

# Virtual Interactive Session with Dr. K G Narayanan

On the 5<sup>th</sup> of July 2021, we the students of Mushtifund Aryaans Higher Secondary School had yet another brilliant opportunity to interact with Dr. K.G Narayanan.

Dr Narayanan did his B.Sc. from the Madras University, B.Tech from IIT Kharagpur and Ph.D. from the prestigious Indian Institute of Sciences (IISc) Bangalore. Dr. Narayanan also has more than 37 years of professional experience in research and development in electronics and aeronautics at DRDO. Dr.Narayanan has been the director of Aeronautical Development Establishment (ADE) (which is a key Aeronautical Systems Design House involved in the design and development of the state-of-the-art Unmanned Aerial Vehicles and Aeronautical Systems and technologies to meet the requirements of the Indian Armed forces) and also The Defence Avionics Research Establishment (DARE) Bangalore which is a prime organisation for the design and development of radar warners, airborne electronic warfare and mission avionics systems to enhance the combat aircrafts' survivability and mission effectiveness. Dr. K.G Narayanan has also led many crucial projects for the Indian Armed Forces and also guided in the development of flight controls, flight simulation and avionics for India's own TEJAS aircraft.

Dr.Narayanan has also been an Emeritus Professor at IIT Kharagpur from 2006-07 and a Technology Advisor to the Indian Avionics Industry..

Such an eminent personality who has achieved so much! The session was surely going to be an amazing one!

Sir Narayanan reminisced about his life at the IITs and the system in the IITs in the 1960s, sharing with us so many interesting anecdotes! One of them being the time when Sir had prepared for the difference in meaning of “engineering and technology” which at first, was quite intriguing for us... but then sir enlightened, that Technology is making a scientific principle, useful for, an application

And the best definition for Engineering according to Sir, is that “Engineer is one who can make for a shilling what any fool can make for a pound”, which made total sense and was also well appreciated by VPD sir.

Sir started the presentation with a beautiful quote by Dr. Sarvapalli Radhakrishnan,

*“Your institute bears witness to the two principal features of modern society of the modern world, that we are members of one another and that there is no decree of God of man which compels us to be sick and hungry, poor and unemployed.”*

The quote triggered the young attendees in the session..

Before taking up the topic of discussion, Dr. Narayanan gave us a brief background about climate change, and how the environmental systems have degraded over the years, and how human activity and interference in the ecosystem has been the major reason for this.

Aviation according to Sir, is the best gift mankind has given to itself. But everything has a positive and a negative side. Aviation too, has a negative impact on the environment, particularly the gas turbine engines, during it’s manufacture and also during operation. Hence, there is a need to change this to prevent an “environmental

disaster”. This is how Dr. Narayanan introduced us to the topic “Aviation and Green Energy”.

Today, Jet fuels are run mostly on petroleum-based products, which pollute the atmosphere in numerous ways... hence there evolved development in search of new fuels, like Bio-fuels, hydrogen gas, electricity, and the novel prospects of solar powered aircrafts.

Talking about the Science behind Climate Change and Impact of Aviation on the Atmosphere and the Environment, Sir Narayanan gave the students a broad perspective, right from the manufacturing of aircrafts, to it’s operation, the need for a high efficiency usage of energy/fuel, and what carbon footprint does the aviation technology make on the Earth.

During flight operations, the impact on the environs can be broadly classified into,

- 1) Noise: i.e. During Landing and Take-Off, the supersonic bang created by many supersonic aircrafts and so on.
- 2) Green House gases (GHGs) emissions during flight.

Dr. Narayanan emphasised that the Greenhouse effect is similar to one in plant nurseries where, they (the plants) are shielded with the help of, kind of a semi-transparent net, which traps the air inside and allows the air to get heated, thus helping in the growth of plants.

Though this may seem helpful to the atmosphere, Dr. Narayanan stated otherwise, some gases in the atmosphere like Carbon Dioxide, Methane, Nitrous Oxide, etc. are sensitive to certain incoming radiations, which these gases trap and thus the atmospheric

envelope and the surface of the earth gets heated up.

Dr. Narayanan drew our attention to the rising consciousness of climate change right back in the 1960s, with the initiative of the “Club of Rome” wherein scientists and environmentalists had studied the unanticipated rapid pace of development by virtue of the Industrial Revolution and how atmospheric pollution (due to technological developments) would be a major limitation to the growth, which sir then linked to the theory given by Malthus in those days, according to which, the rate of production of commodities was in the form of an Arithmetic Progression, but the consumption/demand rates were in a Geometric Progression, thus there had to be inherent limits to the so-called “growth” during the mid-20<sup>th</sup> Century..

Hence, going up on the technology would affect the air, which cannot breakthrough.

Sir continued that this growing concern then had led to the IPCC (Inter-governmental Panel on Climate Change), to study the impact of *Anthropogenic Emissions* on the environment

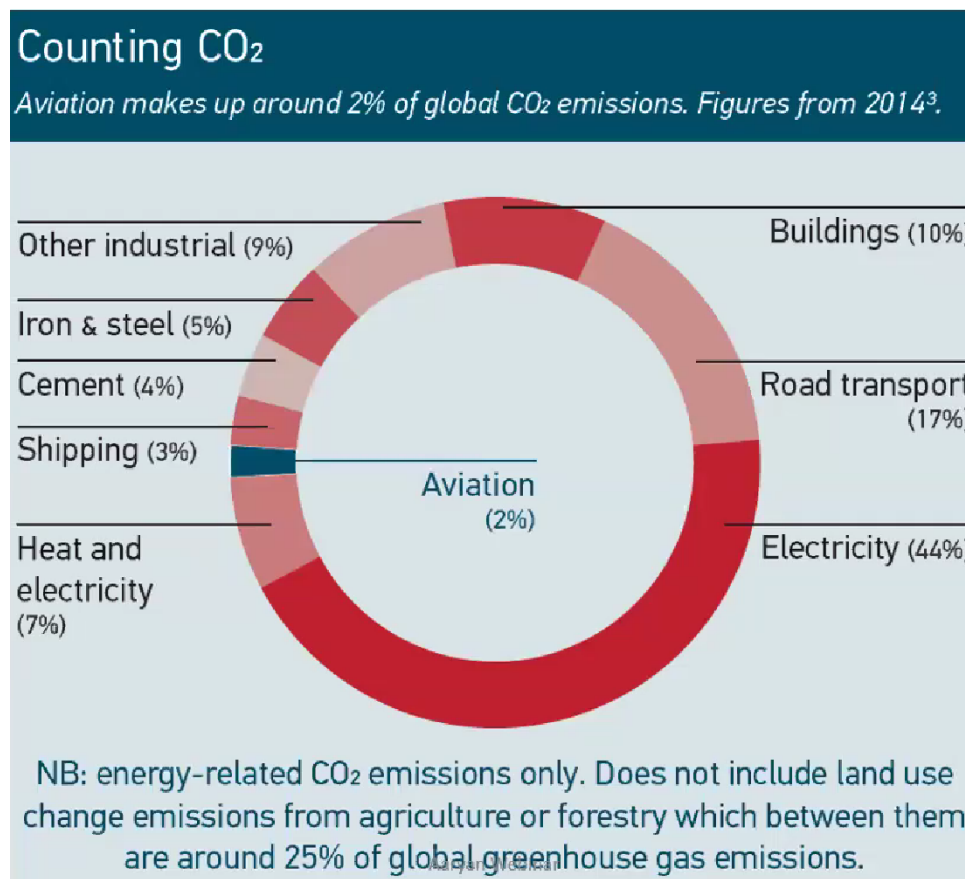
The increase in GHG emissions had led to a *Positive radial forcing of Climate*. Dr. Narayanan then elaborates this, that the atmosphere has a radiating function, i.e. It receives some amount of radiation, and emits some back. If the net exchange in radiations is positive, it would lead to the rise in global temperatures

Dr. Narayanan pointed to the statistics, that indicate the global temperatures are already on a rise, which if uncontrolled in the future, depending on how we shape our own life, can lead to serious global issues like melting of ice and polar caps, leading to a rise in ocean levels.

Sir, presented a fact that even a rise of a metre in sea levels could lead to flood-related calamities and extreme weather events in the different parts of the world, specifically the low-lying and coastal regions, which left us astonished!

At this point in the session, Sir had made us completely involved into the topic, and the students were keen to know more!

Dr. Narayanan then showed us the pie chart below depicting the contributions of different sectors in the CO<sub>2</sub> emissions



Sir highlighted that though aviation contributes just 2% to the total emissions and is not a major culprit, the growing rates of population and aviation passenger load shooting up will lead to aviation contributing nearly 9-10% in a few decades which is a matter of concern.

As Dr.Narayanan continued, and told us about the working of a jet turbine engine in an aircraft through a diagram which seemed quite daunting at first sight, but as he continued explaining it in a very lucid way, involving some of basic fundamental principles like the Newtons third law of motion, the topic became crystal clear to us!

With the working of the jet engine now known, Sir then alluded to the Effect of Aircraft on the Climate and Stratospheric ozone.

Aircrafts emit a mixture of gases (including the GHGs) directly into the atmosphere which leads to a change in the resulting composition in the atmosphere, leading to the greenhouse effect.

In addition to this, Water vapour comes out from the jet exhaust, triggering the formation of condensation trails, also called contrails, increasing the formation of cirrus clouds in the sky.

Highlighting more about contrails, Dr. Narayanan tells us that the research done about the effect of these contrails on the atmosphere is not quite conclusive about the warming and cooling effect on Earth. The contrails may trigger formation of the cirrus clouds which have a chance of affecting the atmosphere, but is incomparable to the damage done by the GHGs

Dr. Narayanan added to the discussion that ,The IPCC of 1999 was specifically concerned about understanding the aviation and global atmosphere, and to assess effects of aircraft on climate and atmospheric ozone.

This report broadly talked about the Passenger traffic growth, which was faster than the GDP of the world, i.e. faster than the global development rate!

The report also mentioned about the then aircraft technology, operating procedures and options for mitigating aviation's future impact on the atmosphere.

Dr. Narayanan then discussed about the Mitigation Measures that were taken up in the aviation sector which generally involved improving the efficiency, i.e. using lesser fuel for the same distance, optimum route planning and most importantly, usage of alternate aviation fuels like Hydrogen gas, Aviation Bio-Fuel and electricity.

Speaking about bio-fuel, Dr. Narayanan enlightened students that after lots of experimentation, commercial flights started the usage of these fuels, but the aircrafts did not solely use bio-fuel in the jet engines. Instead, there was a blend of hydrocarbons and bio fuel that was combusted in the engine to provide the energy

Some of the merits of usage of bio-fuels as discussed by Sir, were that, emissions were lesser as compared to hydrocarbon fuel engines, which helped to be carbon neutral too. Comparing the life cycle of carbon in the fossil fuels to that of Bio-Fuels, it was quite evident that bio fuel cycle was much better in terms of efficiency and actually recycled the carbon, whereas the fossil fuel cycle was more of a "Uni-directional "flow.

The different and complex processes involving bio-fuels was really well explained by Dr. Narayanan, which kept the session lively and very enthusiastic!

Moving the discussion to Hydrogen Fuels, sir is of the opinion, that the levels of advancements made in this fuel is not as much as those made in the bio-fuels... Hydrogen has many benefits, apart from being a fuel with one of the highest calorific values which I recall we

had learnt way back in class 8 in the chapter 'Combustion and Flames'.. Though at that time we were told using hydrogen as a fuel was a merely impossible task, the truth is that we are actually using it now for aviation!

Hydrogen could be used in two ways,

- 1) Burnt in the jet engines/ internal combustion chambers
- 2) Or as a power to fuel the cells to generate electricity to power a propeller.

The specific energy (No. of Joules of energy per gram wt.) of hydrogen is three times that of the usual petroleum-based jet fuel that we use.

Sharing information with the attendees about the Combustion and Fuel cells, and which one of them is better, Dr. Narayanan conveyed to us that H<sub>2</sub> combustion will not be very different from today's hydrocarbon engines but will involve certain engine modifications... which will reduce the GHGs emission to a significant level (reduced to about 10% approx.)

But something better than the hydrogen combustion is the latter option, i.e. using the Hydrogen Fuel Cells (HFCs) which will not emit GHGs at all! But currently, we are not technologically equipped to put it into operation at the moment. However, there is a possibility of hybrid propulsions, which will use both, HFCs and the hydrogen combustion options, before completely transitioning to engines using HFCs

The production of hydrogen gas should also be such that they are highly efficient, without releasing many toxic substances into the atmosphere.

Dr. Narayanan then discussed about some of the challenges we face with using Hydrogen as an aviation fuel, one of them being storage.



Since the gas is to be stored at a really high pressure of about 700 bar, the storage technology should be well equipped to handle the same.

Also, production of hydrogen for aviation fuel is currently more expensive than fossil fuels in airplane applications, but Dr. Narayanan is really optimistic about the development of hydrogen as a fuel in the future, because of the serious studies and research being done by aircraft manufacturing giants like Boeing and Airbus.

Dr. Narayanan then spoke about the novel aspects of All Electric Aircrafts.

It's obvious that airplanes cannot be plugged in to the wall for usage like we do for our gadgets, hence it has to carry sufficient energy with it on flight.

The Energy needs are broadly classified into,

- 1) propulsion power—which will take up the majority of the needs
- 2) flight control actuation
- 3) Onboard avionics like radars and navigation, etc.
- 4) Environmental control-air conditioning and filtering, etc.
- 5) Other utilities like Braking systems etc.

Sir thus defines an “all electric” aircraft as one, which can do all the above functions solely using the electricity stored onboard.

Or, Sir also mentioned a possibility of using MEAs (More Electric Aircrafts) wherein a good deal of the functions is done by electrical energy and the rest using hydraulic power.

Currently, Sir said, that we are in a phase of MEAs before we actually start using All-Electric Aircrafts

But for an all-electric aircraft, there is a need of a huge load of batteries to run the aircraft, which adds to the problem of storage of these (the current power to weight ratio is quite less as compared to what the optimum levels needed to run completely on electricity)

Hence, presently, all electric aircrafts are not used massively on a commercial scale, but is being used for special purposes which can take up a small load of passengers.

Sir added to this, that the working of an all-electric aircraft needs energy densities of the batteries to be about 400 Whr/kg, but currently we have those which have a battery density of 250-300Whr/kg , as stated by Elon Musk, the CEO of Tesla and SpaceX, who is also working towards the mission of an all electric aviation.

Hence, sir was also of the opinion that this opens a wide research field that has a lot of scope and opportunities.

Dr. Narayanan stressed on generating electricity for aviation with the help of Solar Power.

Researches are still underway with some projects namely Helios Solar Powered (Unmanned) Aircraft by NASA and another called the Solar Impulse developed by André Borschberg and Bertrand Piccard were successful enough.

Here, Sir shared some interesting anecdotes about the Solar Impulse, that the two aviators (who were actually adventurers) wanted to prove a point that they could fly across the globe without a drop of aviation fuel used. They also had proved the human spirit, that if we have the determination, nothing is impossible and global crises like the environmental degradation can be solved easily, which was a lot of motivation for us.

Sir also boosted us with some of his own thoughts regarding the quote of S. Radhakrishnan, that nothing is impossible if we put our mind into it.

The session was really an amazing one, with the students cherishing each and every moment of it. The entire presentation was very well explained, and at the end of it, we were very much enthusiastic to contribute to this field in the future! We thoroughly enjoyed the experiences that Dr. Narayanan shared with us, and had really motivated us to the fullest.

I would also like to thank our Director Sir Vyankatesh Prabhudesai for organizing such guest lectures which give us the opportunity to interact with such eminent personalities from time to time and allow us to gain a lot of new knowledge and experiences!

Report written by,  
Varun Shastry (XI Regular)