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Dear Fellow Engineers,
Bravo India !

As predicted Corona wave has subsided to a great extent. Now it is time for us to review situation at our end. Infra structure projects are picking up, construction industry and demand for structural steels has revised to original level. Tractor and farm equipment industry is on the right track. Demand and sales in the auto industries are up and so also demand for steel and forgings is good now. Barring few incidences of floods, monsoon has done good job for farmers. In short, overall situations are showing signs of booms. Tokyo Olympics have added golden, silver and bronze colours to the horizon of sports.

It is time for us all to tighten belts for improving production in our forging industry to satisfy customer demand and also for introspection of working methods to improve efficiency, using options like six sigma, IOT, etc. and through application of good management systems, not only for revival but also for tomorrow.

Preparations of the virtual conference to be held on $28^{th}$ & $29^{th}$ Oct. 2021 from our forum has reached intensive sessions version for deciding about technical articles ,themes ,etc. to make it more useful to the industry, participants and successful planning under able guidance of Mr. C.B. Mathur, Mr. B .V. Jogalekar and Mr. R. T. Kulkarni.

In this issue we are covering one paper from Murugappa Industries, presented in the earlier conference for energy saving in the Forging industry, hope you will all enjoy.

**With Best Regards,**
**Dr. V. V. Kanetkar - Editor**

FOR YOU

**First Correct Answer will be given one delegate free for any one training programme**

**What is the technic used in colour etching and tinting in austenitic stainless steel ?**

# ENERGY SAVINGS THROUGH MULLITE CERAMIC FIBRE MODULAR LINNING OF REHEAT FURNACE

M. Kadhirvelu, Murugappa Morgan Thermal Ceramics Ltd, Chennai

## Introduction:

Industries are on look out for various options to sustain their business from vagaries of availability/ price of fuel and stricter environmental norms. Energy efficiency and conservation are the simplest and most easily attainable option to overcome the same and for energy security.

Ceramic fibre (Alumino silicate fibres) has been applied to many industrial furnaces throughout the world in order to save energy. Ceramic fibre design due its low mass and thermal conductivity compared to conventional refractories offers good fuel efficiency ,rapid response to temperature change requirements due its low thermal inertia.

However it has not been used so much for furnaces which are operated at higher temperatures like reheat furnaces, forge furnaces because of its defects such as Crystallization and Shrinkage and falling of modules due to trouble of anchor.

In order to apply the ceramic fibre as much as possible in reheating furnaces of steel industry, Thermal Ceramics worldwide have studied, developed unique designs and obtained satisfactory performance.

This paper highlights the few of its designs and its advantages.

## Ceramic Fibre – Better Insulation

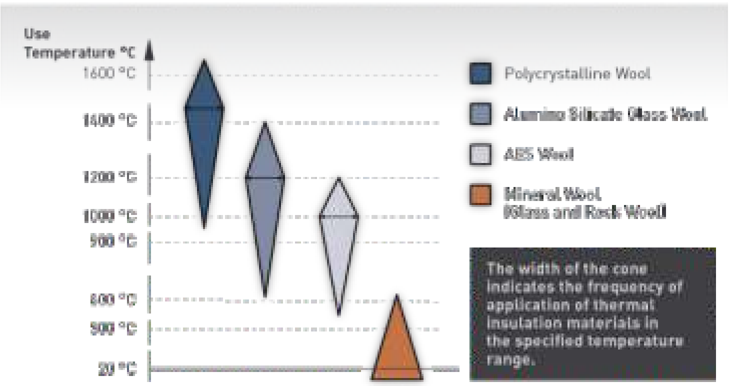
Before we discuss on the above, I wish to inform you the following about "*ceramic fibre*"

Please note that the ceramic fibres are divided in to two groups.

- Alumino silicate fibers (or Amorphous fibers or Non crystalline fibers) with alumina ($Al_2o_3$) content < 60 %.
- Aluminium Oxide fibres (or Poly crystalline fibers) with alumina ($Al_2o_3$) content > 60 %.

Each of these type fibers are produced differently. **The Polycrystalline ceramic fibres are manufactured by "SolGel Process" , where non crystalline ceramic fibres are produced by "Spun Process".**

**Temperature ranges for the application of inorganic synthetic mineral and High Temperature Insulation Wools**




The "conventional" Alumino – silicate fibers / non crystalline fibers (<60% $Al_2 O_3$) has been considered inappropriate as where temperature exceeds 1300 deg C. The reason for this is that non crystalline ceramic fibre is known to crystallize when exposed to high temperature for long period of time, as a result, large heat shrinkage occurs and reduces its fiber strength considerably.

"Poly crystalline fibre (>70% $Al_2 O_3$) 1600 DEG C is able overcome the above deficiencies of non crystalline/vitreous ceramic fibre and manufactured in Japan only.

Please note that in the world only few plants are manufacturing "Crystalline ceramic fibers."

## Key Characteristics of Ceramic Fibre:

Ceramic fibre is an alumino – silicate made from high purity alumina and silica. A unique combination of physical and refractory properties makes this an outstanding material to use in high temperature applications.

Key properties of ceramic fibre are
- Low thermal conductivity
- Light weight
- Low heat storage
- Resistant to thermal shock

Alumino silicate Ceramic fibre exists in "**amorphous"** form as produced. Amorphous is best defined as "lacking crystalline structure or definite molecular arrangement. These molecules remain in the random orientation until sufficient energy is added to the system to promote rearrangement or restructuring to form crystalline products. This process is called "**recrystallisation"**

## Shrinkage of ceramic fibre products

Shrinkage is inherent property of ceramic fibre due to its amorphous form. When ceramic fibre is heated, it begins to transform from in stable amorphous form to stable crystalline form (mullite, cristobolite) leads to shrinkage of fibre.

For AZS ($1425^0$ C) fibre, the first recrystallization product - mullite started forming at 950 – 1000deg C. Secondary recrystallization occurs at 1270 deg C as cristobolite begins to precipitate. This shrinkage determines the fibre's ultimate use limit temperature. When furnace design engineers decide the lining pattern they need to consider the effects of shrinksge. The majority of shrinkage occurs with in 24 hours of start – up as fibre filaments adjust to their new environment.

In designing furnace linings with ceramic fibre, several steps are taken to counteract this shrinkage and maximize lining life depending on the lining system selected.

Higher Density, Compression, short lengths of blanket, batten strips, overlaps and edge grain configuration are some of the ways shrinkage is minimised in ceramic fibre by understanding the specific mechanisms which cause ceramic fibre to shrink

From the above you will note that the designing the appropriate lining considering various operating parameters is the key for the trouble performance of Furnace.

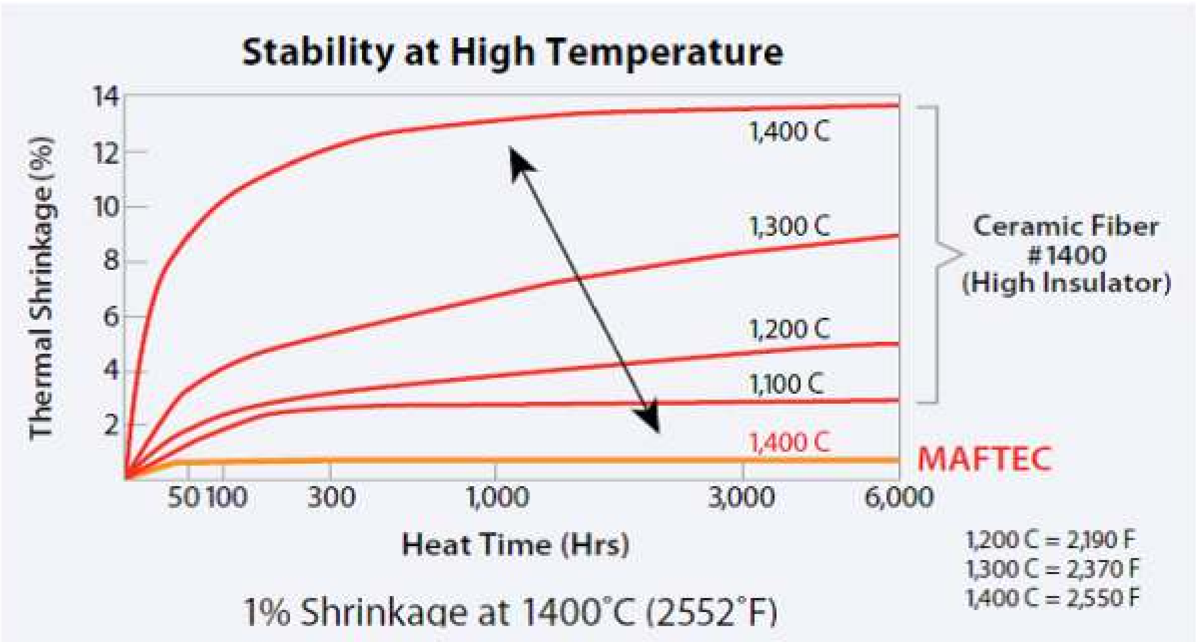
## Properties Comparision and advantages of 1600 C BLANKET :

1600 C Blankets is a mullite fiber. Mullite is stable material that does not change molecularly through temperature range up until it melts ($1850^0$ C). The silica in 1600 blanket is contained within the structure of Mullite and is not allowed free silica. 1600 fibre diameter averages 5 microns.

Please note in comparing the specifications of the above hot face materials you will notice the 1600 blanket has got higher alumina percentage, lower silica and lower shrinkage even at $1500^0$ C will lead Better life and material of choice for reheat furnace linings.

## Properties:

| Sr. No | Properties | Conventional – Alumino silicate fibres | Proposed poly crystallin – high alumin fiber | Remarks |
|---|---|---|---|---|
| 1 | Max working tem | 1325 $^0$C | **1600 $^0$C** | Only high alumina is suitable for operating temp 1300$^0$C for longer lif |
| 2 | **Chemical composition:** | **$_2O_3$ : 33–36%**<br>$SiO_2$: 46–50 %<br>$ZrO_2$ – 16–19% | **$Al_2O_3$ : 72%**<br>$SiO_2$ : 28 % | More alumina m more refractorines less silica means b resistance to redu atmosphere |
| 3 | **Linear Shrinkag** | <3.5%<br>(% after 24 firing at 14 deg C) | **<1.5%<br>(% after 8 h firing at 15 deg C)** | Less shrinkage 1500 $^0$C (more tha operated temp of reheat furnace $^0$1 C)Leads to better lif |
| 4. | High tempera restoration ration | 0% | <u>**83%**</u> | High restoring a therefore regarded useful material for temperature |




As explained earlier the lesser shrinkage at operating temperature means better life of lining. Please note that the shrinkage is hardly 1.5% at 1500 deg c for 1600 blanket **<u>means that at operating temperature of reheat furnaces – 1300 deg C the shrinkage effects will be negligible.</u>**

**<u>Fiber lining methods:</u>** Generally there are three all fiber lining methods; paper /blanket lining, board and module lining. In constructing high temperature furnaces/kilns, we have recommended module method. By using this method, the metallic anchors are placed in low temperature sides of modules, nearer to the shell side and compression is applied to module while lining as a pre treatment to compensate for shrinkage of ceramic fiber.

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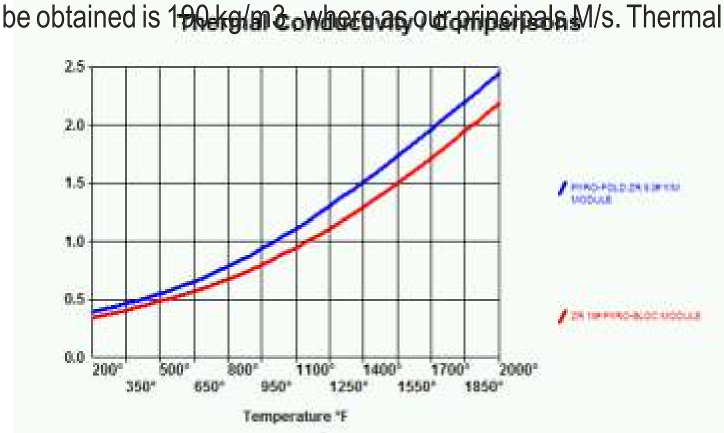
**<u>Anchor materials:</u>** Based on interface temperature / anchor point temperature calculated in the module lining we have used SS 310 – steel grade Please note that the scaling temperature and oxidation temperature of SS 310 was the highest among the other steel grades. For roof since the modules were hanging, we have recommended SS310 anchors for better factor of safety.

**<u>Density:</u>** The lesser shrinkage effects and better cold face temperature can be achieved using high density modules. Please note that using blanket strips the maximum density can be obtained is 190kg/m3, where as our principals M/s. Thermal

Thermal Conductivity Comparisons



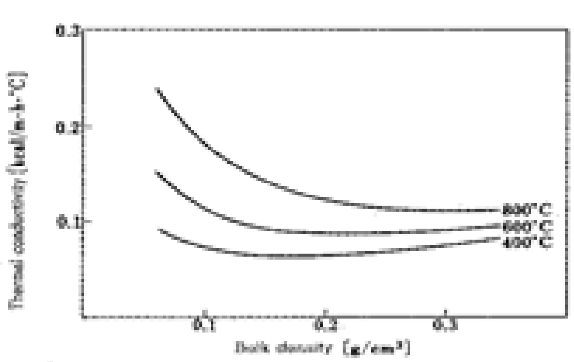




Fig.2.4. Relationship between bulk density and thermal conductivity of ceramic fiber blanket

From the above graphs Relationship between bulk density and thermal conductivity of ceramic fibre blanket you will understand that the K value is the lowest where bulk density is between 200 kg/$m^3$(0.2g/$Cm^3$) – 240kg/$m^3$(0.24g/$Cm^3$).

**Please note that Pyrobloc is the only product having highest density – 240 kg/Cu.m as produced available in the world.**

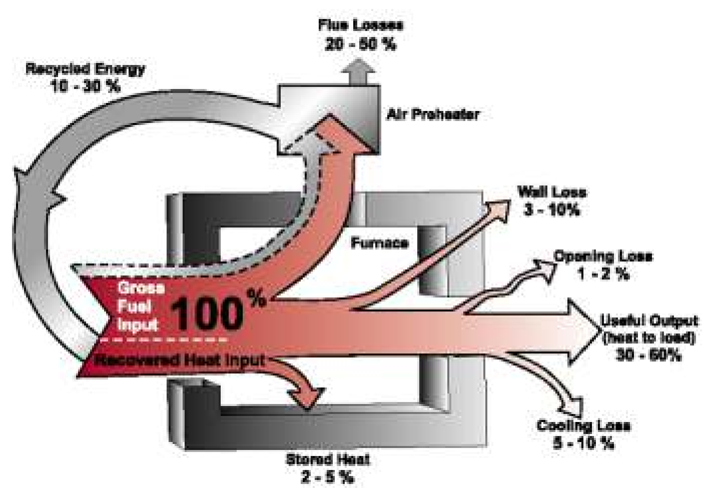
**<u>Coating</u> : " Thermo Plug – H Coating – 1500 Deg C ".**

The advantages of spraying the ceramic coating on hot face are

- The coating over the Hot face reduces module shrinkage by keeping the hot face surface "**<u>tight".</u>**
- Guards the ceramic fibre module against metal oxide, chemical and contaminant attack.
- Protects against velocity damage and erosion of Hot face.

Please find below the typical lining sketches and module sketches for your ready reference and understanding.

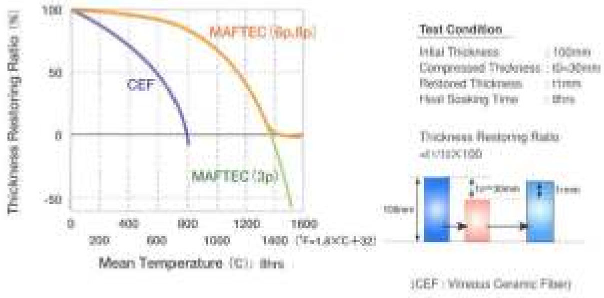
<u>References :</u> Our principals STCC Japan had done many furnaces in Nippon Steel with 1600 Z blok module design and have trouble free life over 5 years or more and TC Korea had done many furnaces with Pyrobloc Combi modules .



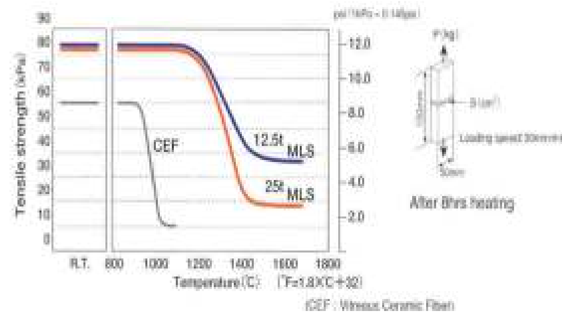

Energy Balance of Reheat

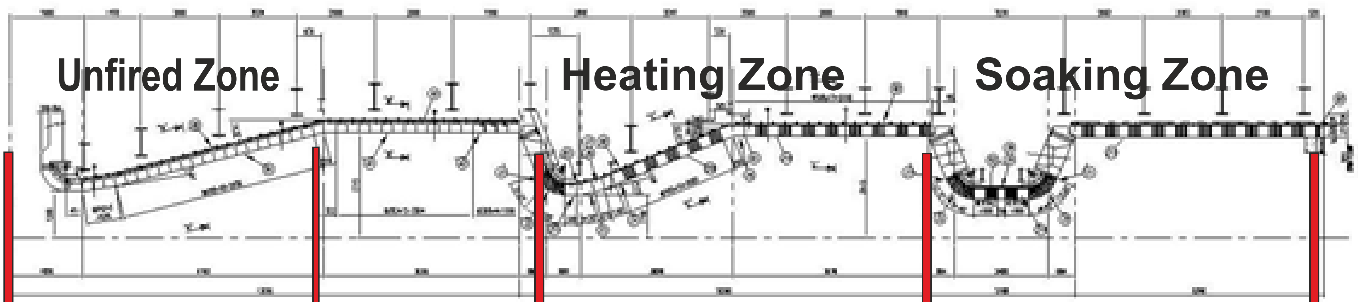
<u>Conclusion:</u> Fuel cost and availability dictated an efficient unit. By using Crystalline Ceramic fibre lining, various units have reported minimum 13% fuel savings on accounts of lower heat loss through the wall and Lower thermal inertia of the furnace which makes temperature adjusting time considerably shorter over a wider temperature range. The above energy conservation measures automatically implies to preserving the environment.

## Thermal Resiliency : Cushioning Ability




## Tensile Strength of Blankets




| | | | | |
|---|---|---|---|---|
| Temp : 1000~1200℃<br>Pyro-Bloc Zr or<br>Pyro-Bloc Cr Grade | Temp : 1250℃<br>Pyro Combi-15 | Temp : 1300℃<br>Pyro Combi-15 or 1600 Z Blok B | Temp : 1350℃<br>1600 Z Blok A | |

Pyrobloc Combi Module, Grade – 1550

1600 Z Blok Module, Grade - 1600 Deg C

**1600 Z blok module lining in RHF**

**Combi Pyrobloc Module in RHF**

Forge Industry – Furnace lined with Ceramic fibre – Pyrobloc

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# Training Programme Calendar 2021-2022

## April

**Steel Making and Quality Control**

23 (Fri) **FFTC 1**

April 2021

## May

**Types of Polymers Quenchant & its Application in Forging Industries**

21 (Fri) **FFTC 2**

May 2021

## June

**Open Die Forging : A Metallurgical Aspect**

24 (Thur) **FFTC 3**

June 2021

## July

**Failure Analysis**

15 (Thu) **FFTC 4**

July 2021

## August

**Raw Material Quality Control for Cold Forging**

26 **FFTC 5**

August 2021

## September

Quiz Programme

8 (Wed)

**Corrosion Basics**

23 (Thu) **FFTC 6**

September 2021

## October

**Spectrometer Calibration, Maintenance, latest Development**

8 **FFTC 7**

**FORGING Annual Conference**

28 29

October 2021

## November

**Introduction to Sealed Quench Furnace and it's Applications**

25 - 26 **FFTC 8**


November 2021

## December

**NDT Technologies latest Eddy Current case depth measurement**

23 (Thu) **FFTC 9**

December 2021

## January

**Personality Development, Communication skills**

14 (Fri) **FFTC 10**

January 2022

## February

**Forging Product Development**

1 or 4 (week) **FFTC 11**

February 2022

## March

**Surface Engineering and Protection**

(Saturday) **FFTC 12**

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