

Combustion science and Technology – past-to-future

- Role of academic research... Industry-academia cooperation?.....a brief story line.. (my life)
- How are electricity needs met in future? Coal, oil getting depleted?
- Would reciprocating engines go away?
- Aircrafts and g-t engines as well as battery based electricity based engines
- Aircraft engines with premixed combustion relevant?
- What is new in propulsion technology? Space and Defense
- Special fuels for military applications. Fuels or Devices for better environment - Domestic cooking?
- Will gasification of biomass and coal be taken seriously? AI and Machine learning

- Outstanding problems - large scale burning in Punjab? Biomass for agricultural output management (driers).

Role of academic research... Industry-academia cooperation?.....a brief story line.. (my life)

1. Every academic in India has to graduate to function at three levels
 - a. International research arena
 - b. National reputation for working with R & D institutions (ISRO, DRDO, BHEL.....)
 - c. Science based new product R & D and Tech transfer

2. If achievement on (a) is “low”, you may get ignored by colleagues within the institution and you may have little leverage in getting things aligned the way you desire.

If (b) is missing, you may loose touch with reality, because research becomes good only when theory (or computational work or modeling) gets its approval from experiments in the laboratory at one level and those in the field or large scale system behavior Or experimental studies get sanction of theory or exhibit new insight otherwise unavailable

(c) is the special aspect that is normally NOT expected of Science segments, but is emphasized particularly these days in Engineering segments. It is important and valuable for getting greater joy (and suffering some associated pain) but not essential for academic growth. Even small success adds much more to perceived strength all around.

Just to list what all happened with me (and colleagues)

- High velocity burners (LPG) for stress-relieving large vessels (BHPV, Vizag) - 1980
- Tech transfer to Kaveri Engineering, Tiruchirapalli - 1982 (Kerosene burner)
- Building IR tow targets with LPG - flight worthy - 1983 - 1985
- Research on biomass combustion (1984+) to fill my "black hole" in understanding biomass combustion and Technology development of biomass gasification for high grade clean heat and for use on turbo-charged reciprocating engines over all these years.
- Tech transfer in India and overseas - Japan and GE-USA over this period and about 15 MWe of electric and high grade thermal power systems up to 1 MWe class
- To meet lower cost clean combustion for domestic and other applications, research and technology development of combustion devices of 0.75 to 10 kg/h (Oorja class for higher density pellets - Dr. Varunkumar finished an important piece of work that was used in the design of larger systems by FEPL) - 2005 - 2014
- Continuous combustion systems - HC³D and VEBCOD for any class of biomass (from wood shavings to firewood with varying density, shape and size) 2014 +
- Tech transfer to many applications...some aspects continuing even today

How are electricity needs met in future? Coal getting depleted?

- Coal cannot be wished away for power generation over the next 10 years. Of course, grid-synchronized intermittent power supplies from SPV and Wind will increase but will be limited.
- But storage technologies - battery based or others will not make such inroads as to reduce the coal and hydro based power supplies in the foreseeable future.
- It is true that Stanford research document advocates SPV and Wind as the only solutions to energy of the World in the near future.
- I find it difficult to agree totally because half-the-World still depends on biomass for cooking.
- Further, quarter of the World depending on the highly polluting Charcoal stoves even now.
- Changing the World order so soon is a myth.
- Improving is a certain possibility. Making charcoal stoves emit little CO through use of fan based air supply - from 400 to 1000 ppm to near zero is technically feasible, but very hard to penetrate the sector that considers it unaffordable....what to do?

Would reciprocating engines go away? Aircrafts and g-t engines as well as battery based electricity based engines? Aircraft engines with premixed combustion relevant?

1. It is not impossible that over the next 20 years a large number of SUV's in the urban setting will get replaced by electric vehicles when widely dispersed charging stations become available - perhaps through an intermediary hybrid vehicle option.
2. But it is very remote that heavy vehicle transport will be any different from what is there now. Petroleum fuels are so friendly that replacing them is very tough!
3. Very short haul transport - (150 to 200 km) will become battery based electric motor driven high efficiency propeller pushed aircraft. I am unhappy we have done not much in this regard. This is an important segment of high significance to our country.
4. Long distance transport will continue to be dominated by GE/P&W/SNECMA/Russian engine based aircraft. No replacement seems possible in the foreseeable future.
5. Premixed combustion process is needed for reducing emissions. This is needed for civil aircraft.
6. I do not see any influential action on the part of academic R & D would do (or has done) for item 1 or item 4/5. They are dominated by Europe and the USA. We continue to stay behind by at least three decades!
7. However, we can jumpstart on item 3. Here again academic role is not much. Good industries with adequate deep pockets can take the initiative. Perhaps, good start-ups can do something significant too.

Will gasification of biomass and coal be taken seriously? AI and Machine learning

- As I indicated earlier, coal cannot be escaped. Whether we will do innovative work on coal gasification - to lead to methanol (as conceived at present) or power generation at lower capacities is a function of the environment.
- Regarding biomass, it will always be at distributed scale and not large. It will be there for a long time around as far as I can see. But what can be done should be done to improve the combustion quality or upgrade the biomass quality, etc.
- My guess is that these may not happen - why? Some of them have been there for some time and have not excited the decision makers
- Artificial intelligence and Machine learning. - These are tools. What is the question or are the questions needing them? We should look at them first.

What is new in propulsion technology? Space and Defense Special fuels for military applications. Fuels or Devices for better environment – Domestic cooking? Others?

- Methane-LOX liquid rocket engines - already being tried out at LPSC.

- Hypersonic flights - Mach No of 6+ treated as an important segment by DRDO.

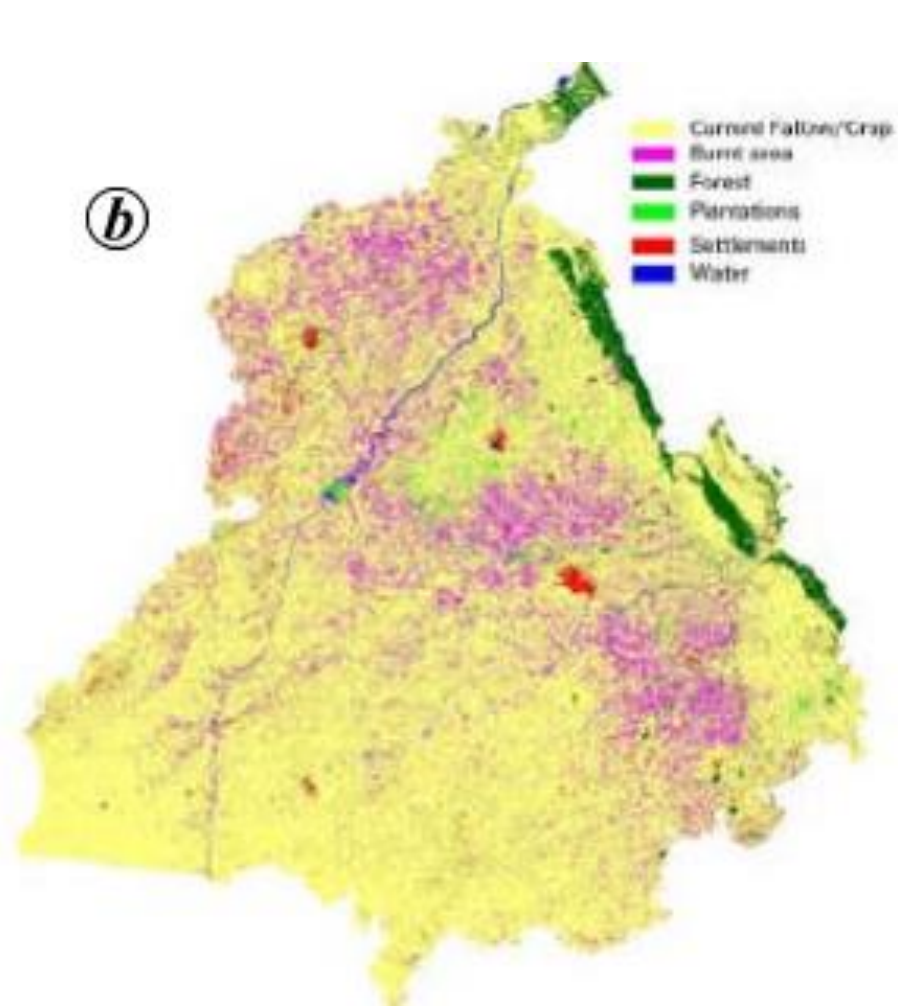
- New possibility - Low cost space flights for satellites and travelers for space experience and should involve hybrid rockets - being tried out, but I do not know when important things of this kind will ever happen knowing the pre-occupation with Moon and Mars

- Fuels for military applications - JP 10 available in USA and Russia (and China) for over three decades, but we do not have - not more than a few kg here (Joint project under GATET with IITM got closed some time back); Other endothermic fuels can be conceived and developed. Requires multi-disciplinary talent.

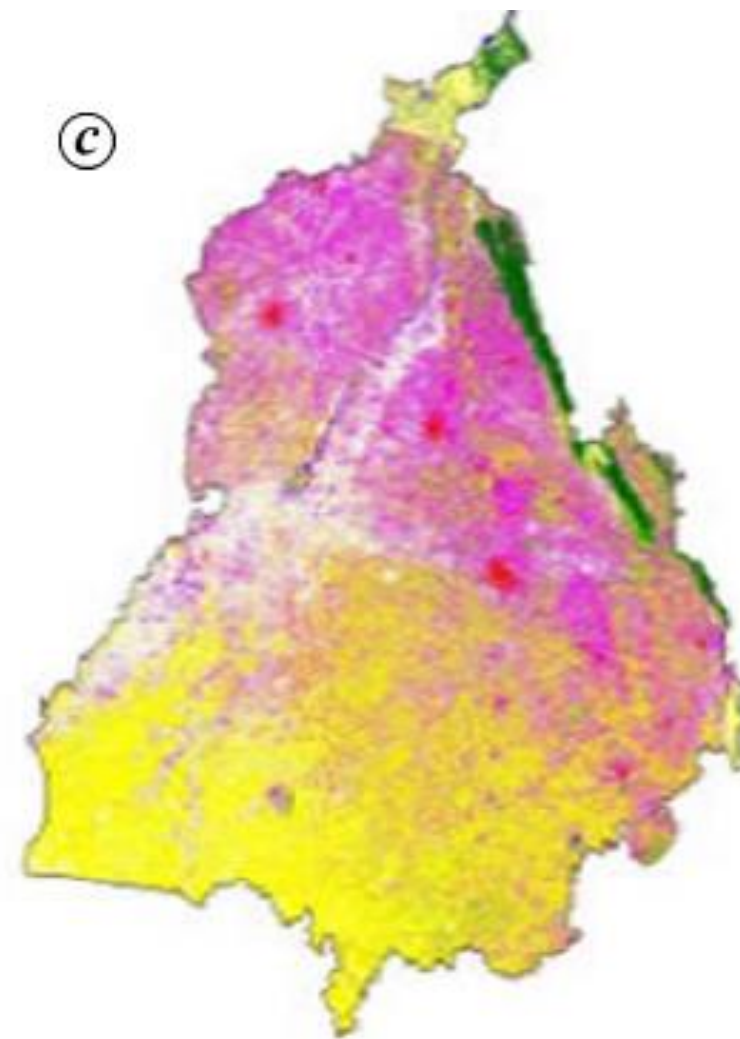
- Domestic cooking - dominated by LPG. Circumstances may arise for need of clean solid fuel combustion. There should be preparedness on this (of course, it one of lifetime activities)

- Problem of what straw burning in Punjab is a much publicized news. Can something be done? Do you have ideas?

- What about urban solid waste? Is it only management problem? Are there no simple technical solutions - of combining waste with generation of charcoal an important product for fuel or other applications? - My solution - pre-treatment with Oorja technology.



Wheat field burning after harvest
Punjab - 5500 km² May 2005



Rice field burning after harvest
Punjab - 12,600 km² Oct 2005

From an NRSA paper, Current Science, June 2006



.....More comments and discussion.....