Brick Kilns in India

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BRICK PRODUCTION IN ASIA

1. Very large and traditional industry in Asia
2. Mechanized and fully automated process for brick production is used by Developed countries

	Bangla-desh	India	Vietnam	Nepal	Pakistan	China
No. of brick units	-	1,40,000	10,000	700	>10,000	80,000
Production in billion	17.2	240-260	26.59	3.15	50	800-1000
Labor in '000	1000	9,000	NA	NA	1500	5000
Population in million	149.7	1210	176.5	18.6	176.7	1334
Brick use/ capita	115	215	151	169	283	750

INTERNATIONAL SCENARIO

INTERNATIONAL SCENARIO World over- Tunnel and Hoffman Kilns considered as environment friendly EE technology and is being promoted

	USA/ Europe – Natural gas fired Tunnel Kilns	•High Initial cost (5-10 crores) •Lack of Know-how •Access to finance •Hot environment inside Hoffman kiln
	China – Tunnel/ Hoffman Kiln	
	Vietnam – Coal fired Tunnel Kilns	
	Bangladesh – Hybrid Hoffman Kiln/ Tunnel Kiln	

- Replacement with REBs (perforated bricks, hollow bricks, bricks with internal fuel/ flyash bricks etc).
- Mechanization for clay preparation and molding
- Min. 20-30% savings in fuel and clay.
- In China, upto 80% of total fuel requirement mixed as internal fuel and remaining 20% fuel used during firing process – *Emission reduction from kiln to a large extent.*

HOFFMAN KILN

(Product Stationery and Fire Moving)

Tunnel Kiln

(Product Moving and Fire Stationary)

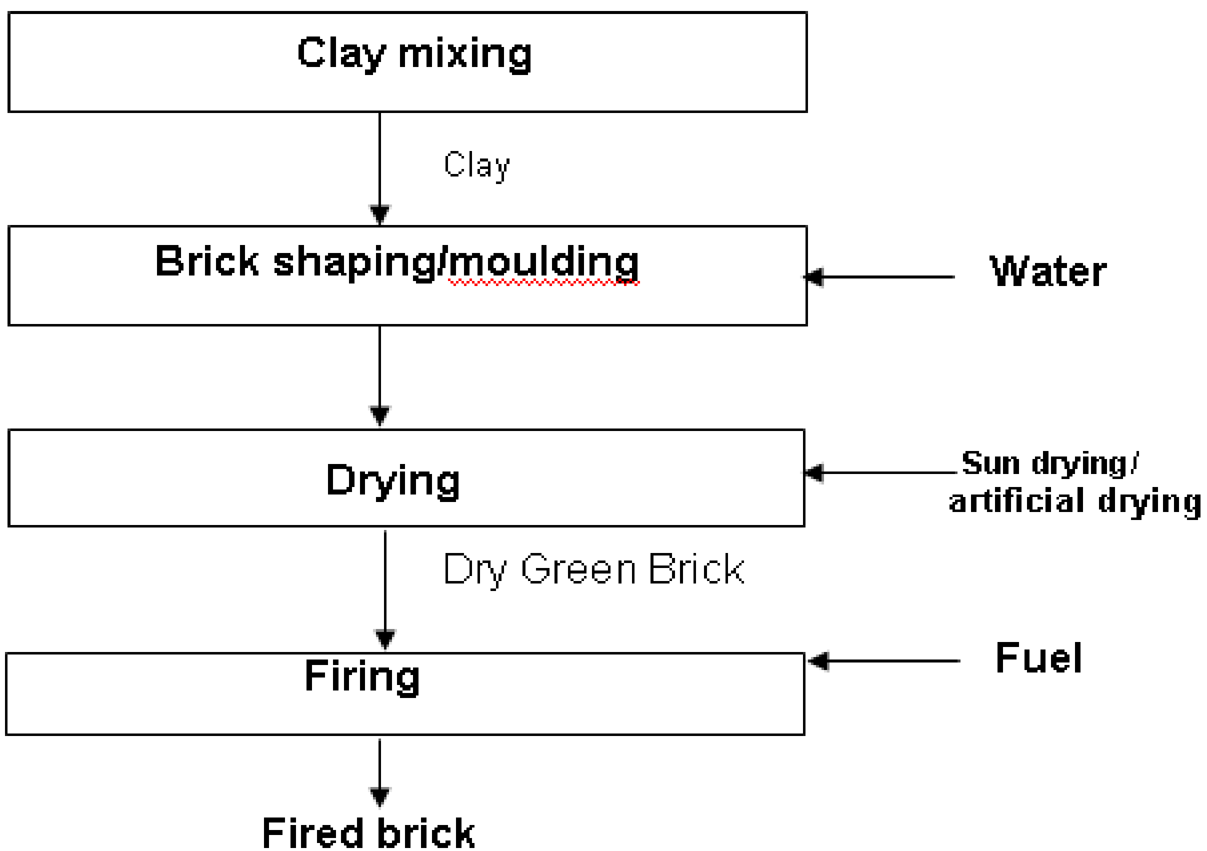
INDIAN BRICK INDUSTRY

- Annual brick production growth: 5-10%
- 2nd largest brick producer after China.
- 74% of total production through BTKs and 21% through Clamps (100K).

Brick-making enterprises (all types)(no.)	1,40,000
Brick-making fuel used	coal & biomass
Annual brick production	240-260 billion
Coal/biomass consumption (million tce)	35-40
CO_2 emissions (million t)	66
Clay consumption (million m^3)	500
Total employment (million employees)	9-10

Distribution of different type of kilns in India

BRICK MAKING PROCESS



- 99% brick production through hand molding
- Use of biomass/biomass waste/flyash with low CV as internal fuel in some areas of Central/East and West zones.
- Clay preparation through pug mills/tractors with mixers in Central/west/south India.

BRICK MAKING PROCESS: MANUAL EXCAVATION & MOULDING

Manual Excavation

Preparation

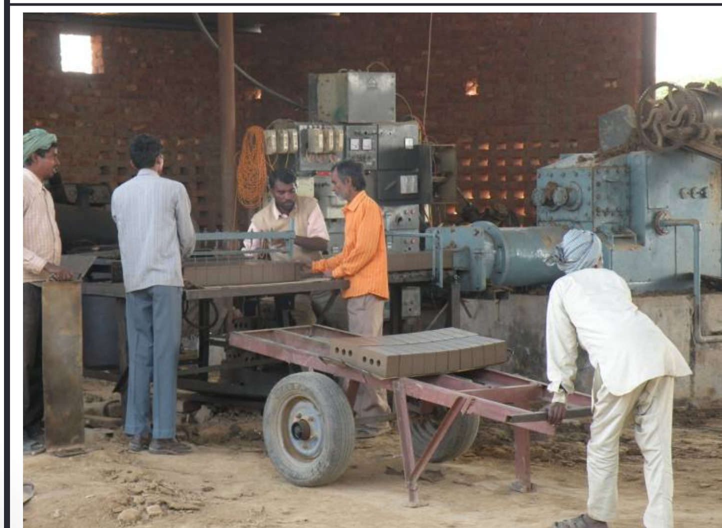
Manual Moulding

Table moulding

BRICK MAKING PROCESS: MECHANICAL

Excavation

Box feeder



Extruders

Extruders

Bull's Trench Kilns

EXISTING TECHNOLOGIES

FCBTK

HDK

Hoffman

VSBK

DOWNDRAFT/ CLAMP KILNS

SOURCES OF EMISSIONS

- Stack Emission
- Fugitive Emission
  - During charging of fuel
  - Crushing of coal
  - Clay excavation
  - Loading and unloading of bricks
  - Laying and removal of dust/ash layer '*keri*' over brick setting
  - Cleaning of bottom of trench/side flues
  - During high winds




DIFFERENT TYPES OF FUELS USED

 Cotton straw & wood chips	 Assam coal
 Mustard straw	 Wooden chips, mustard & cotton

FUEL ANALYSIS

Type of Fuel	Moisture (%)	Ash (%)	Volatile (%)	Fixed Carbon (%)	GCV (Kcal/kg)
Coal					
Assam Coal	0.96-2.99	11.03-26.46	22.84-37.71	37.06-49.88	4864-5603
Chandrapura Coal	3.96-8.36	22.19-37.16	25.07-30.96	33.81-38.49	4077-4867
Indonesian Coal	13.5-16.7	2.82-15.16	42.31-46.29	28.85-35.6	5386-6316
Jharia Coal	0.31-1.48	34.47-46.89	15.83-26.85	33.78-50.06	3520-5034
Raniganj Coal	6.83-8.61	31.3-23.86	25.1-27.41	34.46-42.43	4607-5258
Biomass					
Mustard straw	5.38-9.09	3.1-6.23	70.47-73.79	16.51-17.1	3998-4306
Rice Husk	5.63-19.4	17.4-23.89	48.26-55.95	14.53-14.92	3403-3471
Cotton straw	12.18	3.77	66.75	17.3	4219
Saw Dust	30.61	5.31	53.38	10.7	3235
Internal fuel					
Katni Coal Dust	1.92	45.77	19.66	32.65	3336
Coal Rejects of thermal Power	2.43	68.5	18.09	10.98	2049

FIRING PRACTICES AND PERFORMANCE OF FCBTKS IN FIVE ZONES

Parameters	North		East Zone	Central Zone			West Zone		South Zone
Fuel	Coal	Biomass	Coal	Coal	Biomass	Coal	Coal	Biomass	Coal
No. of columns	23-31	25-27	19-23	22	21-23	19-21	19-26	20-21	12-21.
Trench width (m)	8.2-11.6	9.5-9.94	7-8	7.8	7.6-8.2	6.4-10.4	6.4-8.7	7.8-8.54	3.6-6.4
Daily production capacity	32,000-40,000	36,000-40,000	16700-32000	28,000	19,000-40,000	20,000-26,000	30,000-45,000	35,000-40,000	22,000-27,000
Firing temperature (^{0}C)	980-1050	940-1020	960-1070	880-980	900-980	960-1016	860-1016	925-973	720-850
SEC in MJ/Kg of fired brick	**1.18-1.32**	**1.33-1.95**	**1.05-1.41**	**1.29**	1.60-172	**1.08-1.16**	**1.13-1.82**	**1.7-1.77**	**0.95-1.24**
Stack Temperature (^{0}C)	60-82	52-77	63-118	116	92-95	90-128	80-172	80-90	90-119
Velocity (m/s)	1.2-3.7	1.4-1.9	1.84-2.32	1.54	2.4-2.5	1.49-1.58	2.1-3.65	2.28-2.29	2.8-5.2
Volumetric flow rate (Nm^3/hr)	11115-16040	14487-25938	7597-25938	20373	20610	9115-10600	11843-32284	24462-27984	9600-11100
SPM Charging (mg/Nm^3)	517-1375	268-382	124-865	619	294-330	500	122-422	122-147	75-364
Non-Charging	107-257	83-105	103-301	108	100-115	110-130	78-186	90	42-224
Integrated	102-688	140-374	162-742	566	169-271	357-450	90-384	96-146	55-298
SO_2 (mg/Nm^3)	10-595	5-8	34.1-563.3	10.5	7.9-3.1	13.1-23.6	5.2-943.2	18.3-52.4	0-437.5
CO (mg/Nm^3)	193-1419	2275-2952	282-1748	205	495-1311	147-238	355-3579	2622-5026	269-880
CO_2 %	**0.6-2.85**	2.4-2.6	1.2-2.4	1.2	0.7-1.7	1.7-15	1.0-2.4	1.7-2.0	1.5-2.1

Operating practice	North		East Zone	Central Zone			West Zone		South Zone
Fuel Type	Coal	Biomass	Coal	Coal	Biomass	Coal	Coal	Biomass	Coal
Size of fuel	1/2" to 2"	Chopped 1" to 2"	1/2" to 3"	1" to 6"	Chopped 1" to2" size	Same as coal fired kiln	1" to 6"	Chopped 1" to 2" size	coal (1" to 6")
Capacity of feeding spoon	Heavy feeding using spoon of 1.0-2.0 kg	With tokris or vehngis	Spoon size: 0.6-1.6 kg	Spoon size 1.5-2.5 kg	Tokri size: 25-30 kg & vehngi size: 45-50 kg		Spoon of size: 0.7-2.0 kg	Tokri size: 25-30 kg & vehngi size: 45-50 kg	With tokris of 25-30 kg capacity
No of rows being fed	Fuel feeding in two lines	Fuel feeding in one line	Fuel feeding in two lines	Heavy feeding in one line	Heavy feeding in one line		Fuel feeding in one or two lines	Heavy feeding in one line	fuel feeding done in two lines
Feeding frequency **Charging**	5-10 mins	Heavy 15-25 mins	7-12 mins	10-15 mins	15-25 mins		8-15 mins	15-25 mins	10-20 mins
Non-Charging	20-40 mins	20-40 mins	20-40 mins	30-50 mins	30-50 mins		30-50 mins	30-50 mins	30-50 mins
Remarks	**Thick smoke during charging period**	**High surface temperatures result in self ignition of biomass at surface only.**	**Coal crushers used in some kilns**	**Thick smoke during charging**	**High surface temperatures result in self ignition of biomass at surface only**		**Resulting in thick smoke due to charging**		**Due to feeding coal lumps the light greyish smoke emitted**

PERFORMANCE OF DESIGNS OF KILNS (OTHER THAN FCBTKs)

Parameters	FCBTK-Zig-Zag	High Draft Kiln (HDK)		VSBK	Down Draft Kiln	Hoffman Kiln
	East Zone	North Zone	East Zone	East /Central Zone	(DDK) South Zone	South Zone
No. of columns	15,000 bricks/ Chamber	18,000-20,000 bricks/ chamber	10,500-19,500 bricks/ chamber	440 bricks/ batch in 6 layers	Batch process	4,000-5,000 bricks/ chamber
Trench width (m)	5.2-6.6	10-10.4	5.2-8			2.7
Daily production capacity	20,000-30,000	30,000-60,000	15,000-28,000	6000-8800	30,000 bricks /chamber	10,000-12,000
Fuel	Coal/pet coke/ biomass	Coal/pet coke	Coal	Coal	Biomass	Coal/fired wood
Firing temperature (^{0}C)	970-1015	970-1020	960-1050	870-915	820-850	650-810
SEC in MJ/Kg of fired brick	**0.92-1.06**	**1.08-1.10**	**1.07-1.15**	**0.9**	**2.80-3.14**	**1.21-1.52**
Stack Temperature (^{0}C)	118-163	107-109	54-146	152-179	181-252	118-128
Velocity (m/s)	2-2.83	3.4-3.99	2.01-3.37	2.55	2.8-4.3	2.04-2.86
Volumetric flow rate (Nm^3/hr)	7390-10008	11377-23845	8971-20761	4444-9285	5036-5498	8200-8500
SPM Charging (mg/Nm^3)	155	119-147.6	145.5-432	452	150-454.5	275-353
Integrated	128-134	49-116	149-316	314-405	75-359	200-315
SO_2 (mg/Nm^3)	393-469	1045-1053	13.1-615.7	84-89	118-975	5.2-7.9
CO (mg/Nm^3)	95-158	332-1027	290-667	951-1440	4398-11309	2931-3518
CO_2 %	2-2.4	1.8-1.9	1.27-2.4	0.6-1.1	8.1-11.9	4-4.4

Parameters	FCBTK-Zig-Zag	High Draft Kiln (HDK)		VSBK	Down Draft Kiln	Hoffman Kiln
Size of fuel	Crushed coal	Crushed coal	Crushed coal	Upto 1”	For first 15-20 hrs fuel feeding rate is 30-400kg/hr whereas for last 8-10 hrs fuel feeding rate is 700-750 kg/hr	
Capacity of feeding spoon	Spoon size: 0.175-0.3 kg	Spoon size : 0.25-1.0 kg	Spoon size : 0.25-0.5 kg	NA		
No of rows being fed	6 chambers	6 chambers	2-3 chambers	Packed within the brick settings	Total firing time 24-30 hrs	3 chambers
Feeding frequency **Charging**	10-15 mins or continuous Charging	7-10 mins or continuous Charging	7-12 mins	NA	Continuous charging is done	Fire wood Charging done for 8-10 mins
Non Charging	5-15 mins	12-15 min	10-12 mins			25-30 mins
Remarks	thin smoke	Thin smoke during fuel Charging		Bloating of fired bricks due to lumps of internal fuel	Thick smoke during last 8-10 hrs of Charging	

INFERENCES - PERFORMANCE OF KILNS IN DIFFERENT ZONES

- **FCBTKs/HDKs**
  - Trench width: 6.4-10.4 mtrs.
  - Min. Production capacity: 22,000 bricks/day
    (trench width of 3.6m in South)
- High stack emissions/ thick smoke in kilns with shorter combustion zone & poor operating practices.
- Excess Air levels of 400-1000% were observed during stack emission monitoring.
- During fuel <u>charging period SPM levels upto 1375</u> mg/Nm^3 observed in kilns with poor operating practices.
- High CO levels observed in kilns using <u>biomass</u> as fuel.

SPECIFIC ENERGY CONSUMPTION (SEC)
IN MJ/ KG OF FIRED BRICK

FCBTKs-Coal fired	**0.95-1.82**	
FCBTK-Biomass fired	1.33 – 1.95	
HDKs/FCBTK zig-zag	0.91-1.15	Better operating practices
VSBK	0.90	Limited brick production and high initial cost
Hoffman Kiln	1.21-1.52	Produce hollow block, roof tiles
DDKs	2.8-3.14	
Clamps	1.38-1.92	

ENERGY BALANCE

Basis: 1 Ton of clay brick											
Sr. No.	**Parameters**	**FCBTK** (coal)		**FCBTK** (Biomass)		**FCBTK** (zig-zag)		**HDK**		**VSBK**	
	Heat Input										
1	Fuel (coal, biomass, etc.) consumed	in MJ	in %	in MJ	in %	in MJ	in %	in MJ	in %	in MJ	in %
		1134- 1445	100	1364-1772	100	1162	100	1038-1097	100	834	100
	Heat output										
1	Surface heat loss from kiln (Top surface & side walls)	161-424	*14-29*	288-424	*21-24*	236	*20*	150-328	*14-30*	27	*3.2*
2	Heat loss in dry flue gas	35-107	*3-7*	51-153	*3.7-8.6*	71	*6.1*	22-82	*2-7.5*	205	*24.6*
3	Heat required for removing the mechanically held water in green bricks	36-339	*3-23*	33-244	*2.4-13.8*	186	*16*	102-169	*10-15*	68	*8.2*
4	Heat loss due to hydrogen & moisture in fuel	40-80	*3-5*	98-132	*7.2-7.5*	46	*4*	33-49	*3.2-4.5*	15	*1.8*
5	Heat loss due to partial conversion of C to CO	5-28	*0.5-2*	21-75	*1.5-4.2*	4	*0.3*	23-37	*2.2-3.4*	29	*3.5*
6	Sensible heat loss in unloaded bricks	4-20	*0.3-1.4*	20-26	*0.5-1.5*	23	*2*	27-60	*2.6-5.5*	47	*5.6*
7	Other heat component*	477-960	*42-66*	442-1250	*32-70*	596	*51*	440-613	*42-56*	443	*53.1*

Heat required for irreversible chemical reaction & losses such as trench bottom, periodic heating and cooling of kiln structure & due to unburnt carbon in ash

PERFORMANCE EVALUATION OF APCD IN FCBTKs

The particulate removal efficiency of different design of Gravity Settling Chamber (GSC) generally ranged from 20-63%. The stack emission levels at inlet of GSC vary between 592-1495 mg/Nm^3.

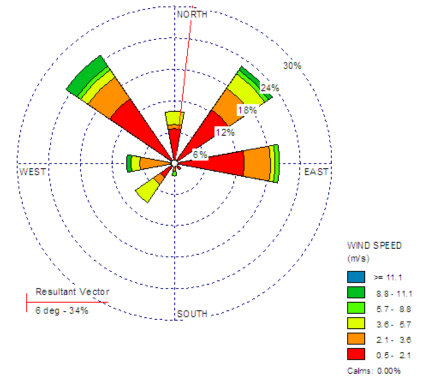
General ambient air QUALITY-brick kilns

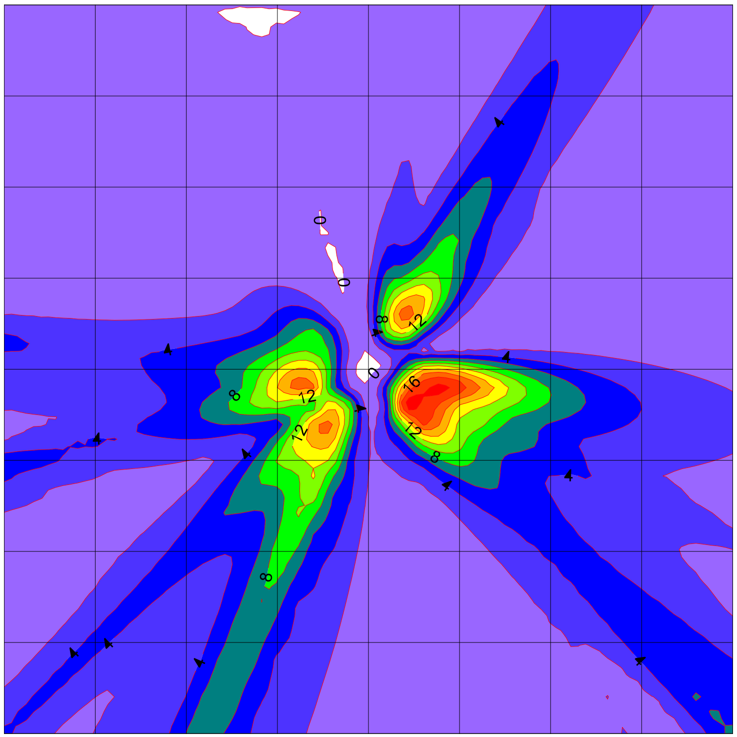
- Impacts not continuous or long term because brick kilns are seasonally operated and operations is cyclic in nature.
- Ambient SO_2 & NOx levels rarely exceeded 25 µg/m3
- The NOx emissions from kiln stacks were also very low and hence its impact on GLCs, the impact of kiln emissions would be insignificant.

AIR POLLUTANT DISPERSION MODELING

- To assess the maximum impact of stack emissions (SO_2 & SPM) on Ground Level Concentration (GLC).
- To formulate stack height guidelines for ensuring the safe impact levels in the context of prescribed Ambient Air Quality Standards.
- To recommend siting guidelines for brick kilns.

EMISSION DISTRIBUTION PATTERNS IN NORTH ZONE USING ISCST3 MODEL:

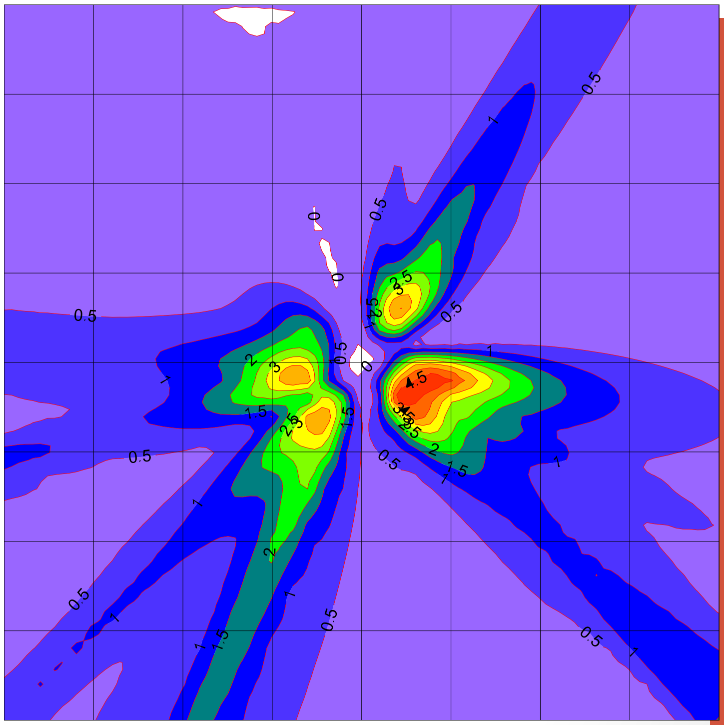




Maximum GLC- 21.94 *μg/m³* ,

co-ordinates (200,-200)

SPM EMISSIONS



Maximum GLC-5.13 *μg/m³* , co-ordinates (400,-200)

SO_2 EMISSIONS

Emission Factor

- The emission factor for SPM & Sulphur Dioxide is mainly due to quality of fuel and its feeding & operating practices.
- In case of coal fired brick kilns the average emission factor for SPM was in the range of 0.79 to 1.85 g/kg of fired bricks in the three zones namely North Zone, East Zone and Central Zone wherein brick firing temperature is above 950^0C.
- *Low average emission factor of 0.57g/kg observed in the South Zone which is mainly due to low firing temperature (around 850^0C) and feeding of big lumps of coal after longer intervals. Moreover the quality of brick is also comparatively inferior to the bricks produced in North, East and Central Zones*.
- FCBTK using biomass has lesser emission factors as compared to coal fired FCBTKs (SPM emission factor in the range of 0.78 to 1.19 g/kg of fired bricks).
- The average emission factor for SPM in FCBTK with zigzag firing was 0.37 g/kg of fired bricks due to longer combustion zone in comparison to conventional FCBTKs and good combustion practices adopted in the process. The emission factor is almost comparable with High Draft Kiln.

Ctd…

- The emission factor for SPM in High Draft Kiln were in the range of 0.21 to 1.12g/kg of fired brick due to efficient burning of fuel by adopting good firing practices.
- The emission factors for SPM in VSBK was 1.86 to 2.6 g/kg of fired bricks.
- The biomass fired DDK and Hoffman Kiln in South Zone has emission factor of 0.38 to 1.82g/kg of fired bricks.
- Emission factor for SO_2 were mainly due to sulphur content in the fuels used. Low emission factors of 0.03 to 0.23g/kg of fired bricks were observed in biomass fired brick kilns. Whereas, in case of coal fired kilns it varied from 0.04 to 0.67 g/kg of fired bricks.
- The average emission factor for NO_x were generally low and was found in the range of 0.03 to 0.32g/kg of fired bricks.

PROPOSED ACTION PLAN

- Two Fold Strategy proposed:
    1. Long Term Measures
    2. Short term Measures

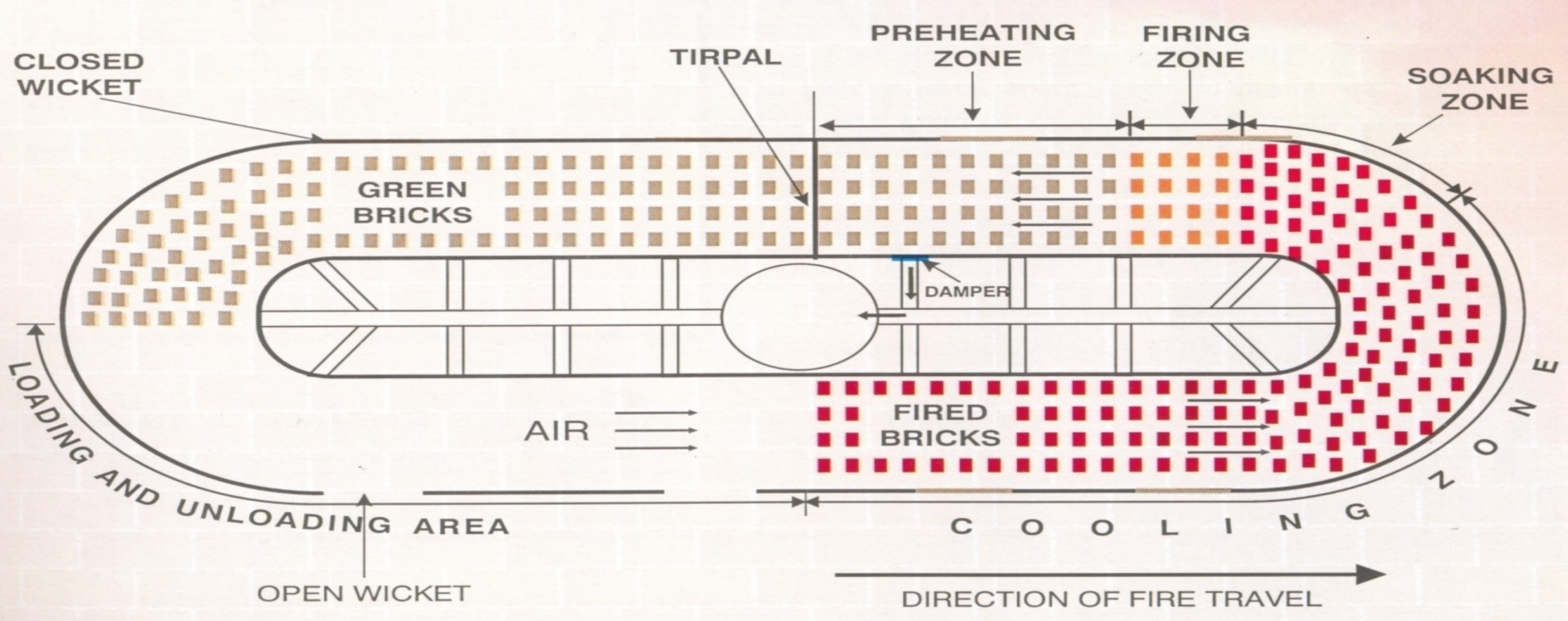
PROPOSED ACTION PLAN

1. Long Term Measure:

- Effective policies and regulations required for implementing energy efficient technologies like Tunnel Kiln, Hoffman Kilns etc.
- Need for establishing the demand/market for resource efficient products like hollow and perforated bricks, and limiting the production of solid bricks in phases.
- The technologies being capital intensive, requires mechanism for financial support before its replication on large scale.

Short Term Measures

a) Adoption of improved feeding, firing and operating practices in existing FCBTKs
b) Retrofitting of kiln and converting into High Draft Kiln/ Fixed Chimney Bull's Trench Kiln with zig-zag firing.
c) Extensive Capacity Building Program for 'a' above.



ZONES IN BULL'S TRENCH KILN

TECHNOLOGY SELECTION

- Need for initiatives for promotion of EE technologies while framing new Regulations for:
  - Reducing the emissions from brick making process
  - Conserving resource materials and
  - Reducing carbon footprint.
- FCBTK is the most prevailing technology, producing 74% of the country's brick production.
- Need based changes have been incorporated in brick production technology which has improved its EE.
- Use of locally available biomass in FCBTKs has also picked up especially in North and Central Zone.

TECHNOLOGY SELECTION.. Inferences

- However, the smoke emission from the kiln stack, especially during charging time is a cause of concern which can be reduced by only adopting better feeding, firing & operating practices.
- In India, High Draft Kilns (HDKs) and Vertical Shaft Brick Kilns (VSBKs) are comparatively more energy efficient technologies. constraints are
  - need for electricity/power back up in case of HDKs and
  - high initial cost/ low production & non availability of skilled manpower in case of VSBK, these technologies has not been replicated on large scale

Existing Standards for Brick Kilns

Sr. No.	Industry	Parameter	Standards
1	2	3	4
74	Brick Kilns	**i. Bull's Trench Kiln (BTK) Category***	Limiting concentration in mg/Nm3
		Particular matter	
		Small	1000
		Medium	750
		Large	750
		Stack height	minimum (metre)
		Small	22 or induced draft fan operating with minimum draft of 50 mm WG with 12 metre stack height.
		Medium	27 or induced draft fan operating with minimum draft of 50 mm WG with 15 metre stack height.
		Large	30 or induced draft fan operating with minimum draft 50 mm WG with 17 metre stack height.
		*Category Trench width (m)	Production (bricks/day)
		Small BTK <4.50	Less than 15,000
		Medium BTK 4.50-6.75	15000-30000
		Large BTK above 6.75	Above 30000

74	Brick Kilns	**(ii) Down-Draft Kiln (DDK) Category****	Limiting concentration in mg/Nm3
		Particular matter small/medium/large	1200
		Stack height	minimum (metre)
		Small	12
		Medium	15
		Large	18
		**Category Production (bricks/day) Small DDK Less than 15000 Medium DDK 15,000-30,000 Large DDK Above 30,000	

74	Brick Kilns	**(iii) Vertical Shaft Kiln (VSK)**	
		Category**	Limiting concentration in mg/Nm3
		Particular matter small/medium/large	250
		Stack height	minimum (metre)
		Small	11 (at least 5.5 m from loading platform)
		Medium	14 (at least 7.5 m from loading platform)
		large	16 (at least 8.5 m from loading platform)
		**Category No. of shafts	Production (bricks/day)
		Small VSK 1-3	Less than 15000
		Medium VSK 4-6	15,000- 30,000
		Large VSK 7 or more	Above 30000

1. Gravitational Settling Chamber along with fixed chimney of appropriate height shall be provided for all Bull's for all Bull's Trench kilns.
2. One chimney per shaft in Vertical Shaft Kiln shall be provided. The two chimneys emanating from a shaft shall either be joined (at the loading platform in case of brick chimney or at appropriate level in case of metal chimney) to form a single chimney.
3. The above standards shall be applicable for different kilns if coal, firewood and / or agricultural residues are used as fuel."

PROPOSED EMISSION STANDARDS

FIXED CHIMNEY BULL's TRENCH KILN (FCBTK),
HIGH DRAFT KILN (HDK) &
HOFFMAN KILN

Guidelines for better fuel charging & operating practices in and siting of Bull's Trench Kilns and Clamp Kilns

IMPROVED FUEL CHARGING & OPERATING PRACTICES

(For improving the combustion efficiency and reduce emissions)

- The coal charging in Bull's Trench Kilns should be properly graded and maximum size of coal charged should be limited to 20 mm.
- Fuel charging in Bull's Trench Kilns should be done in minimum 3 rows of brick setting at a time in case of coal and in minimum 2 rows of brick setting at a time in case of firewood and agricultural residues.
- Minimum 3 fuel charging shall be done every hour in Bull's Trench Kilns.
- Internal fuel, such as powdered coal, flyash etc. should be used by mixing with clay during brick making in Bull's Trench Kilns and clamp brick kilns.

PROCESS EMISSION CONTROL

- Crushing of coal should be done in enclosed equipment/ area to avoid process emissions.
- Following measures be adopted to control dust emissions due to airborne ash from the top of brick settings:
  - Raising a 2 feet wind breaker wall along the outer trench wall of bull's trench kilns.
  - Covering of the top ash layer in the preheating zone with sheet in bull's trench kilns.
- The approach road and the road around brick kiln should be paved/stabilized.
- Water should be sprinkled frequently over roads around brick kiln and over the ash layer before its removal and transfer.
- Two or three rows of trees should be planted along the outer periphery of kiln area.

PROCESS IMPROVEMENT

- Use of Temperature gauge in firing zone, flue duct and chimney to monitor and control combustion process.
- Use of double walled insulated feedhole covers packed with insulation material such as ceramic or asbestos fibers to prevent heat loss from fuel charging holes bull’s trench kilns.
- Double walled wicket with kiln ash filled in between Bull’s Trench Kilns instead of conventional single brick wicket wall with brick on edge which results in leakage.
- Closing of side flue ducts with brick wall (1 ½ brick thick) plastered with a mix of sand clay and cow dung bull’s trench kilns or alternatively, shunt system should be used for transferring the gas from side flues to central flue, connected with chimney.
- Minimum 7 inch thick brick kiln ash layer over the brick setting bull’s trench kilns to provide heat insulation.
- Placement of fuel in multi-layers during brick stacking in clamp kilns to reduce emissions and to produce better quality bricks

NORMALISATION OF EMISSION STANDARDS IN FCBTK/HDK

- The air supply in a (FCBTK) drawn through the cooling/ fired brick withdrawal zone has following role:
  - Assist in the combustion of the fuel
  - In addition to the combustion, air is needed to carry forward the heat through different zones for transferring the heat (i.e. cooling of hot fired bricks and drying/ pre-heating freshly set green bricks before combustion)

Normalisation of Emission Standards in FCBTK/HDK

Therefore, in addition to air required for combustion, excess air is required for transferring of heat to different zones. Various authors have indicated the total quantity of air as:

- 6-7 times the quantity of air required for the combustion of fuel (Alfred B. Searle, 1956)
- 500% excess air is required in a continuous kiln (Tim Jones, 1996)

Better practices

- Fuel Storage
- Size of Coal
- Fuel quality
- Fuel feeding
- Kiln Maintenance
- Use of internal fuel
- Fugitive Emissions
- Monitoring
- Protection to workers health

Fuel Storage

- The coal should be stacked on a raised platform with pucca flooring and proper drainage arrangements.
- Coal should preferably be stored under shed with proper ventilation
- The height of coal stack should not be more than 1.5 meter otherwise it will loose its heat value due to self ignition under intense heat and pressure.

Size of Coal

- The size of coal should be such that the coal should either be completely burnt or atleast should have caught fire before the next round of feeding. Hence the coal size should be between powder to ¾ inch i.e. properly graded coal. This would help in uniform brick quality as the powdered coal ignites immediately on feeding thereby releasing heat to the top layer of brick setting. Whereas large sized coal particles release heat at the bottom of brick setting.
- Small sized coal improves air-fuel mixing thus accelerating the rate of combustion. Appropriate size of coal can be obtained by screening/ crushing of large sized coal.
- The crushing of coal leads to fugitive emissions. It is advised that coal crushing should be done in enclosed area with high walls so as to avoid cross currents.

Fuel quality

- Use of coal with high ash content will not only lead to high stack emission but will also pose a problem of handling of ash. It is, therefore, recommended that coal with ash content more than 35% should be avoided.
- Coal with high sulphur content (more than 2%) should not be allowed to use in brick kilns especially in the areas in the vicinity of orchards or flower bearing crops.

Fuel feeding

- Feeding of fuel in more number of lines would increase the length of firing zone and would result in more efficient combustion thereby reduction in stack emissions. Besides this the SEC of brick kiln would also improve.
- The recommended firing pattern as shown in the sketch should be followed: (Sketch)

Kiln Maintenance

- Constructing double walled wicket with rapish/keri in between. The conventional practice of single brick wicket wall with brick on edge results in leakage and hence should be avoided.
- Closing side flues with brick wall (1 ½ brick thick) plastered with a mix of sand clay and cow dung.
- Using double walled insulated feedhole covers. The existing feed hole covers are made of single layer steel plate. The insulated feed hole covers consists of double walled steel plates packed with insulation material such as ceramic or asbestos fibres.
- Providing a minimum ash/keri thickness of 7 inch over the brick setting.

- It is also observed that the kiln structure is partially/fully below the ground level in many States. And even the side walls/base of the kiln is unlined. During rainy season, the trench of brick kiln use to be filled with water. As a result, during first cycle of firing, additional fuel to the extent of 40-50% is consumed in order to evaporate the excess moisture present in the kiln structure, thereby emitting dark smoke from the kiln chimney. Besides this the quality of bricks is also severely affected during first cycle. It is, therefore, recommended that:
  - The kiln should always be above the ground level with proper drainage facility.
  - The kiln structure should preferable be covered by providing a shed over the kiln portion. Provision of shed over kiln would save at least 20-30 tons of coal every first cycle. The shed will have a payback period of around 4-5 years depending upon the weather of particular location.
  - Providing shed over the kiln would also improve the ambience of the area and provide shade to the workers working in the kiln.

Use of internal fuel

- Internal fuel such as ash with carbon, powdered coal or other waste with fuel value should be used in clay. Better mixing of fuel in clays can be achieved using mechanical means. Use of internal fuel will reduce the feeding requirement thus leading to reduced emissions.

Fugitive Emissions

- During summer winds/ storms, the ash layer over the top of brick settings, become airborne resulting in fugitive emissions. To minimise this, wind breakers should be raised along the outer trench wall of brick kiln by constructing two feet high brick wall.
- Provision of shed over the kiln structure will also reduce the fugitive emissions.
- Water should be sprinkled over the keri/ ash layer before its removal and transfer.
- The coal crusher should be installed in an enclosed area with minimum 6' high walls.
- Brick paved/earthen stabilized roads shall be constructed along the outer periphery of brick kiln and approach roads. The water should be sprinkled frequently over these roads.
- Two or three rows of trees with thin leaves should be planted along the outer periphery of kiln area.
- The ash layer in the preheating zone can be covered with plastic sheet/tirpal.

Monitoring

- Since the process of loading, unloading and firing system is totally manual and its performance and efficiency depends on the efficiency and skill of the workers, it is utmost important to monitor the activities, especially the feeding and operating practices in the kiln by using instrumentation, installing monitoring gadgets.
  - It should be made mandatory for a kiln owner to employee a supervisor with minimum 10+2 qualification who will keep the log of temperature in the firing zone, in the side flue and chimney.
  - A temperature gauge shall be installed in the kiln chimney to monitor the temperature of flue gas.

Protection to workers health

- Covering of the kiln top with a continuous layer of bricks or tiles.
- A full face mask is to be provided to workers to protect their eyes, ears and nose.
- Hand gloves are to be provided to workers to protect their hands from ill effects of coal handling and also from hot flue gases coming out of fire hole during the charging.
- Special coat/apron and shoes are to be provided to the workers for their protection against these hazards.

Thanks