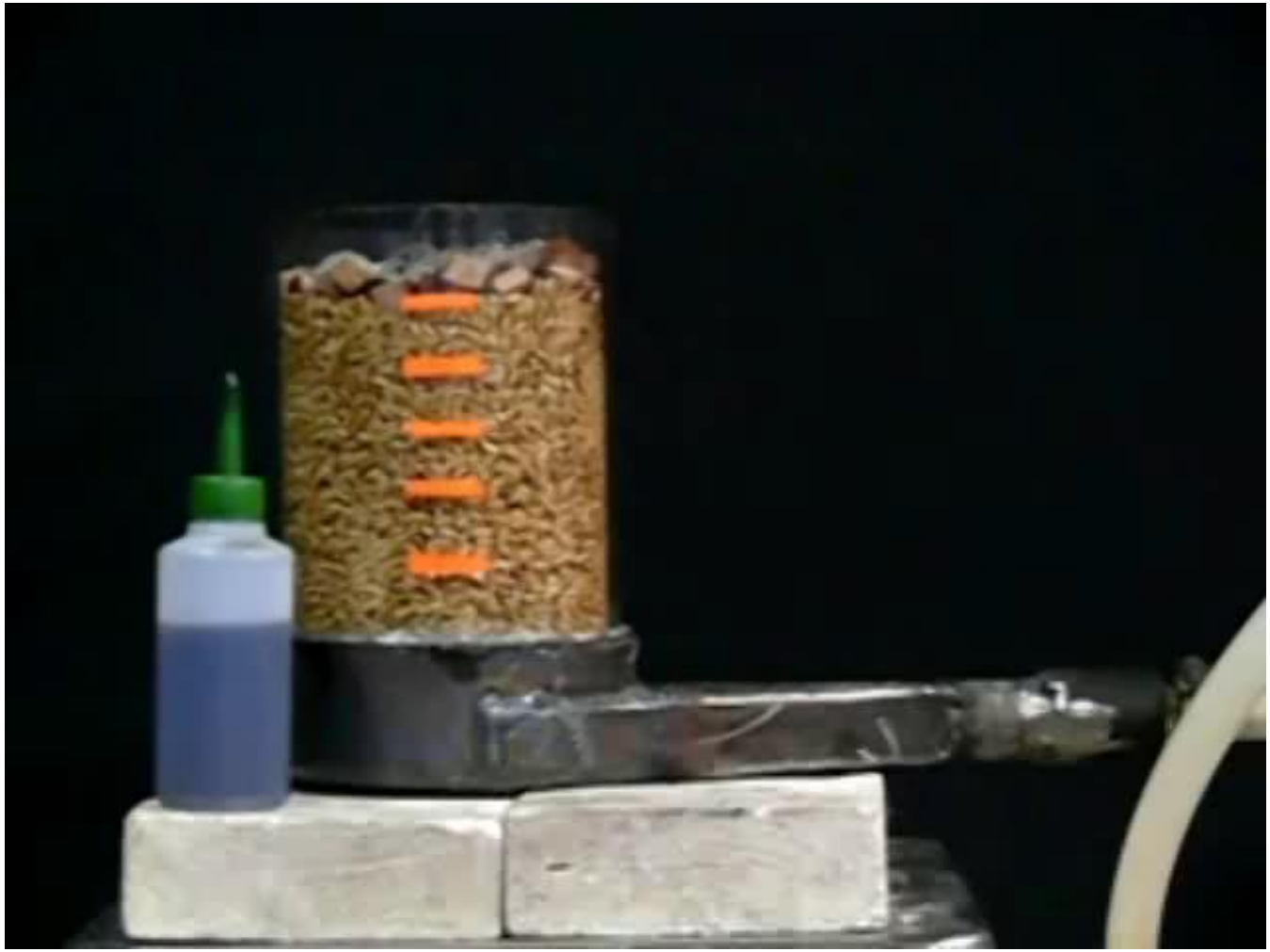
Travails of Tech-Transfer

Science based creative technology transformation

1. Date lines of gasification based thermochemical conversion process
2. ……..before that a bit about…what is all this about gasification?
3. Gasifier - Pre-tech-transfer Science & tech-development
4. Reliving Seethadevi's Agnipariksha many times over!
5. Tech-transfer process – Patenting and commercials – in India and overseas
6. Technology is good, but expensive…..
7. Outreach – support from MNRE over two decades and sun-down process of the gasification based electricity generation….in India
8. Moving over to in-situ gasification principle based combustion, science, tech development, tech transfer and outreach on the batch process
9. The continuous solid biofuel fed combustion – HC3D, VEBCOD – science, tech development, tech transfer and field operations

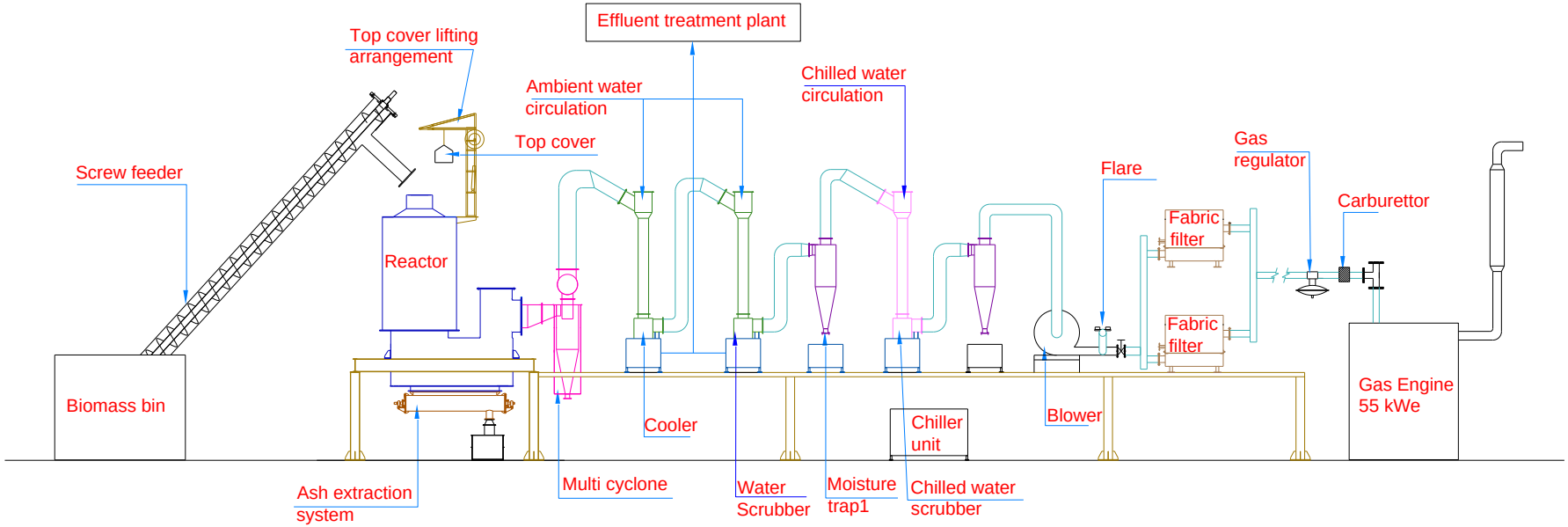
What is gasification: Burn from top to bottom with air from bottom; otherwise, there will be power fluctuations



What is this new gasification technology?

- A staged air-ingestion open top reburn multi-fuel gasifier. Research and development, field testing and interactions of over 25 years at IISc.
- Has been tested with natural gas engines with fitments to operate on producer gas from 1 kWe to 1000 kWe for 1000 to 30000 hours, larger ones as commercial projects supported by the IISc laboratory.
- Technology transferred to many Indian companies and Japan and GE-USA.

Many more elements needed from principles to technology ----------



Some systems

GASIFIER(750Kg/Hr)

Persuading an engine giant

•600 tonnes of coconut shell being stored on the industrial site and a 1500 kWe reciprocating engine systems with 1700 kg/h gasification system (IISc design)

Reliving Seethadevi's Agnipariksha many times over!

Every new aspirant of technology would need a demonstration at least as good as the previous one – with repeating the same questions or more questions than the previous aspirant!

Aspirants expecting to be taken to existing installations, wishing to have private talks with the industry that has acquired the technology needed perseverance and patience.

Date lines…..

- 1970-1980: Development of Hybrid (LOX-Rubber) Rocket System.
- 1982+: Study Gasification as a process; Why is combustion of biomass not as good as kerosene or LPG
- 1982–1994: Exploration to Gasification: open top, throat based system close to WW II class and Open top Downdraft Re-burn System
- 1994-1996: Demonstrations of the Gasification Systems on meeting Swiss technology standards.
- 1996–2000: Presentations of the Gasification Science and the results internationally and patenting of the process.
- 2000-2004: Packaging of Gasification Technology; Execution of industrial and field projects; Licensing of Entrepreneurs for Commercialization.
- 2004-2008: Adaptation of Gas Engines to Gasification systems; Development of other technologies for value added products and for energy generation from biogas.

……. Further

·1999 - 2007: Major Project of MNRE – Strategic Development of Bio-energy (SDB) in two phases

·2000 - 2003: Major Project of MNRE – Advanced Biomass Gasification – high pressure gasifier and gas turbine (with BHEL, IICT, IITM)

·1999 – ABETS formed as an Autonomous Society of IISc for handling Biomass and other special purpose projects

Q: Where was the need for a new society when SID was already there?

A: Persuasion needed arguments - Independence of negotiation & financial management with answerability only to IISc and not through SID
Persuasion was not entirely "gentle" – either this or almost nothing!

- **Technologies developed:**
- Gasification of any biomass to produce Electricity or Heat.
- Package with Electricity/Heat + Activated Carbon (4-5%)
- Precipitated Silica from Rice Husk/Ash/Char
- Biogas Clean-Up (of H_2S) & Electricity via Reciprocating Gas Engines

….Further

- Patents in India on all these technologies. – Technology transfer to about six licensees in India over a fifteen year period.
- It is this aspect that needed independence because negotiation can be done only by one person. Hierarchical arrangement leads to delay and break down of functionality.
- Technology transfer terms slowly tightened financially as well as freedom to operate overseas, keeping in view the need to protect the quality and the name of IISc.
- The technology has been such that even if all the drawings are given, and system is built as per the drawings, any "good" party would not be able to handle the operations unless hand-holding took place during the early stages.
- Overseas technology transfer has been done to Japan; GE, India also has received the tech transfer after my retirement by colleagues. GE came to IISc after studying all other technologies – so they stated to Director, IISc
- Considerable effort was needed to be made by the laboratory in managing the technologies and ensuring that its quality is well perceived

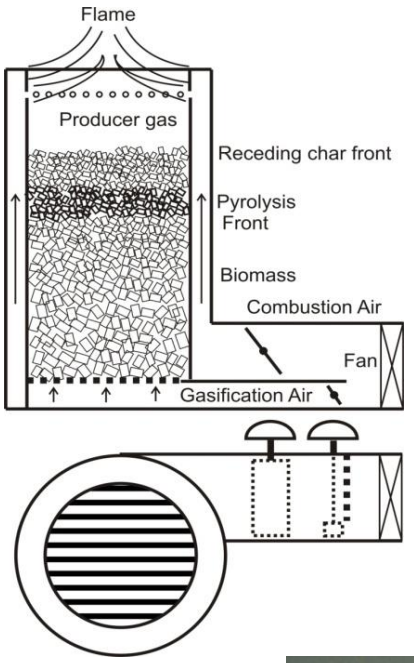
Field outreach - commercial – through licensees

- 50+ Gasification Installations – Electricity (10 MWe, total), including 3 in Brazil, 1 in Chile, 1 in Japan, 1 in Switzerland, 1 in France, 1 Thailand, rest in India (1995 – 2015)
- 10+ Gasification Installations – High Grade Heat ~ 8 MWth
- Biomass – Coconut Shell, Prosopis Juliflora, Forest Residues, Sawdust and Agro-Waste Residues – Briquetted
- About 5 Biogas Clean up and Power Generation from Effluent Treatment Plants and Sewage Treatment Plants ~ 6 MWe

Gasification based combustion devices

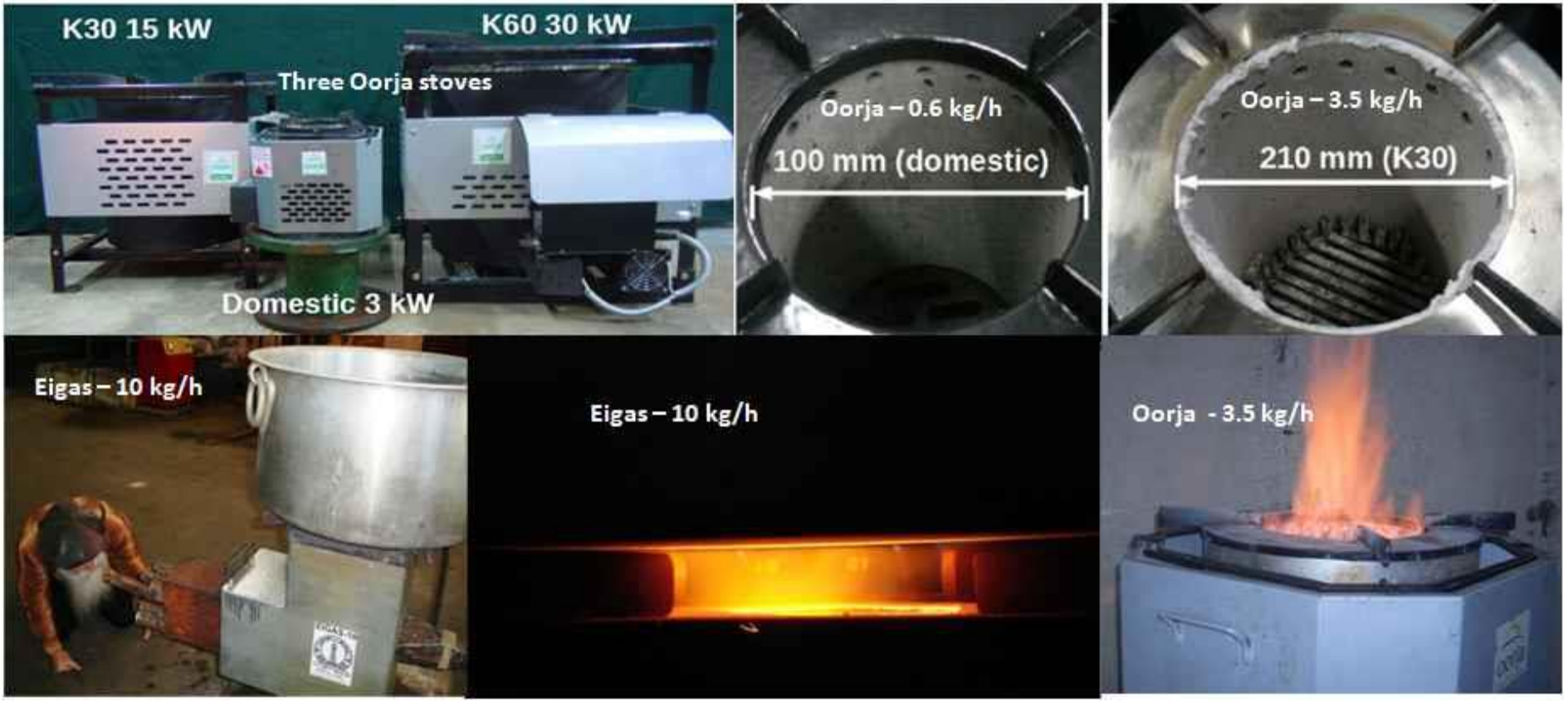
1. Gasification based power generation devices had to compete with solar electricity over a time and became less interesting
2. Clean combustion using gasification process was also economical only in select situations when heat had to be piped over a distance to several locations
3. Local clean heat delivery became a very important opportunity to explore.
4. This led to reverse-downdraft designs as well as continuous combustion variants in 2005+ period.
5. Oorja at 0.75 k/h (domestic) to 6 kg/h (hospitality industry) became a target of BP-India and FEPL.
6. Continuous clean combustion alternatives became important

New methods for Domestic cooking/heating needs



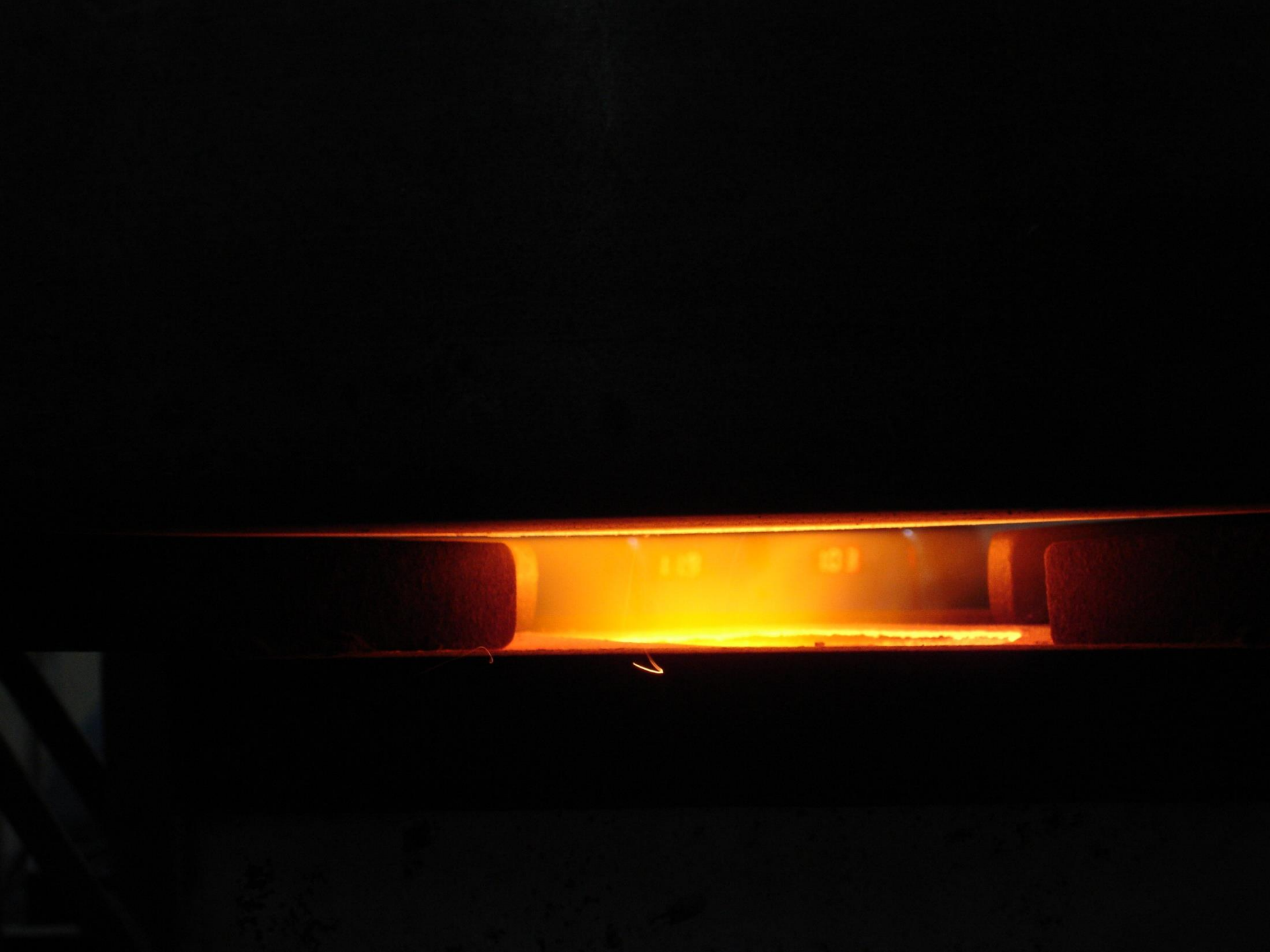
Principles - first technique – fire and forget/control

1. Burn from top to bottom of a pile instead of bottom to top (practiced for several thousand years)
2. Recognize that this is a two stage combustion process in which sub-stoichiometric combustion occurs first and then combustion of the gases is completed at near-stoichiometric conditions. The first phase is also termed gasification. Such devices are called “Gasifier Stoves”
3. The power output is proportional to the air flow rate. Hence, controlling it helps vary the power.



•**Various industrialized modern fan based HELE biomass stove designs realized by industries and used in practice**

Achieved: 2 x 0.6 kg = 1.2 kg pellet fuel using agro-residues or fuel wood for cooking = 55 % (water boiling efficiency) = 80 % more than three-stone fire stove



- **Fixed fuel magnitude** - fixed burn time, clean combusting, High efficiency combustion, minimum most emissions

•1 kg/h, waste wheat (or biomass pieces) •only primary air – controls the burn rate. Product – combustible gases	6 kg/h biomass pellets Commercial hardware Has both primary and combustion air

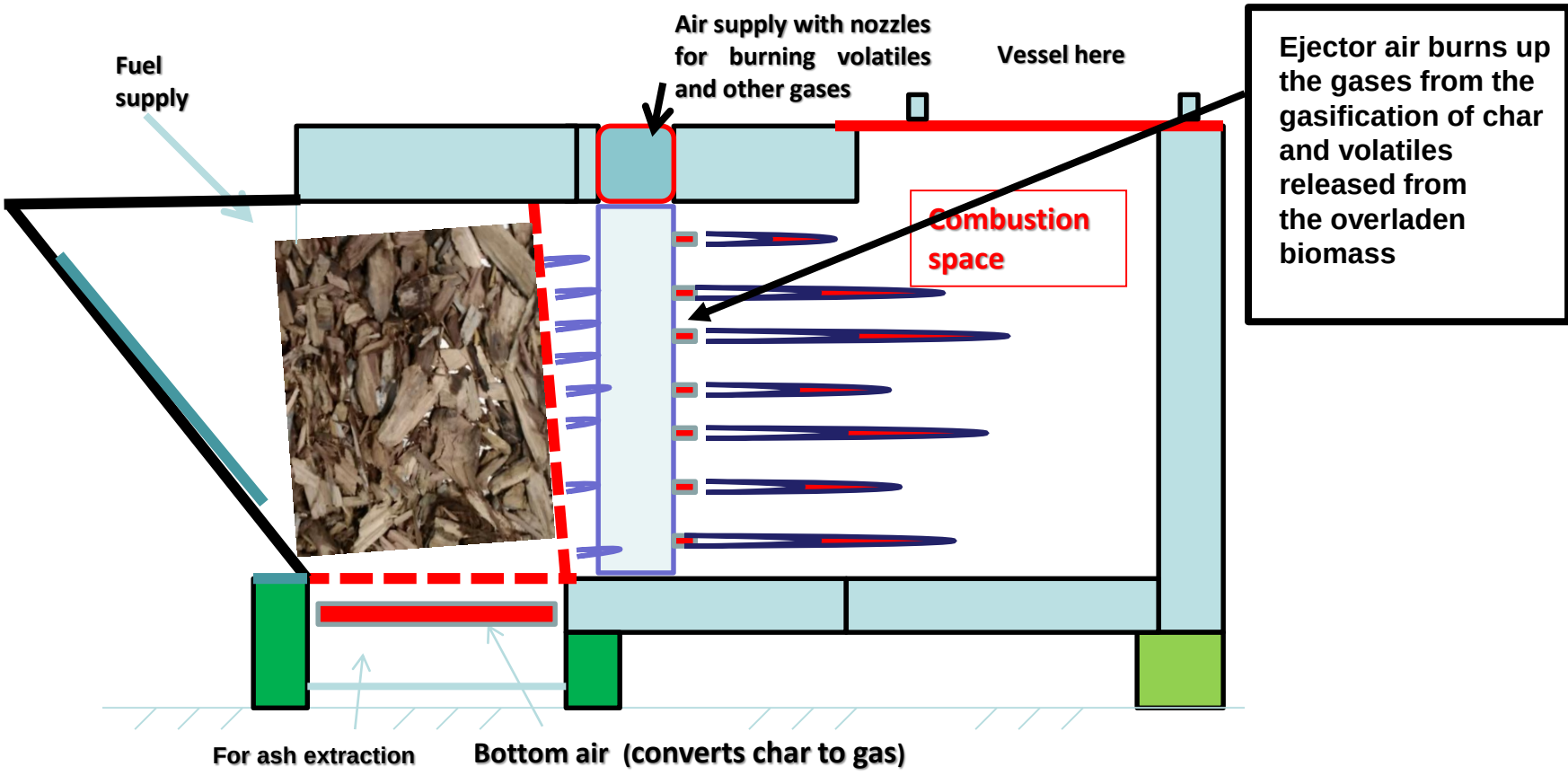
2013 – 2014 saw a new development on continuous stoves both large and small

Based on requests for sand drier from Sameer Kanabargi, Belgaum, the development of a horizontal combustion device was pursued in October 2014.

The combustion behavior appeared smooth and clean unobserved with other modes.

Partial gasification based combustion process

(patented in March 2015 independently with commercial benefits to FEAST)

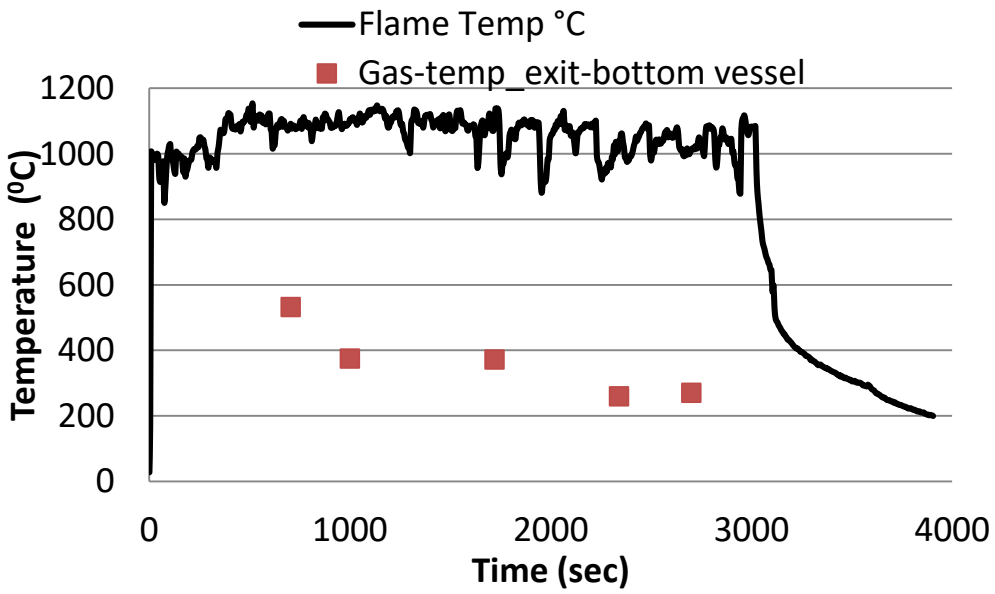


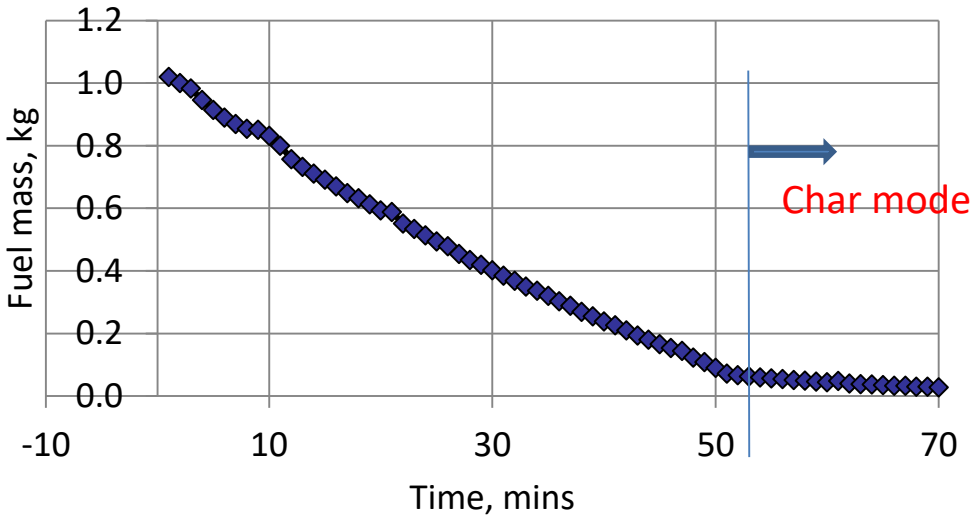
Range of fuels for use in continuous combustion system

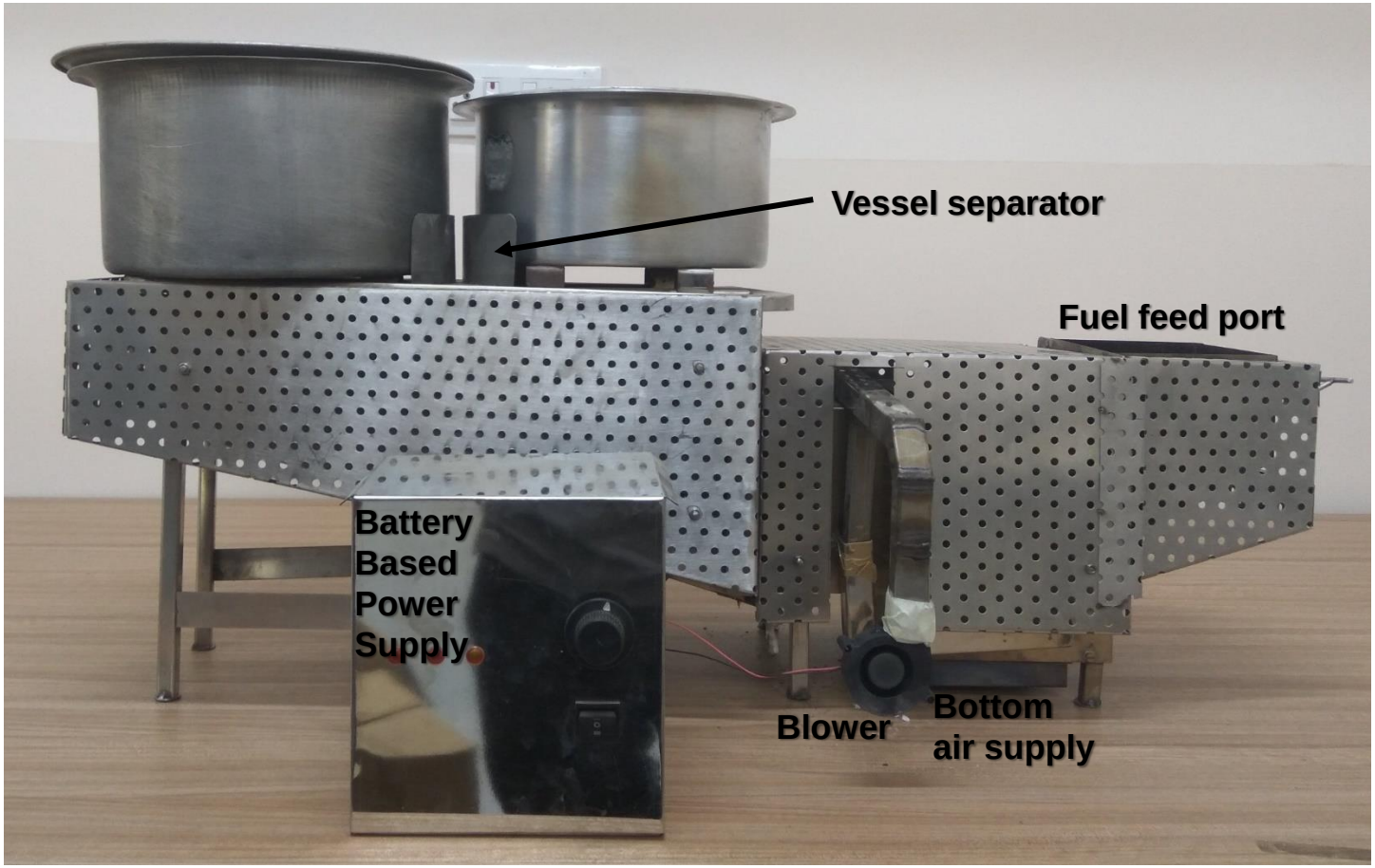
AGNI – SAKHI on a emission-efficiency test

Cooker on a 1 kg/hr single pan stove (with a 12 V fan) running on chipped dry fuel

Performance






Vessel separator
Fuel feed port
Battery
Based
Power
Supply
Blower
Bottom
air supply

3 kg/h system (AGNI-MITRA)

System in laboratory test

System at Mother Theresa's care home for distressed

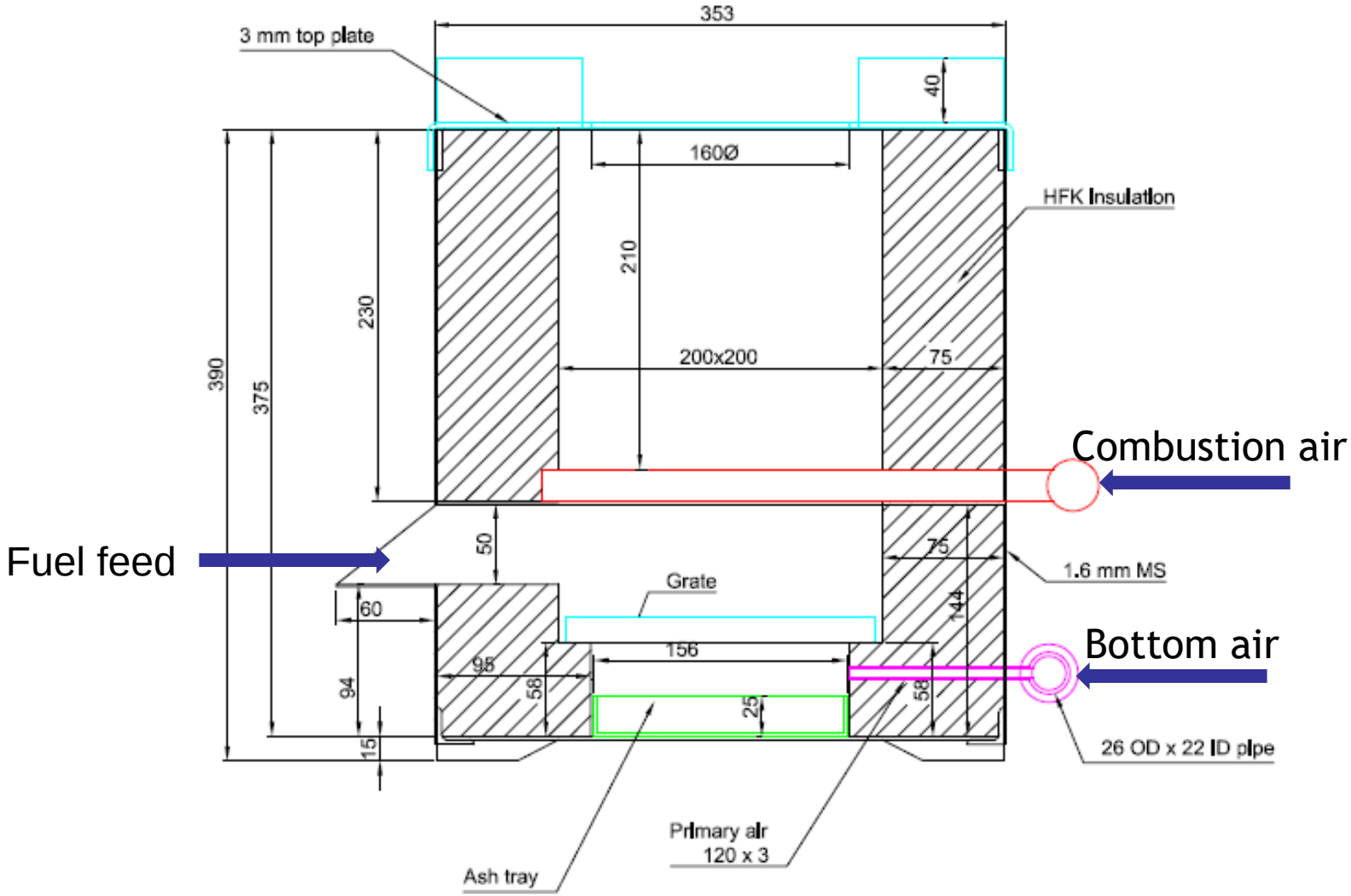
50 kg/h installation

for a blackening process industry (Peenya, Bangalore)

The 50 kg/h system being operated daily using waste wood bought at Rs. 6/kg for 4 to 16 hours daily using a blower of 3 kW capacity.

The exhaust is taken out in a pipe at the top (right side picture) and particulate matter out of the exhaust is negligible

VEBCOD –
Vertical Ejector Based COmbustion Device



1 kg/h domestic combustion system

Industrial Combustion systems

- Potato frying, Blower – 5 hp Centrifugal

•HC^{3}D = Horizontal continuous clean combustion device

Puffed rice production system

60 kg/h combustion system with Wood shavings – furniture industry waste

Legal issues

- FEPL (earlier BP, India) that had exclusive license of Oorja class stoves was fastidious of others violating the patent rights.
- Having seen the functionality of this class of devices, many entrepreneurs used to copy the design and exploit it commercially.
- FEPL used legal means to deal with these people.
- One of these, Abellon, eco (Ahmadabad) was so upset that they went into litigation against IISc stating that the design is not maintainable as a patent (cleared even internationally in 2010) in 2014!
- My colleague Dr. Dasappa had to deal with this between a not-so-enthusiastic IISc and pressuring FEPL to progress IISc's defense on their patent rights.
- The legal process was intense in 2015 and tapered off over a time because Abellon lost interest - it may have uncovered other ways of continuing its activity.
- My suggestion on this to FEPL was that when copying occurs, to talk to the prospective violators and make them partners in a judicious way because any entry into legal process is always a drain on all concerned – both financially and mentally. My view remains the same even now.

Summary

- Several science based technologies for use of biomass with varied shape, size, density aspects have been developed through new design procedures, choice of materials and rigorous testing and patented.
- These have been transferred to Industries for commercial exploitation by also providing continuous technical back-up support.
- Without the freedom enjoyed on tech transfer and operational aspects while being controlled by the board chaired by Director, IISc, nothing was achievable.
- The pain of dealing with difficult clients has been borne successfully.
- These required IISc more as an iconic background than a active supporting system. "IISc" also had to be persuaded to support at various situations.
- Even so, there were many situations when crucial actions needed taking note that the IISc support is only "nominal" – when royalties are received, at which time they may be show happiness inevitably and not care much when difficulties arise. Sometimes their support was seen more problematic than being helpful
- Doing research, teaching, product conceptualization, design, development, and tech-transfer have both been joyful and painful.

…..Thank you