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Boiler Furnace, Capacity & Performance Assessment

By

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Introduction

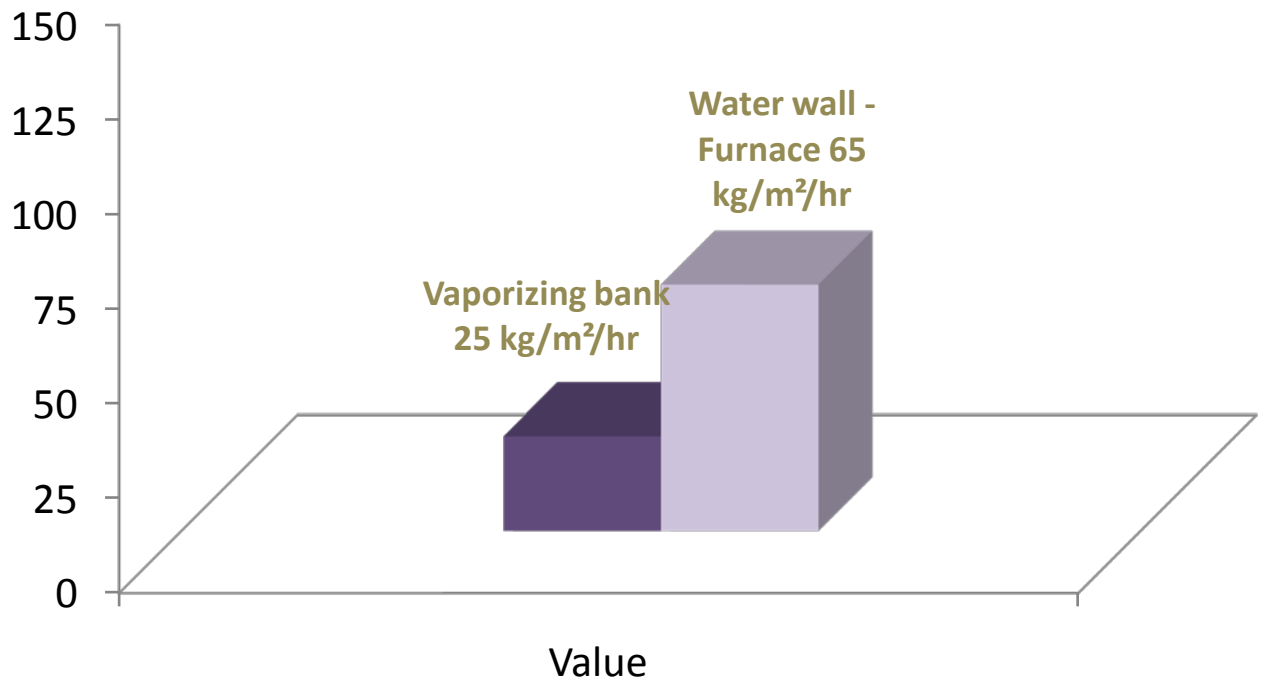
- By & large, when the term opportunities for boiler efficiency is being discuss, heat recovery devices, reduction in flue gas temperatures & protection of steam leakages are generally matter of concerns. However, furnace itself a potential vicinity which can contribute to greater extent to enhance boiler capacity with efficiency through radiation heat transfer.
- Furnace heating surface comprises on water wall (generation tubes) which have 12 - 21% share of the overall boiler heating surface. Although, heat absorption can be realized from 27 – 34 % of liberated energy.
- Principally, grate area, furnace volume & heat release rate are the core aspects taking in to account when capacity modifications under taken.
- Basically, water walls (generation tubes) use to perform bigger generation with small surface area due to the principle of greater temperature difference ΔT between two mediums.
- Potential availability of intense radiation & enormous absorbent property of water walls, 10 – 15 % capacity rise can be attained with 30 - 49% additional heating surface on the available bagasse fired furnaces depends on design permissibility.
- The term furnace is the space between the grate, side walls, front wall & rear wall. However, combustion chamber includes furnace & free space traversed by the gases between leaving the furnace & reaching the boiler tubes.
- Combustion efficiency is the measure of how effectively the heat content of fuel is transferred in the burning process & determined to know the CO_2 concentration ranges between 10 – 12 %. Preheating air which realizes the 60% impact on the greater side of combustion temperature.

Characteristics;

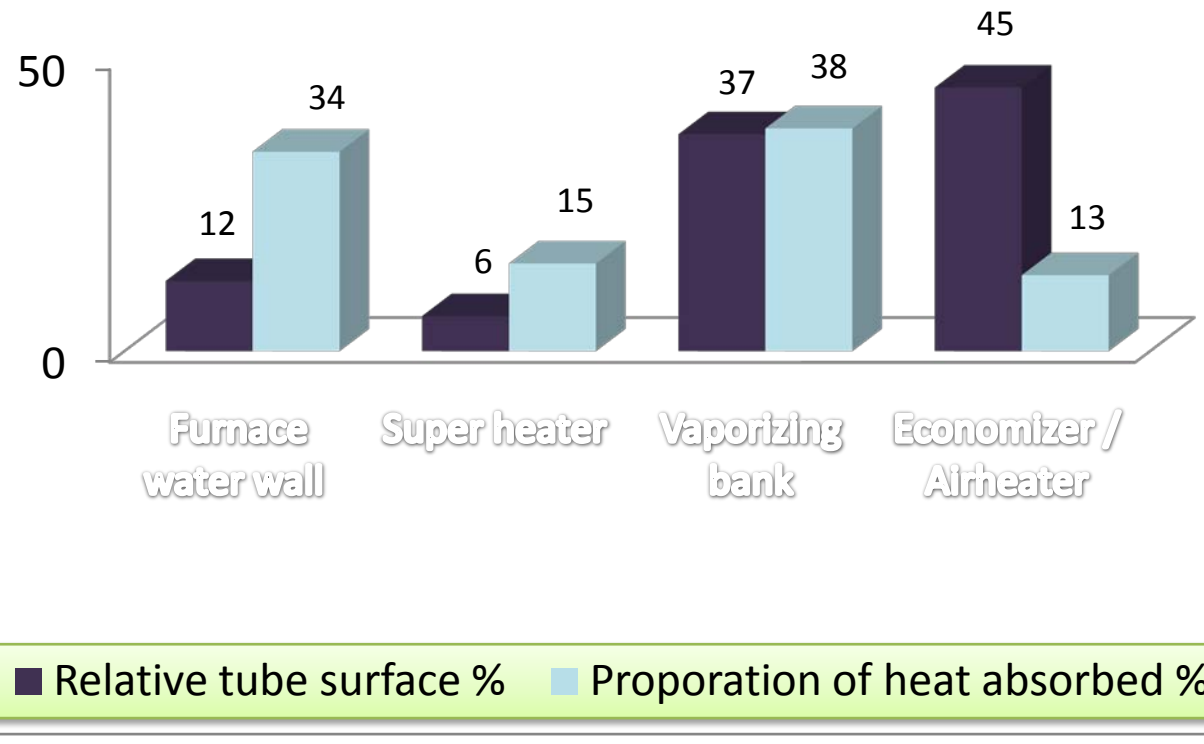
- Combustion rate — 220,000 – 260,000 Kcal/M^3/Hr
- Evaporation rate Vs Grate area — 2162 – 2500 Kg/M^2/Hr
- Evaporation rate Vs Furnace volume — 195 Kg/M^3/Hr
- Heating surface with respect to boiler — 12 – 25 % (Design aspect)
- Temperature range — 900 – 1050 ^{O}C

Proportion of heat absorption as weight of steam produced.

Boiler tubes will acquire 25 kg/m²/h while correspondingly water walls will 65kg/m²/h due to vertically placement, fully exposed to intense radiation.

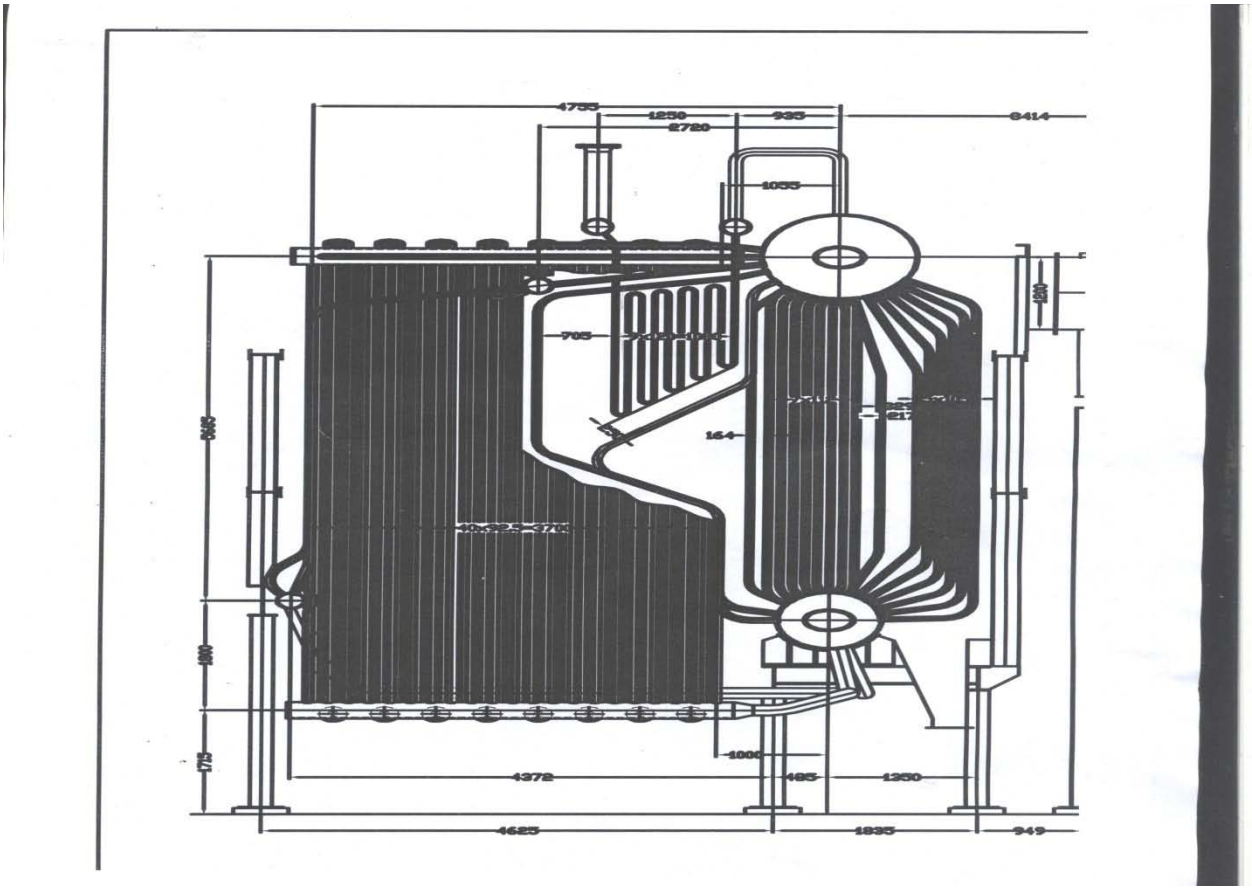


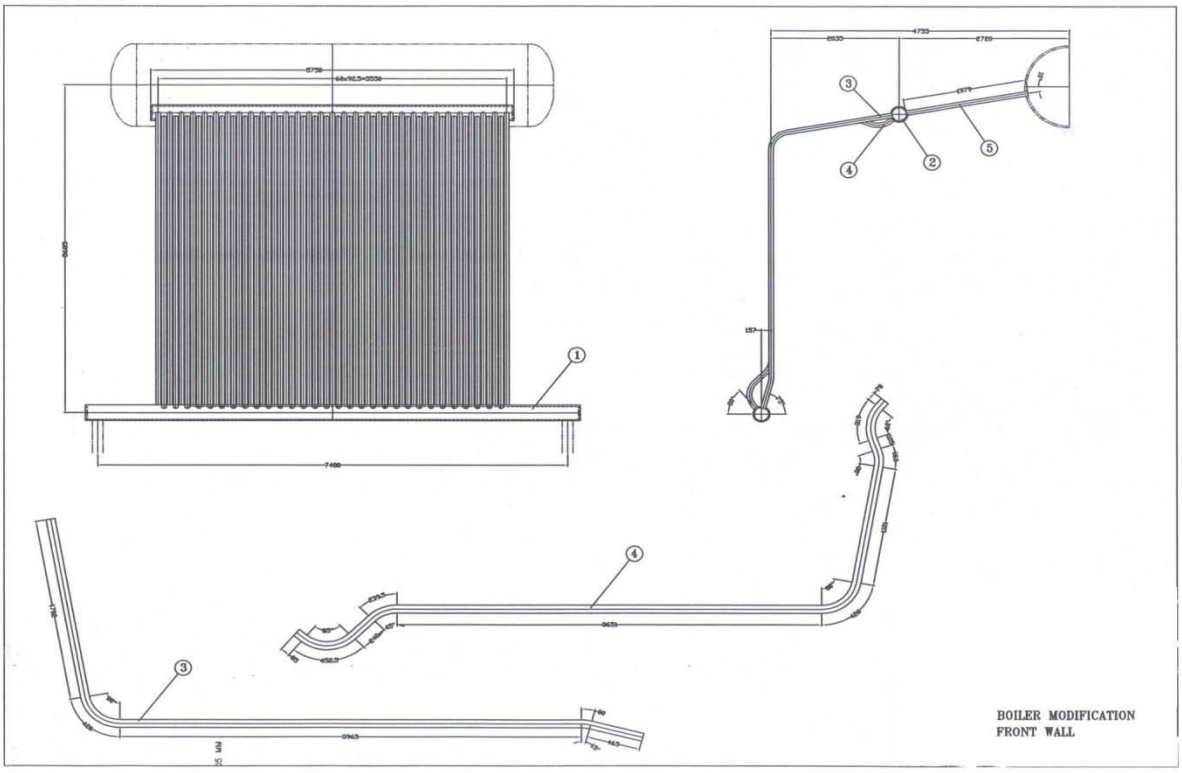
Comparison of relative tube surface Vs proportion of heat absorbed at boiler on specific locations

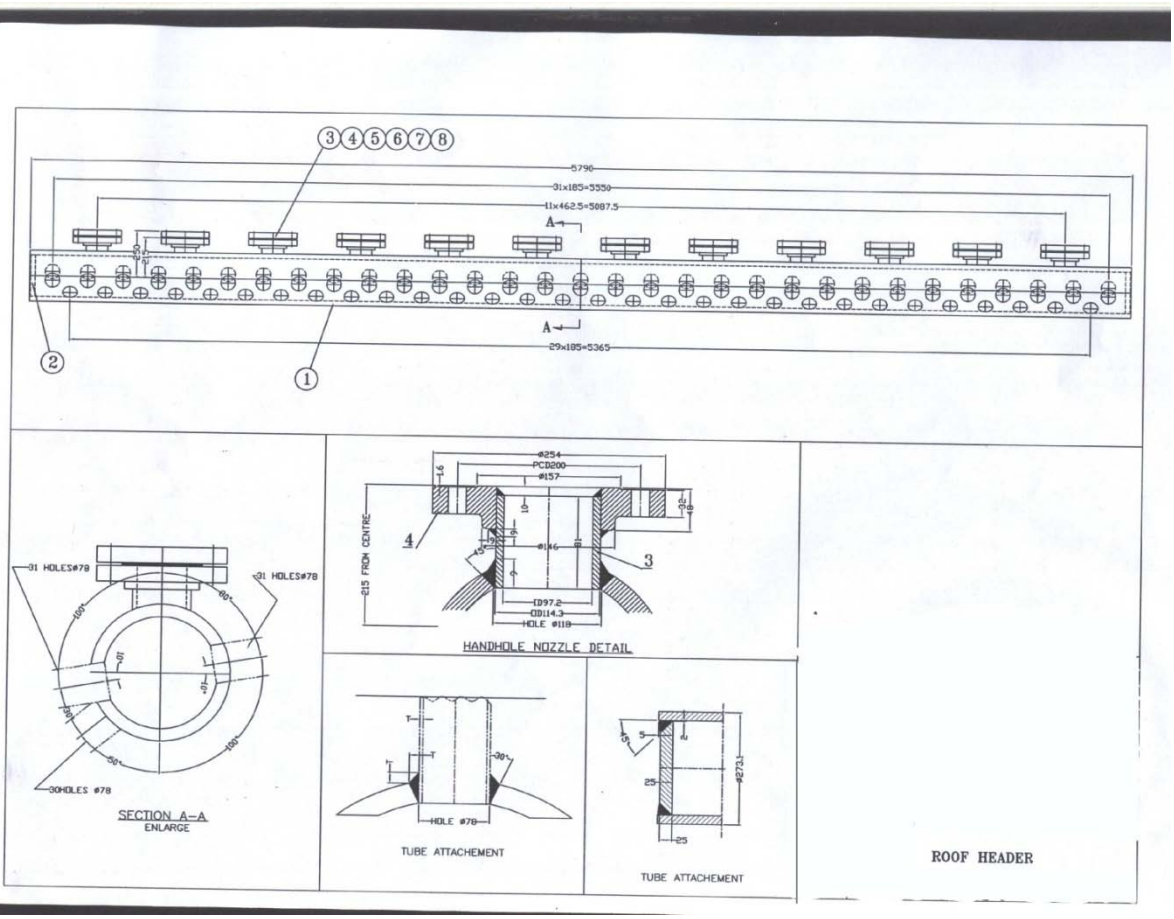


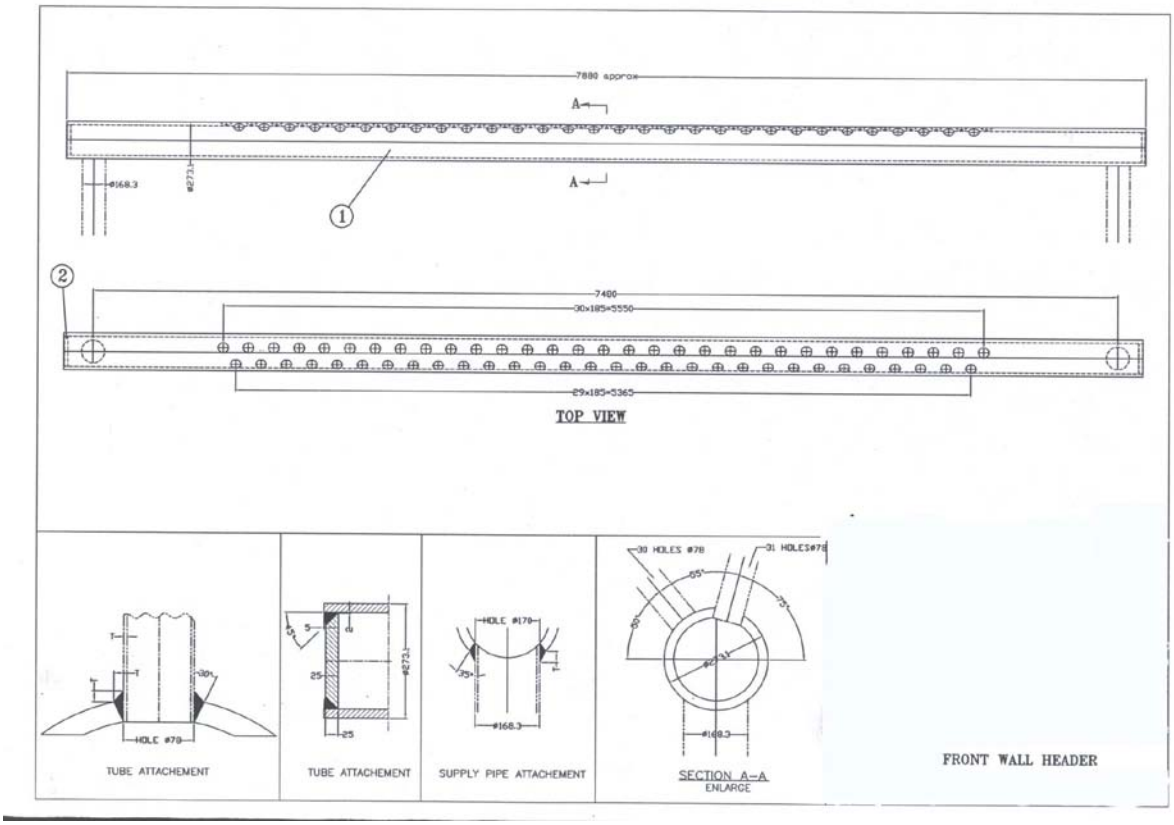
Modified activities

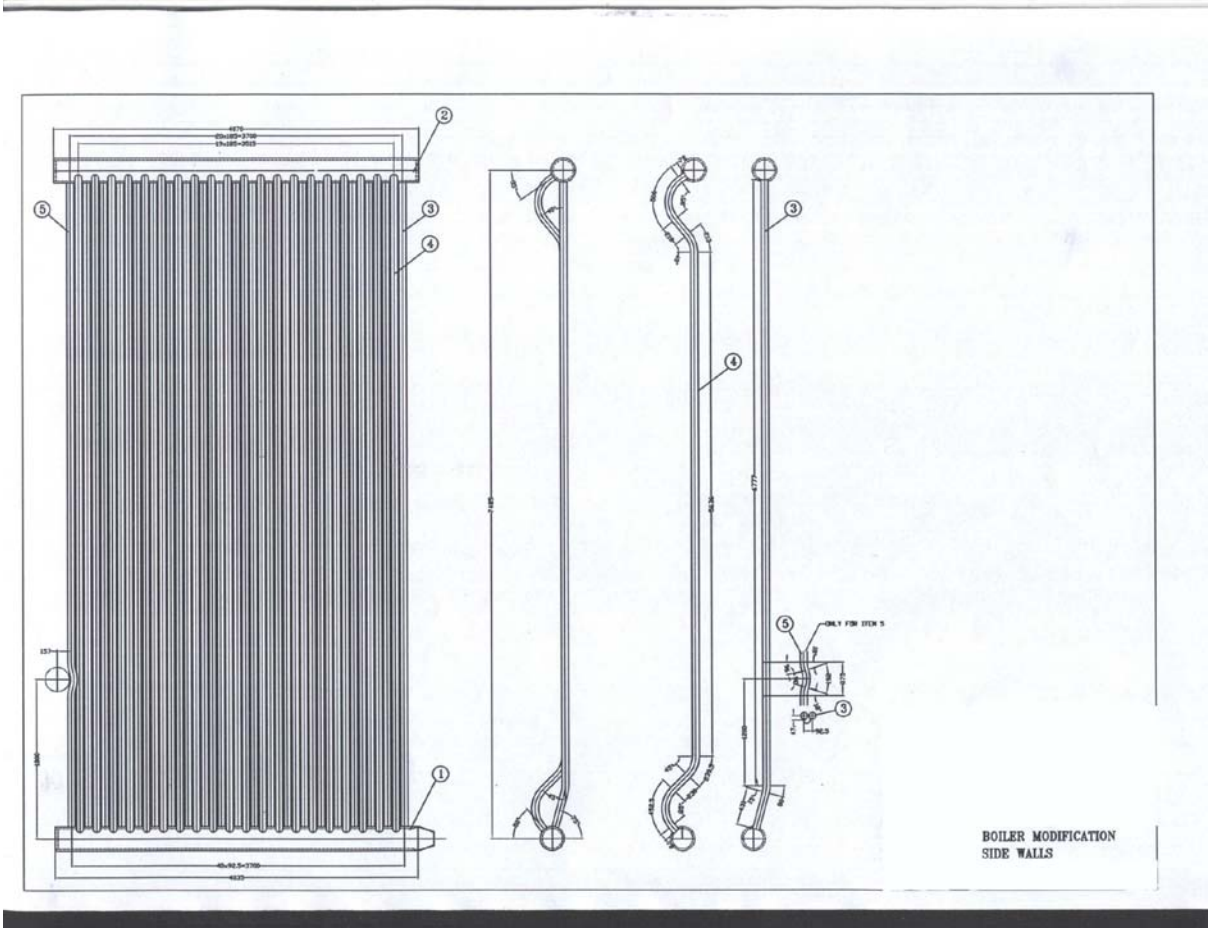
- After assessment of grate area, furnace volume & heat release rate, designed modifications were under taken in order to ensure permissible safe operational limits in the following manner.




BOILER MODIFICATION
FRONT WALL


5796
31x185=5550
11x462.5=5087.5
29x185=5365
31 HOLES ø78
31 HOLES ø78
30HOLES ø78
SECTION A-A
ENLARGE
HANDHOLE NOZZLE DETAIL
HOLE ø78
TUBE ATTACHEMENT
TUBE ATTACHEMENT
ROOF HEADER





Case Study/Implementation

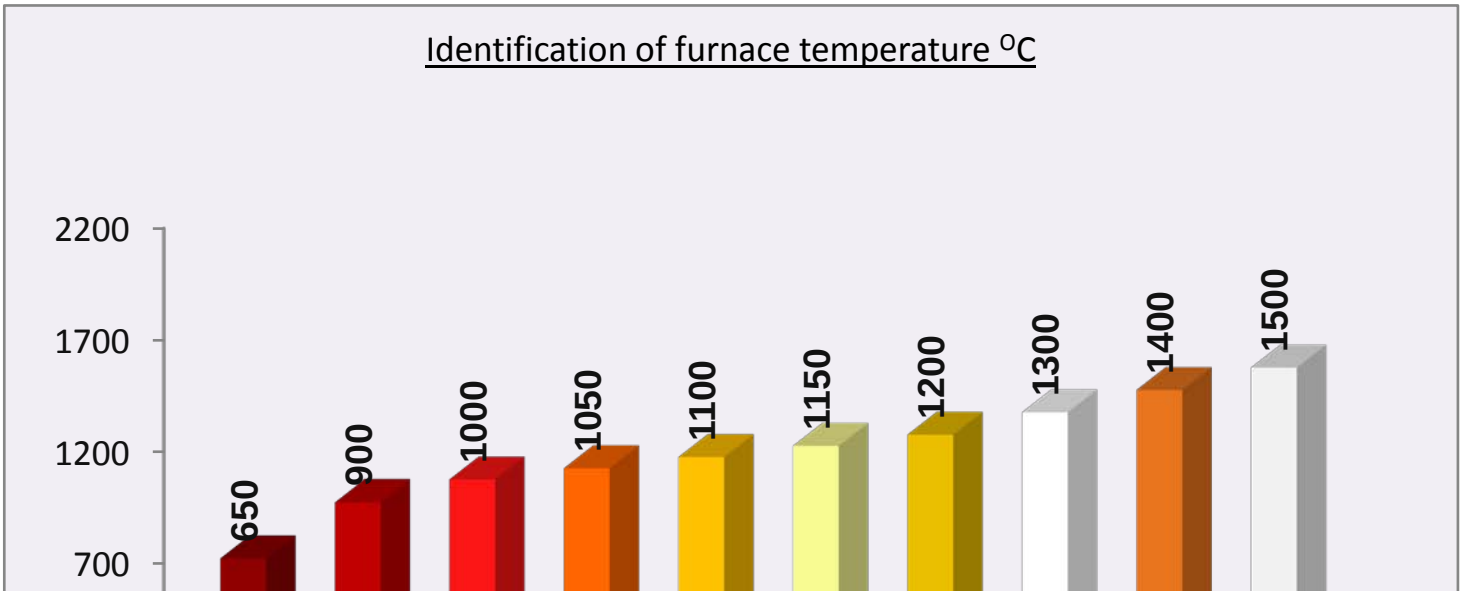
- Type of boiler — FCB (Spreader – Stocker) bagasse fired
- Working parameters — 24 Bar / 330 ± 10 ^{O}C

- Initial capacity 34 TPH
- Capacity enhancement 40 - 42 TPH
- H.S (original) Furnace/Over all boiler $251M^2$ / $1005M^2$
- H.S Enhancement $123M^2$ at furnace
- Modified H.S (Furnace/Over all) $374M^2$ / $1128\ M^2$
- Impact furnace /Over all from original 49 / 10.90 %
- Modified H.S w.r.t. boiler 8.18 % (From 25 – 33.18)
- Capacity enhanced 6 – 8 TPH
- Grate area $22\ M^2$ (Same)
- Furnace volume $150M^3$ (Same)
- Temperature rise 7-10 ^{O}C at super heater

Results & Discussion

1. It's imperative from the case study, there is proved potential in terms of capacity & efficiency enhancement. These modifications are especially fruitful for existing boilers have capacities 30 – 80 TPH.
2. Due to the addition of 123 M^2 heating surface at furnace, radiation absorption increased by 7.2%. It's evident that around 10 - 15 % capacity can be attainable with these sorts of modifications in the existing boilers to ensure safe operations.
3. Super heater, heating surface raised by 8 % to meet additional capacity generation.

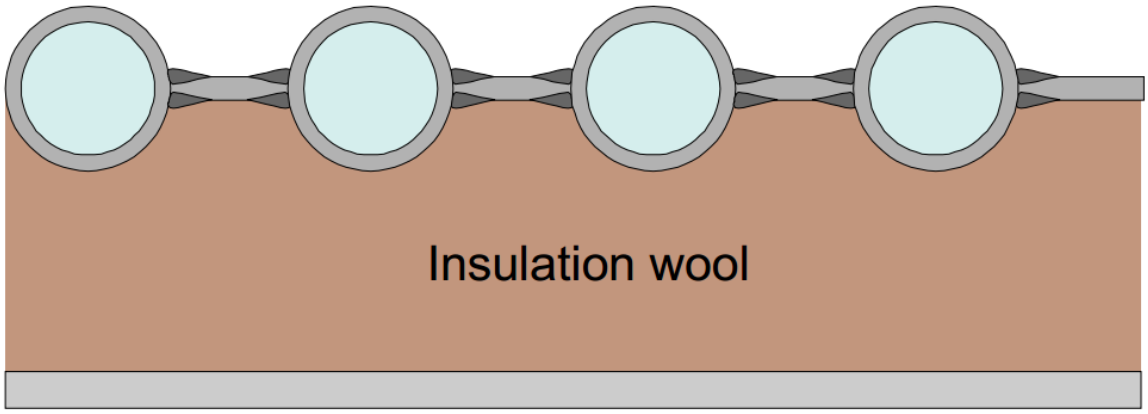
4 Furnace temperature is one of the significant parameter to analyze the performance during operation. This was remained in the range of 902 – 972 ^{O}C. A handy reflection can be assessed with flame identification such as,



Results & Discussion

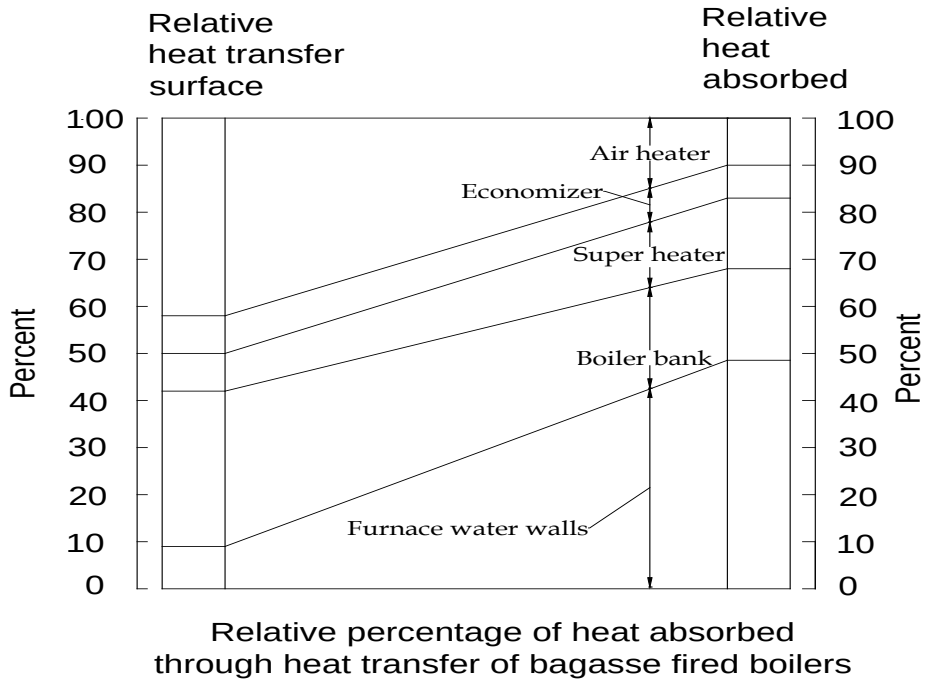
- Application of re-injection nozzles which contributed to re-inject the unburnt particles again to furnace for ultimate combustion, a value added aspect regarding combustion.
- Flame length significantly controlled through optimum air combination. Efforts being made to restrict it 7 – 8 meter height. However, gases below 7 meter & particularly 5 meter would not completely burnt on reaching the cold water tubes also effects the combustion, resulting formation of CO in the combustion gases . This further translate loss of 4.36% of calorific value of bagasse/unit formation of CO
- For suspended combustion, air requirements as follows,
    a) Primary air or under grate 86%
    b) Secondary for distribution 6.5%
    c) For turbulence above grate 7.5%
- Primary or under grate air which is 86% of total requirement supplied through 4-5 mm small holes from grate elements. This area of holes should be @ 3 - 5 % of the total furnace grate area.
- Deposition of clinker over grate elements having inverse effect on primary air flow. Therefore, these holes re-drilled from 4 - 8 mm Ø to overcome the operational inconsistencies & subsequent meets required combustion.
- O_2 remained in the range of 3 – 4.7% on capacity load.

- Induction of membrane wall, a value added aspect, consists of tubes which use to weld together separated by a flat iron strip, called the membranes. They act as fins to increase the heat transfer. They also form a continues, rigid & pressure - tight construction for furnace.



Outer wall

Bench mark profile



Relative percentage of heat absorbed through heat transfer of bagasse fired boilers

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Conclusion

- Furnace modifications can contribute 7.2% rise in heat absorption which subsequently increase generation capacity 6 – 8 TPH by virtue of potential furnace radiations. The activity facilitated the safe limits of boiler operation.

Acknowledgement

- Author is thankful to the management of Kamalia Sugar Mills limited particularly Mr. Maqsood Anwar Qureshi (General Manager) for their kind approval, valuable advise & support. Here, I am acknowledging the design contribution made by Mr. Imdad Shah during activity.