted capacity addition of 100,000 MW each in the 12th Five Year Plan (2012-17) and 13th Five Year Plan (2017-22).
India has launched its ambitious solar energy mission which aims to generate 20,000 MW of solar power by 2022.

Solar thermal power generation program of India

1. The first Solar Thermal Power Plant of 50kW capacity has been installed by MNES following the parabolic trough collector technology at Gwalpahari, Gurgaon, which was commissioned in 1989 and operated till 1990, after which the plant was shut down due to lack of spares. The plant is being revived with development of components such as mirrors, tracking system etc.
2. A Solar Thermal Power Plant of 140MW at Mathania in Rajasthan, has been proposed.
3. Few states like Andhra Pardesh, Gujarat had prepared feasibility studies for solar thermal power plants in 1990's. However, not much work was carried out later on.

The Ivanpah Solar Electric Generating System - The world's largest CSP plant (Concentric Solar Plant) of capacity of 392 MW has been commissioned in the month of June, 2013.
Main features of the Ivanpah Solar Electric Generating System

Plant Configuration

Location: Ivanpah Dry Lake, CA (California)

Solar Field

Heliostat Solar-Field Aperture Area:	2,600,000 m²
Heliostats:	The solar field consists of 173,500 low-impact heliostats
Heliostat Aperture Area:	15.0 m²
Heliostat Description:	Each heliostat consists of two mirrors
Tower Height:	459 ft
Receiver Manufacturer:	Riley Power
Receiver Type:	Solar receiver steam generator
Heat-Transfer Fluid Type:	Water
Receiver Inlet Temp:	480F
Receiver Outlet Temp:	1050F
Receiver Temp. Difference:	570F

Power Block

Turbine Capacity (Gross):	392.0 MW
Turbine Capacity (Net):	377.0 MW
Turbine Manufacturer:	Siemens SST-900
Output Type:	Steam Rankine
Power Cycle Pressure:	160.0 bar
Cooling Method:	Dry cooling
Annual Solar-to-Electricity Efficiency (Gross):	28.72%
Fossil Backup Type:	Natural gas

Thermal Storage

Storage Type:	None

PRODUCTIVITY

.... ***Dr. Abhijit Chakraborty***
Principal, Technique Polytechnic Institute

Productivity has now become an everyday watchword. It is crucial to the welfare of the Industrial Firm as well as for the economic progress of the country. High productivity refers to doing the work in a shortest possible time with least expenditure on input without sacrificing quality and with minimum usage of resources.

Productivity is the quantitative relation between what we produce and what we use as a reference to produce them, i.e. artithmatic ratio of amount produced i.e. output to the amount of resources i.e.input. Productivity can be expressed as :

Productivity=Output / Input

Productivity refers to the efficiency of the production system. It is the concept that guides the management of production system. It is an indication of how well the factors of production , i.e. land, capital, labour and energy are utilized.

As per **European Productivity Agency (EPA)** has defined productivity as:-

"*Productivity is an attitude of mind. It is the mentality of progress of the constant improvement of that which exists. It is the certainty of being able to do better today than yesterday and continuously. It is the constant adoption of economic and social life to changing conditions. It is the continuous effort to apply new technologies and methods. It is the faith in human progress."*

Productivity is the measure of how well the resources are brought together in an societal aspirations through input-output relationship.

Production & Productivity:- Production is defined as the process or procedure to transform a set of input into output having the defined utility and quality. Production is a value added process. Production system is an organized process of conversion of raw materials into useful finished products.

The concept of production and productivity are totally different. Production refers to absolute output whereas productivity is a relative term where the output is always expressed in terms of inputs. Increase in production may or may not be an indicator of increase in productivity. If the production is increased for the same output, then there is an increase in productivity.

Production can be increased:-

1. When production is increased without increase in inputs.

2. The same production with decrease in inputs.
3. The rate of increase of output is more compared to rate of increase in input.

Benefits from Productivity:- Productivity integrates the objects of owners and workers. Productivity contributes towards increase in production through efficient utilization of resources and inputs rather than making workers to work hard. Productivity strikes to minimise human hazards and human efforts with a view to utilize them to these areas where they can contribute maximum to the output.

Dynamics of Productivity change:- Productivity improvement results is lower cost per unit by effective utilization of all the resources and reducing wastage. Lower cost per unit contributes to increased profit levels so that Company can reinvest the surplus in new technology, equipments and machines. This will result in further productivity increase and also there is a greater employment generation due to new investments. This productivity increase results in higher usages to employees as profit potential of the company increases thereby increasing purchasing power of workers. Thus productivity increase sets in a chain reaction.

Productivity Measures:- Depending upon the individual input partial productivity measures are expressed as:

Partial Productivity = Total Output / Individual Input

Labour Productivity = Total Output / Labour Input

Capital Productivity = Total Output / Capital Input

Material Productivity = Total Output / Material Input

Energy Productivity = Total Output / Energy Input

Total Productivity Measures: It is based on all inputs. This model can be applied to any manufacturing organization or service company.

Total Productivity = Total tangible output / Total tangible input

Total Factor Productivity Measures:- It is the ratio of net output to the labour and capital input

So, Total Factor Productivity = Net Output / (Labour + Capital Inputs)

Factors Influencing Productivity:

The Factors influencing Productivity can be classified into two categories:-

(a) Controllable factors (Internal)
(b) Non-Controllable factors (External)

(a) Controllable factors:-
  - Product

- Plant and Eq uipment
- Technology
- Materials
- Human factors

- Management Style
- Financial factors
- Sociological factors

Non-Controllable factors:-

- Structural adjustments
- Natural resources
- Government Policy
- Infrastructure

At last, for the development of Nation, Productivity plays a vital role. The increase and improvement of Industrial Productivity can develop any Nation and it can move towards a prosperous bright future.

CRYOGENIC MACHINING

............*Indranil Chatterjee*

DME, 3rd Year

INTRODUCTION :- Cryogenic Machining Technology (Cryo) is the next step in advanced machining. This breakthrough technology uses a patented system to deliver liquid nitrogen (at -321° F) directly to the cutting edge enabling substantially faster processing speeds and increased tool life compared to conventional cooling methods. Conventional cutting fluids are known for being expensive, polluting and a non-sustainable part of modern manufacturing processes. Global industrial trends are leaning towards environmental and health friendly technologies. Cryogenic cooling is an innovative and sustainable method, capable of replacing conventional oil-based cutting fluids under various conditions. The method has already proved to have a great potential in many different machining setups, performing equally or better than conventional cooling strategies in all criteria concerning machine ability. Majority of research work published about cryogenic machining has revolved around turning operations most commonly in combination with steels, nickel-based alloys and titanium-based alloys. Other machining operations, e.g. milling and drilling, are less researched leaving the field with a great amount of unexplored areas. Although the technology has been developing for more than 60 years the general knowledge on the subject among machining specialists is relatively low. The room for improvements is large and further optimization is necessary before more generalization of the technique within the industry.

INDRUSTRIAL SETUP (CRYOGENIC MACHINING):-

Fig. cryogenic machining set-up

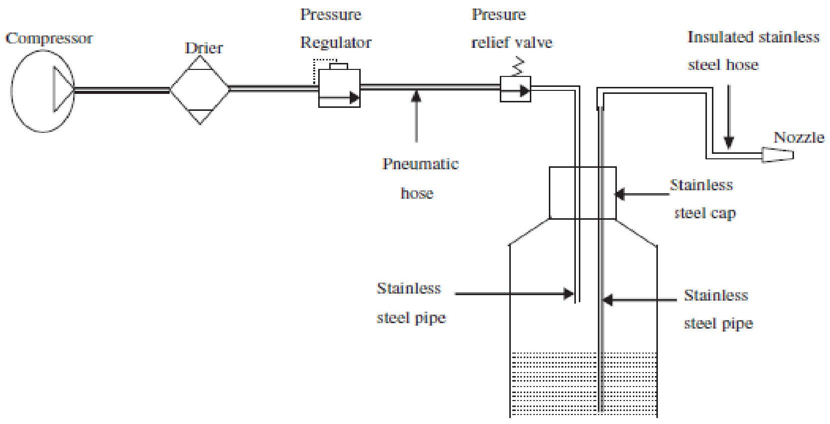
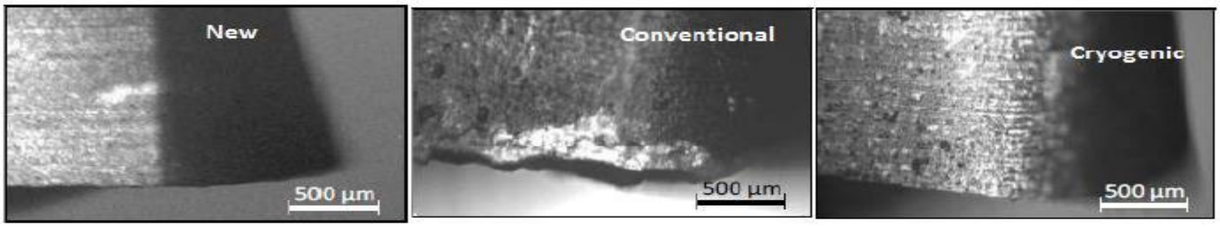


Fig. Schematic diagram of cryogenic cooling setup

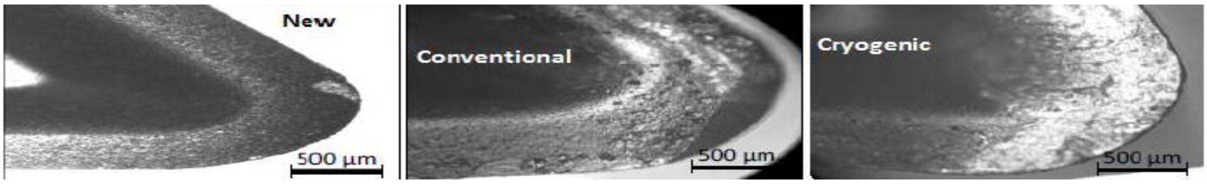
Application of cryogenic cooling :-

The cryogenic liquid is supplied to the cutting zone through various ways and equipment. The liquid is stored in cylindrical or spherical shaped tanks including pressure control and vaporizer. In the process of spraying the cryogenic cooling, the pressure in the tank itself forces the coolant to the cutting zone and no additional energy is needed for the application. In this essay the main distinction is made between internal and external supply. The internal cooling is provided through a specially designed tool where the nitrogen or CO2 enters the cutting zone in the nearest proximity to the tool-chip-work piece interface. The external cooling can either be provided through a nozzle which is positioned to aim the coolant where needed or through a cap-like reservoir which can be used in turning operations where the reservoir is placed above the insert. The most common way of taking advantage of cryogenic cooling is to deliver it to the cutting region, exposing it to the highest temperature in the machining process. It can also be aimed specially at the work piece seeking to change or improve material characteristics. For the highest efficiency, having the spraying nozzle as close as possible to the contact area is essential. The flow can be complicated to optimize when the spraying nozzle is placed far away from the cutting edge. That usually results in much higher flow rate and simultaneously there is a need for preventing the cooling from being wasted to parts of the machine or nearby items where it's unwanted. The extremely low temperature of cryogenic cooling can be harmful by changing the microstructure and mechanical characteristics of a material

Process parameters:- Process parameters are important in every machining operation. In order to get the highest efficiency of the selected combination of cutting tool and material, the process parameters have to be optimized. That can be a highly complex process but necessary to stay competitive. Whether it's the flow rate of the coolant, the shape of the tool the cutting parameters, the slightest deviation can have massive impact on the process.



Flank wear compared between cryogenic (right) and conventional oil-based (middle) turning of titanium after machining at cutting speed, *vc* = 90 m/min, and feed rate, *f* = 0,1 mm/rev, for two minutes



Crater wear compared between cryogenic (right) and conventional oil-based (middle) turning of titanium after machining at cutting speed, *vc* = 90 m/min, and feed rate, *f* = 0,1 mm/rev, for two minutes

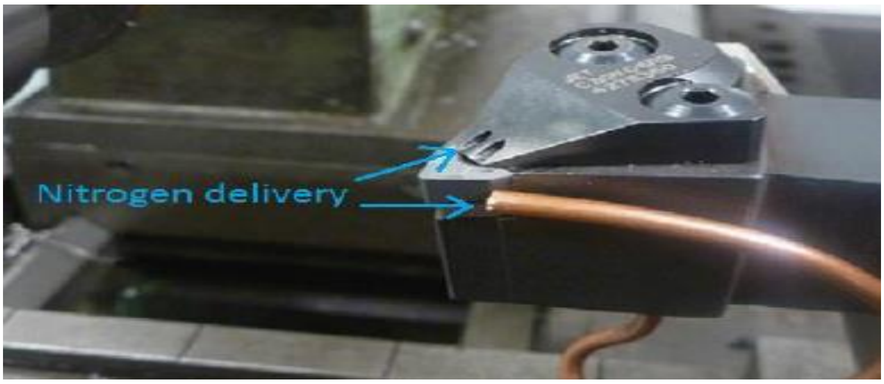


Figure LN2 delivery to the cutting zone

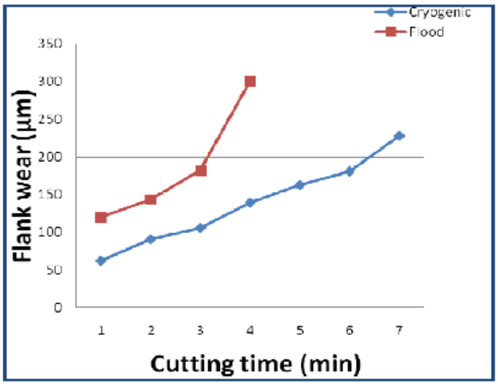
Tool Wear

Fig. (a) and (b) shows the rate of flank wear for both cryogenic and flood coolants. It is clear from

both the figures that there is an increase in flank wear with increase in cutting time. Further the flank wear is less in cryogenic machining as compared to flood machining. The decrease in flank wear is attributed to reduction in chip-tool interface temperature which in turn influences the fast removal of heat at the tool work interface. This is evidenced by the tool integrity as shown in Fig. (a) and (b).

(a) Cryogenic **(b) Flood**

Fig. Images of the chips collected during cryogenic and flood machining.



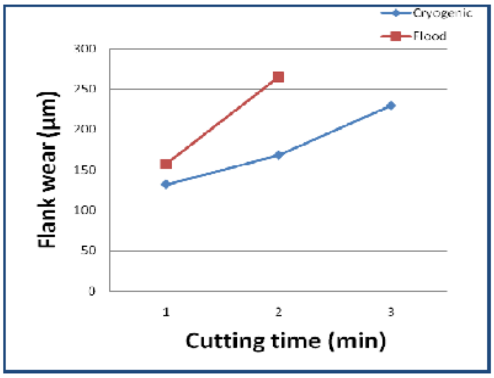
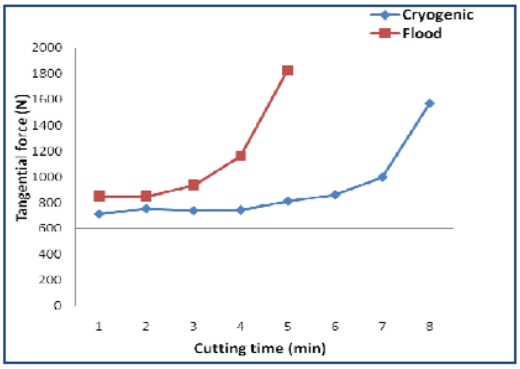


Fig. Flank wear at 200 m/min. Fig. Flank wear at 250 m/min.

Cutting forces

Fig. (a) and (b) shows the effect of cutting time on tangential force for both cryogenic and flood coolants at cutting speed of 200 and 250 m/min respectively. It is clear from both the figures that there is an increase in tangential force with increase in cutting time. The tangential force is less in cryogenic machining at any given point of time compared to conventional flood machining.



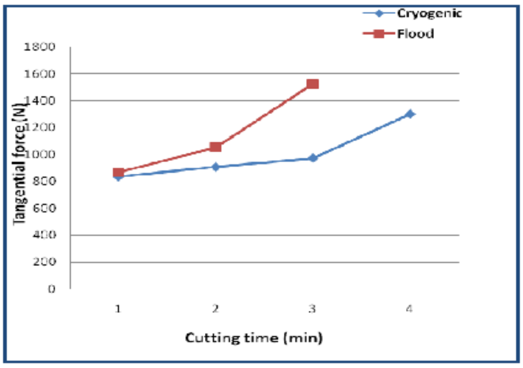


Fig. (a) Tangential force at 200 m/min Fig. (b) Tangential force at 250 m/min

Increased Processing Speed

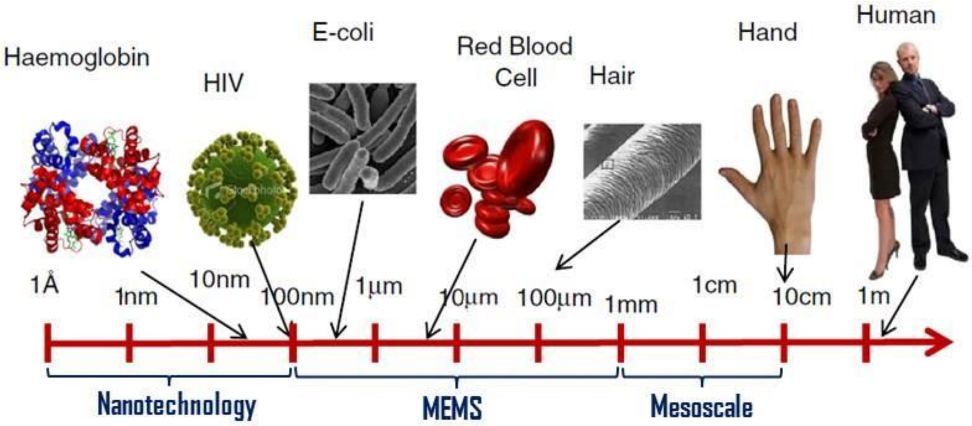
Cryogenic machining allows you to cut more parts in the same amount of time with the same machine. Since our tools have been designed to work with any machine, there's no need to invest in additional equipment to increase your productivity. Instead, with minimal investment, you increase processing speed and consequently, the number of parts machined. More parts means more sales. And more sales means more profits for your business.

MICROMACHINING

............***Arijit Mukherjee***
Lecturer, Technique Polytechnic Institute

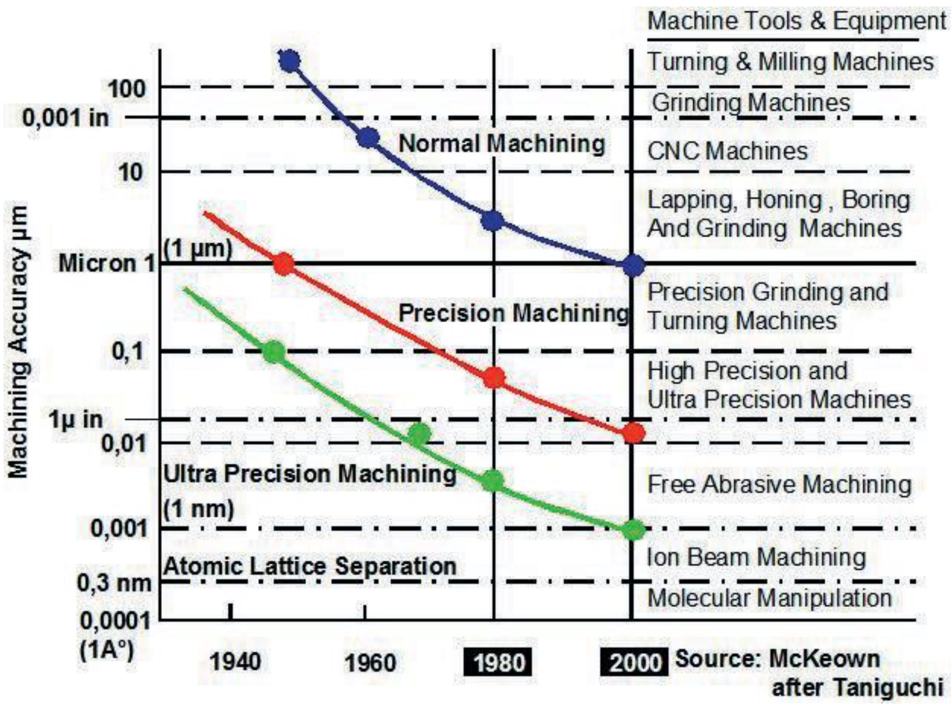
What is Micro?

Micro comes for Greek word “mikros” means small



Needs for Micromachining

The major developments in today’s world are made at a submicron level and the biggest challenge today is to be able to fabricate components at increasingly lower dimensions. Our daily routine depend on micro components and we can find them in the accelerometers of ours car airbag system and mobile phone, for instance. The micro machining or fabrication has its basis in microelectronics and most of research in this field has been focused on microelectronics devices. Nevertheless, the demand for micro-components is increasing in the most various areas like automotive, aviation, electronics, bio-medical, energy and optical fields. It includes systems for microanalysis, micro-volume reactors, Micro Electro Mechanical Systems (MEMS) and optical components among others. For example, the materials that need to be micro machined can be as diverse as a metallic, ceramic or polymeric: super alloys, titanium, gold, silver, aluminium, copper, chromium, tungsten, nickel, platinum, carbides, silicon, silicon nitride, titanium nitride, etc.



In recent years, manufacturing industry has witnessed a rapid increase in demand for micro-products and micro-components in many industrial sectors including the electronics, optics, medical, biotechnology and automotive sectors. Examples of applications include medical implants, drug delivery systems, diagnostic devices, connectors, switches, micro-reactors, micro-engines, micro pumps and printing heads. These micro-system-based products represent key value-adding elements for many companies and, thus, an important contributor to a sustainable economy (Brousseau et al. 2010). As a result of the current trend towards product miniaturization, there is a demand for advances in micro- and Nano- manufacturing technologies and their integration in new manufacturing platforms. These platforms must enable both function integration (i.e. Combination of different functions) and length-scale integration (i.e. mixing of the macro-, micro- and Nano-dimensions) in existing and new products and, at the same time, their cost effective manufacture in a wide range of materials.

Challenges

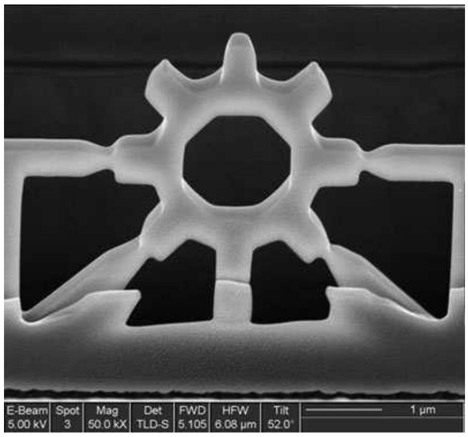
Micromachining have some great challenges like-

- ✓ Huge Machining force, as dislocation of grains takes place in atomic level
- ✓ Fixturing and handling problems

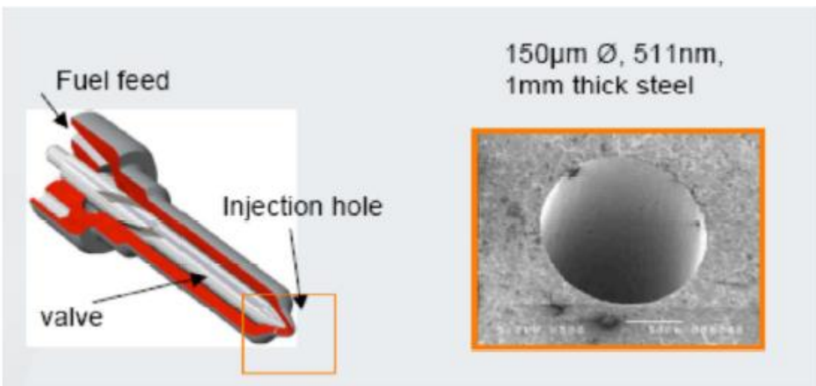
- ✓ Difficulties in tool making
- ✓ Cutting speed is much higher than conventional machining
- ✓ Challenges in micro metrology

Solutions

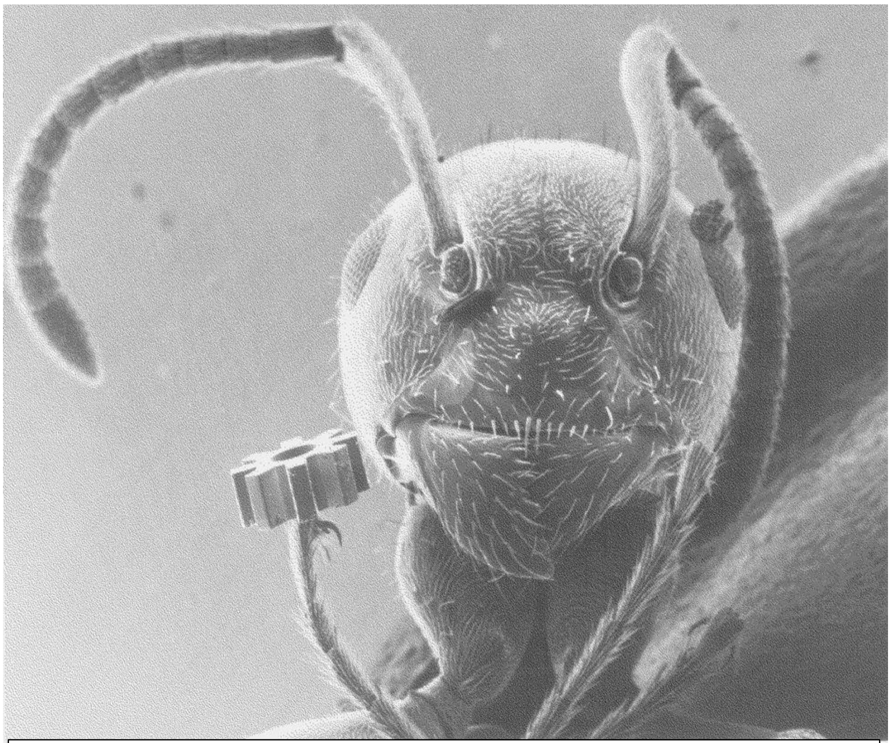
Many machining processes are available and should be selected according to the characteristics of the material that is to be machined. They can work solely as stand-alone (single function) machining tools or they can be combined in groups of two or more processes that are utilized simultaneously (hybrid-micromachining processes).



The Electrical Discharge Machining (EDM) and Electrochemical Machining (ECM) are two non-traditional processes that can be used to produce difficult-to-machine components with components 3D complex shaped features. In the Electrochemical Machining (ECM) the material is removed by the mechanism of anodic dissolution during an electrolysis process where the D.C. voltage is applied across the inter electrode gap between pre-shaped cathode tool and an anode work piece. The electrolyte should flow at high speed through the inter electrode gap. The advantage of this process include its applicability regardless the material hardness, no tool wear, comparable high material removal rate, smooth and bright surface, and production of components of complex geometry with stress-free and crack-free surface. This process is capable of machining metals, semiconductors and composites. A combination with other machining processes is also possible in order to enable improved machining characteristics. The combination of ECM with EDM, with Laser or with a vibration tool has been tried as hybrid micro-machining technologies involving ECM.



LIGA is a German acronym for Lithographie, Galvanoformung, Abformung (Lithography, Electroplating, and Molding) that describes a fabrication technology used to create high-aspect-ratio microstructures. LIGA was a cutting-edge MEMS fabrication technology, resulting in the design of components showcasing the technique's unique versatility. Several companies that begin using the LIGA process later changed their business model (e.g., Steag micro Parts becoming Boehringer Ingelheim microParts, Mezzo Technologies). Currently, only two companies, HT micro and micro works, continue their work in LIGA, benefiting from limitations of other competing fabrication technologies. UV LIGA, due to its lower production cost, is employed more broadly by several companies, such as Tecan, Temicon, and Mimotec in Switzerland, who supply the Swiss watch market with metal parts made of Nickel and Nickel-Phosphorus.



SEM picture of an ant carrying a LIGA micro gear. This picture made the cover of Scientific American Magazine in November 1992 (G. Stix , Scientific American 267, 5 (1992)).

The new trend in micro-machining is replacing the electron based processes by photon systems, and so by Lasers. The reason lies in the fact that in micro-machining with high energy electron beams the penetration of electrons in the surface layers are in depths of many microns and tens of microns, and because the energy is transferred to the atoms in the form of heat over a relatively large zone. This is not suitable for ultra precision machining. On the other hand, the reasons pointed for photons perform better are: their much smaller size relative to electrons, they are electrical neutral which avoids repulsive forces; the optical and thermal penetration depths are only ~10 nm for metals. Short and ultra-short pulse lasers are the most suited for micro-machining operations as they reduce heat affected-damage of the material and enables accuracies in the range of nanometers. Additionally, shorter wavelengths are also sought, as they are better absorbed by the material and allow smaller feature sizes to be produced. The right selection of the type of laser enables the micro-machining of components in almost all types of materials: metals, plastics, ceramics, silicon, inorganic materials, oxides, glass, etc.

The key properties in laser performance are beam quality and output power together with a compact design. The development of diode lasers has successfully fulfilled these requirements relative to conventional CO2 and lump-pumped lasers. Additionally to these improvements these laser sources provide short (nm) and ultra-short (ps and fs) pulses with very high pulse powers, leading to improvements in process efficiency and opening new fields of application. A short pulse laser with a high beam quality allows the material ablation with high quality. Controlled micromachining and high precision are better achieved by low ablation rates.

The femtosecond lasers are the latest generation of pulsed lasers delivering the shortest pulses, bellow 100 fs. Peak powers of more than 15GW can be reached due to the short pulse duration, resulting in further ablation mechanisms. Due to low optical penetration depth and high heat suppression it allows highest precision and minimum heat influence within the material. Furthermore, this process allows the micromachining of any solid material, although with limitations in the amount of removed material per time. The structuring of medical implants and production of coronary stents of memory shape alloys or stainless steel are examples of applications for femtosecond lasers. Another important application for fs-lasers, exploiting its minimal thermal and mechanical influences, is the cutting of silicon and the high precision structuring of semiconductors, as conventional lasers cause thermal melting, cracks and deposits.

All the above micro-machining presented above are complemented by other processes based on lithography, chemical and plasma etching, printing, molding, transfer and assemble techniques in the production of organic and inorganic micro components of simple or complex 3D shapes.

TECHNOLOGY AND INDIA

.... ***Ranajay Maji***
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Introduction

India ranks third among the most attractive investment destinations for technology transactions in the world. Modern India has had a strong focus on science and technology, realising that it is a key element of economic growth. India is among the topmost countries in the world in the field of scientific research, positioned as one of the top five nations in the field of space exploration. The country has regularly undertaken space missions, including missions to the moon and the famed Polar Satellite Launch Vehicle (PSLV).

Currently, 27 satellites including 11 that facilitate the communication network to the country are operational, establishing India's progress in the space technology domain. India is likely to take a leading role in launching satellites for the SAARC nations, generating revenue by offering its space facilities for use to other countries.

Market size

India is among the world's top 10 nations in the number of scientific publications. Position-wise, it is ranked 17th in the number of citations received and 34th in the number of citations per paper across the field of science and technology (among nations publishing 50,000 or more papers). The country is ranked ninth globally in the number of scientific publications and 12th in the number of patents filed.

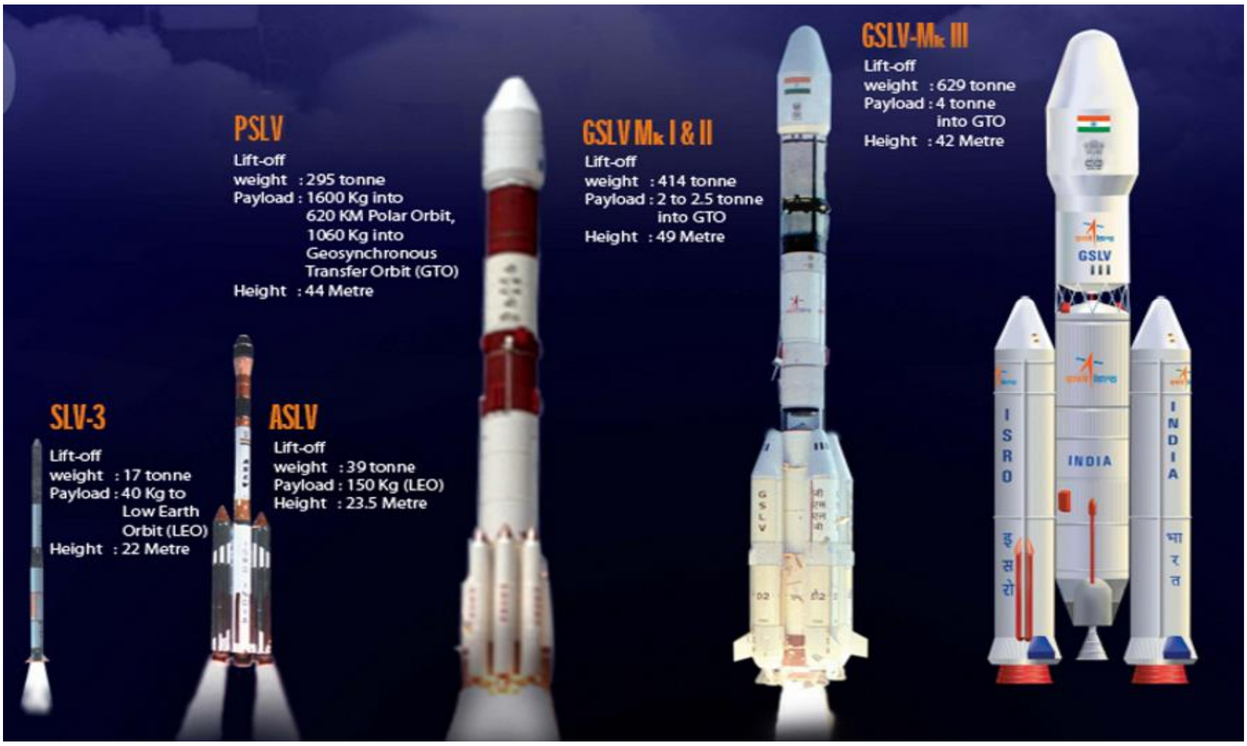
India's analytics industry is expected to touch US$ 16 billion by 2025 from the current US$ 2 billion, as per the National Association of Software and Services Companies (Nasscom).

With support from the government, considerable investment and development has incurred in different sectors such as agriculture, healthcare, space research, and nuclear power through scientific research. For instance, India is gradually becoming self-reliant in nuclear technology. Recently, the Kudankulam Nuclear Power Project Unit-1 (KKNPP 1) with 1,000 MW capacity was commissioned, while the Kudankulam Nuclear Power Project Unit-2 (KKNPP-2) with 1,000 MW capacity is under commissioning.

Recent developments

Some of the recent developments in the field of science and technology in India are as follows:

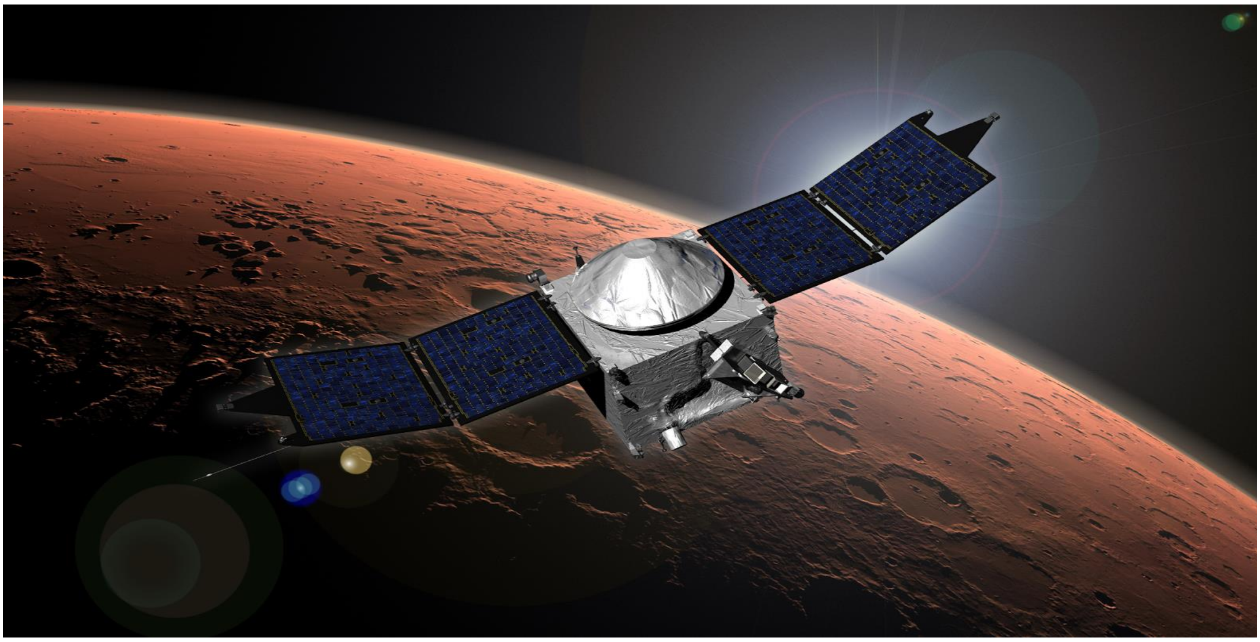
- The Indian Space Research Organisation (ISRO) plans to launch 2 satellites in March and April 2017, which includes the satellite meant for the benefit of the South Asian Association for Regional Cooperation (SAARC) nations. ISRO also targets launch of second lunar mission Chandrayaan-2 in first quarter of 2018.



- ISRO has launched a record high of 104 satellites in one go on a single rocket from Satish Dhawan Space Centre in Sriharikota, Andhra Pradesh.
- ISRO has successfully placed remote sensing satellite RESOURCESAT-2A in orbit, to provide continuity to ISRO's three tier imaging data, which will be extremely useful for agricultural applications.
- Magicbricks has launched India's first real estate Experience Centre in Mumbai, which uses technologies such as virtual reality, augmented reality, and on-demand video-call to provide an intuitive experience in property purchase.
- The Defence Research and Development Organisation (DRDO) has tied up with French engine maker Snecma to guide the Gas Turbine and Research Establishment (GTRE) to improve the performance of Kaveri engines being used in India's indigenously developed Light Combat Aircraft (LCA) Tejas.
- The Indian Space Research Organisation's (ISRO) Polar Satellite Launch Vehicle-C35 (PSLV-C35) has successfully placed eight different satellites in a single rocket mission,

including SCATSAT-1 for weather related studies, five foreign satellites and two satellites from Indian academic institutes into orbit.

- The Ministry of Environment, Forest and Climate Change (MOEFCC) has announced a research and development (R&D) initiative to develop next generation sustainable refrigerant technologies as alternatives to the currently used refrigerant gases like hydro fluorocarbons (HFCs), in order to mitigate its impact on the ozone layer and climate.
- The Indian Space Research Organisation’s (ISRO) geosynchronous satellite launch vehicle-F05 (GSLV) successfully launched India's weather satellite INSAT-3DR into space, which will provide meteorological services and assist search and rescue operations of security agencies including all defence forces, the coast guard, and in shipping industry.
- The Indian Space Research Organisation (ISRO) plans to partner with private firms to jointly build a navigation satellite that it would launch by March 2017, which would allow the space agency to free its resources to focus on research and deep space missions.
- Indian Institute of Technology, Kharagpur (IIT-Kharagpur) and National Highways Authority of India (NHAI) have signed a memorandum of understanding (MOU) for research project to develop technology to construct maintenance free highways in India.
- Intertek Group, a UK-based total quality assurance provider, has launched an Agricultural Technology (Agritech) laboratory in Hyderabad, which will perform high-tech Deoxyribonucleic Acid (DNA) analyses for the agri-biotech, plant seeds breeding, and plant seeds production industries.
- The Indian Institute of Science (IISc) has discovered a breed of natural cures for cancer in Quercetin, a compound found in fruits and leaves, and plant Vernonia Condensata, which can significantly reduce the tumour size and increase the longevity of life.
- The Indian Space Research Organisation (ISRO) has completed its mission of developing India's independent navigation system by launching Indian Regional Navigation Satellite System (IRNSS - 1G), the seventh and final navigation satellite, which will reduce the country's dependency on US Global Positioning System. The Indian Space Research Organisation (ISRO) has signed a memorandum of understanding (MoU) with the



Airports Authority of India (AAI), aimed at providing space technology for construction of airports, which will help make flight operations safer and provide optimum utilisation of land.

- Indian and American delegations have discussed an arrangement for Space Situational Awareness (SSA), a programme for monitoring space environment and track potential hazards and security threats, and have set up a bilateral mechanism for sharing information for tracking movements of satellites, avoiding collisions and identifying potential threats to space and ground assets.
- The Department of Space/ Indian Space Research Organisation (DOS/ISRO) and Kuwait Institute of Scientific Research (KISR) have signed a Memorandum of Understanding (MoU) on cooperation in the field of exploration and use of outer space.
- The Indian Institute of Science (IISc), Bangalore has become the first Indian institution to enter the Top 100 universities ranking in engineering and technology*.

Government Initiatives

India and Israel have agreed to enhance the bilateral cooperation in science and technology in the next two years, under the aegis of the S&T agreement concluded in 1993, by providing US$ 1 million from each side to support new research and development (R&D) projects in the areas of big data analytics in healthcare and cyber security.

India has become an Associate Member State of the European Organisation for Nuclear Research (CERN), which will increase the collaboration between India and CERN's scientific and technological endeavours, and will increase participation of Indian physicists, software engineers and electronics hardware in global experiments.

Ms Nirmala Sitharaman, Minister of State with Independent Charge for the Ministry of Commerce & Industry, outlined plans of setting up a committee to examine and expeditiously implement measures to improve India's innovation landscape.

Dr Harsh Vardhan, Minister for Science and Technology and Earth Sciences, outlined Government of India's plans to pursue a green path to growth by doubling investment in clean energy research to US$ 145 million in the next five years from current investment of US$ 72 million.

The Department of Health Research (DHR), Ministry of Health and Family Welfare plans to set up a three-tier national network of Viral Research and Diagnostic Laboratories (VRDLs) under which 160 VRDLs will be set up with capability to handle around 30-35 viruses of public health importance.

The central government plans to soon institute a nation-wide consultation process with a view to develop the first publicly accessible Science and Technology policy. The policy 'Vision S&T 2020' would articulate the country's future towards self-reliance and technological independence in the 21st century.

The Union Cabinet gave "in principle" clearance for the location of a Laser Interferometer Gravitational-Wave Observatory (LIGO) facility in India which will be the third in the world and will be set up and managed by the IndIGO Consortium (Indian Initiative in Gravitational-wave Observations).

The Department of Biotechnology, Ministry of Science and Technology of the Government of India has become only the second country outside of Europe to join the European Molecular Biology Organisation (EMBO), which consists of 1,700 eminent scientists and 84 Nobel laureates, and aims to encourage research in the field of life sciences.

The National Highways Authority of India (NHAI) has signed a Memorandum of Understanding (MoU) with the National Remote Sensing Centre (NRSC) under Indian Space Research Organisation (ISRO) and North East Centre for Technology Application and Research (NECTAR) to use spatial technology such as satellite data to monitor and manage national highways.

National Council of Science Museums (NCSM), an autonomous organisation under the Union Ministry of Culture, is engaged in the establishment of Science Centres across the country. NCSM is developing a Science City at Guwahati, Assam, which would be handed over to the Government of Assam for future operations and maintenance. The organisation has received proposals from various state governments for setting up of such Science Cities. NCSM has undertaken the Science Centres/Cities projects in a phased manner depending on the availability of resources, project handling capacity of NCSM, and existing level of science centre activities in a particular state.

The Road Ahead

India is aggressively working towards establishing itself as a leader in industrialisation and technological development. Significant developments in the nuclear energy sector are likely as India looks to expand its nuclear capacity. Moreover, nanotechnology is expected to transform the Indian pharmaceutical industry. The agriculture sector is also likely to undergo a major revamp, with the government investing heavily for the technology-driven Green Revolution. Also, several automobile manufacturers, from global majors such as Audi to Indian companies such as Maruti Suzuki and Mahindra & Mahindra, are exploring the possibilities of introducing driverless self-driven cars for India. The Government of India, through the Science, Technology and Innovation (STI) Policy-2013, among other things, aspires to position India among the world’s top five scientific powers.

AIRFOIL

.... ***Nabanita Bhowmik***
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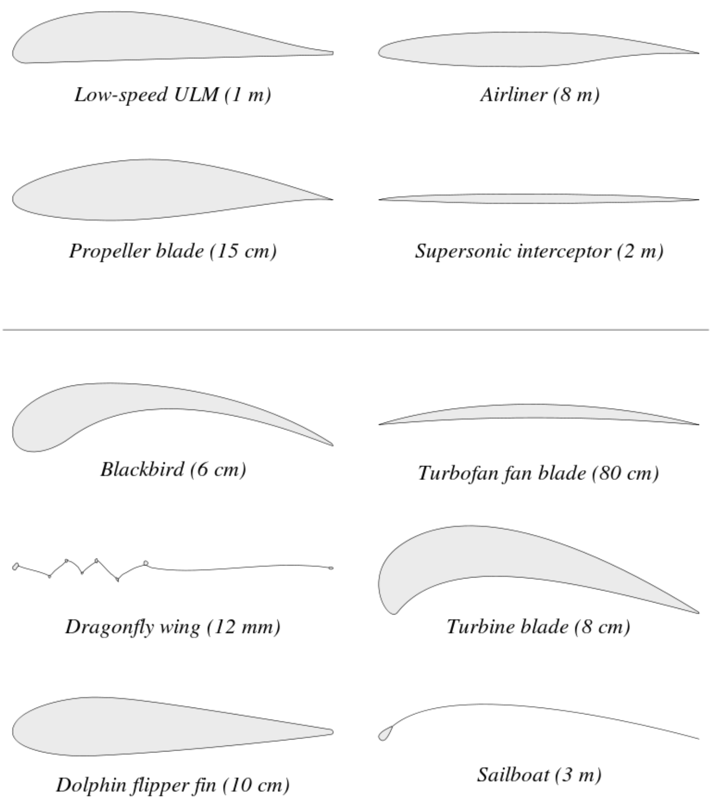
An airfoil (American English) or aerofoil (British English) is the shape of a wing, blade (of a propeller, rotor, or turbine), or sail (as seen in cross-section).

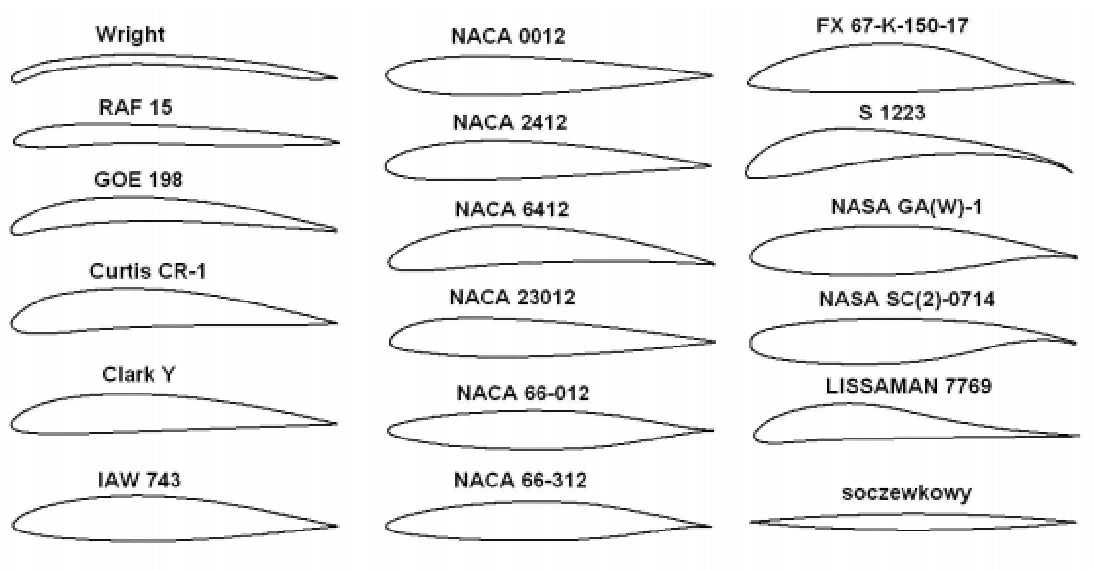
An airfoil-shaped body moved through a fluid produces an aerodynamic force. The component of this force perpendicular to the direction of motion is called lift. The component parallel to the direction of motion is called drag. Subsonic flight airfoils have a characteristic shape with a rounded leading edge, followed by a sharp trailing edge, often with a symmetric curvature of upper and lower surfaces. Foils of similar function designed with water as the working fluid are called hydrofoils.



The lift on an airfoil is primarily the result of its angle of attack and shape. When oriented at a suitable angle, the airfoil deflects the oncoming air (for fixed-wing aircraft, a downward force), resulting in a force on the airfoil in the direction opposite to the deflection. This force is known as aerodynamic force and can be resolved into two components: lift and drag. Most foil shapes require a positive angle of attack to generate lift, but cambered airfoils can generate lift at zero angle of attack. This "turning" of the air in the vicinity of the airfoil creates curved streamlines, resulting in lower pressure on one side and higher pressure on the other. This pressure difference is accompanied by a velocity difference, via Bernoulli's principle, so the resulting flowfield about the airfoil has a higher average velocity on the upper surface than on the lower surface. The lift force can be related directly to the average top/bottom velocity difference without computing the pressure by using the concept of circulation and the Kutta-Joukowski theorem

Preceding:

The earliest serious work on the development of airfoil sections began in the late 1800's. Although it as known that flat plates would produce lift when set at an angle of incidence, some suspected that shapes with curvature, that more closely resembled bird wings would produce more lift or do so more efficiently. H.F. Phillips patented a series of airfoil shapes in 1884 after testing them in one of the earliest wind tunnels in which "artificial currents of air (were) produced from induction by a steam jet in a wooden trunk or conduit." Octave Chanute writes in 1893, "...it seems very desirable that further scientific experiments be be made on concavo-convex surfaces of varying shapes, for it is not impossible that the difference between success and failure of a proposed flying machine will depend upon the sustaining effect between a plane surface and one properly curved to get a maximum of 'lift'."

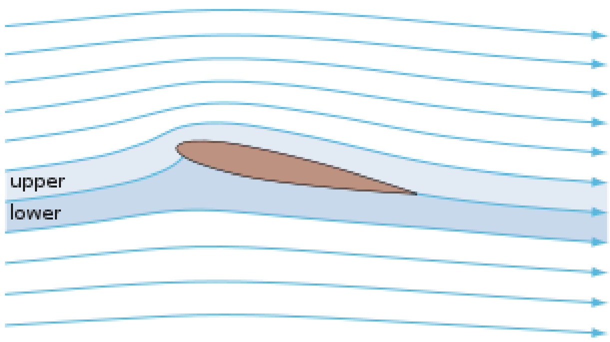


At nearly the same time Otto Lilienthal had similar ideas. After carefully measuring the shapes of bird wings, he tested the airfoils below (reproduced from his 1894 book, "Bird Flight as the Basis of Aviation") on a 7m diameter "whirling machine". Lilienthal believed that the key to successful flight was wing curvature or camber. He also experimented with different nose radii and thickness distributions. Airfoils used by the Wright Brothers closely resembled Lilienthal's sections: thin and highly cambered. This was quite possibly because early tests of airfoil sections were done at extremely low Reynolds number, where such sections behave much better than thicker ones. The erroneous belief that efficient airfoils had to be thin and highly cambered was one reason that some of the first airplanes were biplanes.

The use of such sections gradually diminished over the next decade. A wide range of airfoils were developed, based primarily on trial and error. Some of the more successful sections such as the Clark Y and Gottingen 398 were used as the basis for a family of sections tested by the NACA in the early 1920's.

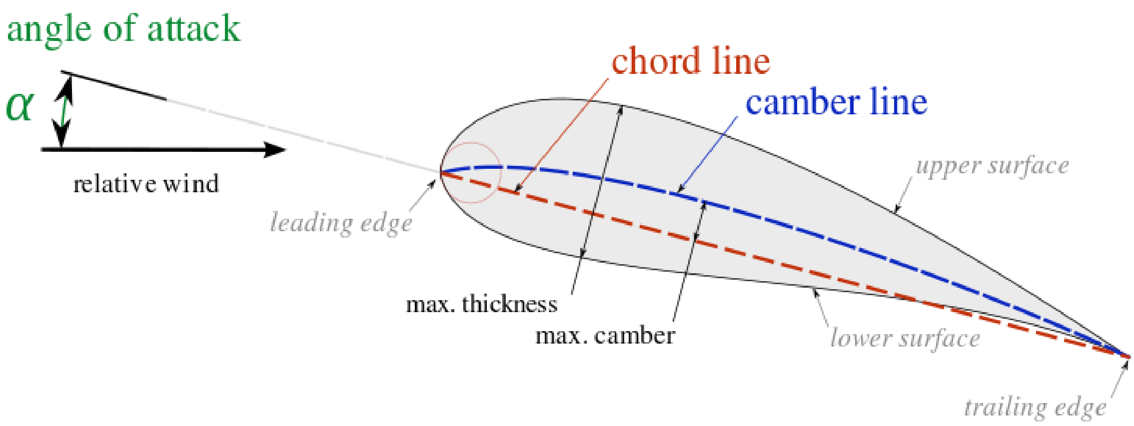
In 1939, Eastman Jacobs at the NACA in Langley, designed and tested the first laminar flow airfoil sections. These shapes had extremely low drag and the section shown here achieved a lift to drag ratio of about 300.

Forces on Airfoil

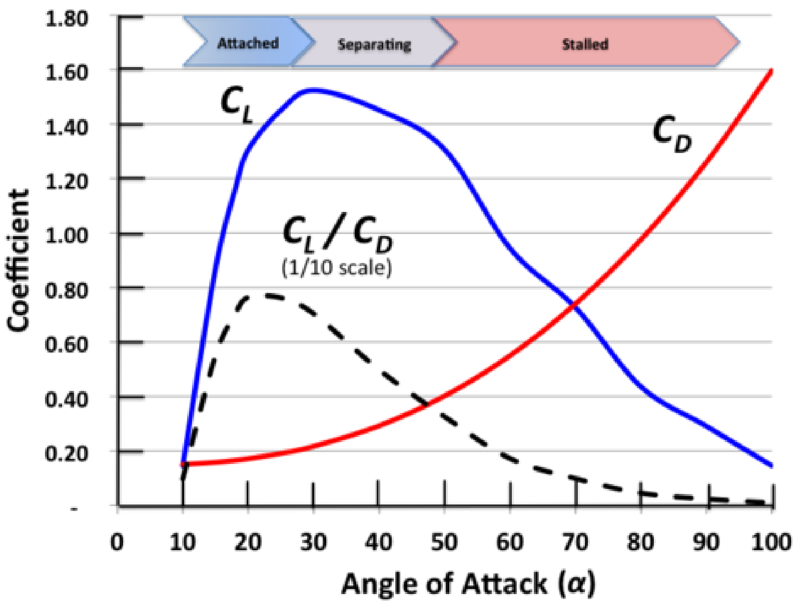


It is a common experience that a body meets some resistance when it is force to move through a fluid. The force a flowing fluid exerts on a body in the flow direction is called drag and the component of pressure and wall shear forces in direction normal to the flow tends to move the body in that direction is called lift force. Also aircraft during its flight is subjected to aerodynamic forces, namely lift and drag. These forces are primarily produce due to non-uniform pressure distribution on aircraft surfaces and skin friction. The force turns the aircraft structure, which results in the development of stresses and deformation in the structure. The aircraft structural design, therefore, necessitates strength and stiffness analysis for operating flight conditions.

This can be accomplished by simulating actual pressure loads on the aircraft and analyzing its structure for strength and deformations. Therefore, to accomplish and verify the structural design one way fluid-solid interaction is sought necessary; where in aerodynamics loads are applied on the vehicle structure for steady-state static structural finite element analysis and its effect on the structure is investigated. The choice of airfoils mainly included NACA series airfoils, NREL S series airfoils, SERI series airfoils, RISF-A series airfoils, FFAW series airfoils and DU series airfoils. At present, the numerical simulation



analysis for the performance of wind turbine airfoils mainly concentrated in the influence of mesh density, turbulence model, leading edge roughness, airfoil camber and Reynolds number for the aerodynamic performance. Given the reality that the aerodynamic performance analysis of domestic wind turbine machine mainly based on the numerical simulation, the deep study on the simulation for common airfoils would provide reliable reference for the aerodynamic design of wind turbine machine. Substantial knowledge base draws breathe for best execution in the evolution of the wing design for transonic performance in standard large transport aircraft. This demonstration examines the airfoil in a low speed wind tunnel at varying angles of attack. Symmetric airfoils are used in many applications including aircraft vertical stabilizers, submarine fins, rotary and some fixed wings.



TURBOPUMP BEARINGS MATERIALS

.... ***Sujit Kumar Garai***
Lecturer, Technique Polytechnic Institute

The life requirement for the angular contact ball bearings in the Space Shuttle Main Engine (SSME) high pressure oxygen turbopump (HPOTP) is 7.5 hours. In actual operation, significantly shorter service life has been experienced. The objective of this writing is to identify bearing materials and/or materials processing techniques offering significant potential for extending HPOTP bearing performance life. Bearing fatigue life, ball-race contact stress,, heat generation rate, bulk ring temperatures and circumferential stress in the inner rings were quantified as functions of radial load, thrust load and ball-race contact friction,

The space shuttle main engine cryogenic turbopumps, and in particular the high pressure oxygen turbopump, (HPOTP), have been experiencing premature bearing degradation. Bhat and ~olanl have reported heavy spalling and prominent wear of the rings and rolling elements of the HPOTP bearings after only 2406 seconds of total running time with only 1090 of those seconds at full power level. Other failure analyses have revealed heavy wear, smearing , microcracking and pitting indicative of surface distress associated with inadequate lubrication. The bearings in these analyses experienced total operating times of less than 6000 seconds. In addition to the above mentioned failure observations, surface oxide films indicative of high operating temperatures have been observed on rolling element and race surfaces of the bearings after 100 to 4000 seconds total operating time. These latter observations are consistent with the failure scenario proposed by Bhat and ~olanl, which attributes the abbreviated HPOTP bearing life to a thermal runaway mechanism.

In an investigative study performed on these bearings, analytical work showed that with full film lubrication the predicted bearing life is on the order of 100 hours (360,000 seconds). The life requirement is 7.5 hours or 27,000 seconds. The current HPOTP bearing lubrication scheme consists of MoS2 films on the balls and raceways, and a woven glass reinforced Teflon (Armolon) cage intended to provide a transfer film to the balls during bearing operation. The very short life of the MoS2 films and the lack of Teflon film formation in the liquid oxygen (LOX) environment results in inadequate lubrication. The attendant wear and thermally induced bearing loading have resulted in the much shorter lives experienced to date.

The failure analysis work highlighted above indicates that significant life improvements may be realized by providing low friction, wear resistant rolling contact surfaces. Computer stress analysis indicates that the means by which low friction and wear resistance are obtained must be consistent with metallurgical requirements associated with successful bearing performance in a very severe rolling contact stress environment.

The required material properties include:

1. Rolling contact fatigue life consistent with the 7.5 hour design goal
2. Dimensional stability at cryogenic temperatures

3. Fracture toughness sufficient to preclude catastrophic component fracture in service
4. Corrosion resistance at least equal to that of 440C steel
5. Ball-race contact friction coefficient less than 0.15
6. Wear resistance consistent with maintaining the required contact friction through the life goal of 7.5 hours.

The above requirements can be can be fulfilled by providing -

Hard coatings (e.g. reactively sputtered TIN) used in conjunction with a high performance bearing steel (e .g . M50) offer significant potential to provide the combination of properties indicated by the analytical studies as requisite for HPOTP bearing design life attainment.

Bearing life approaching the design goal of 7.5 hours may be realized with a coefficient of friction for ball-race contact of 0.15 or less, coupled with minimized bearing wear and thrust loading.