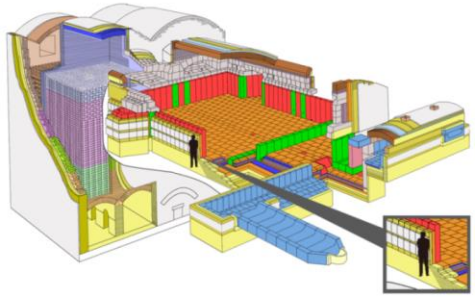
Refractory and Engineering Technology on Glass Melting Furnace

AGC Ceramics Co.,Ltd
Shinji Yamamura

ASEAN FEDERATION OF GLASS MANUFACTURERS

Your Dreams, Our Challenge

Introduction

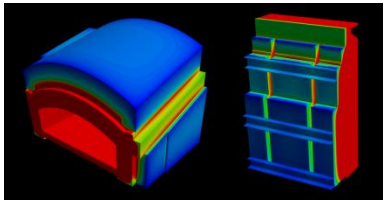


Needs for glass furnace

- Low energy consumption
- High reliability and long life
- High quality glass


Refractory





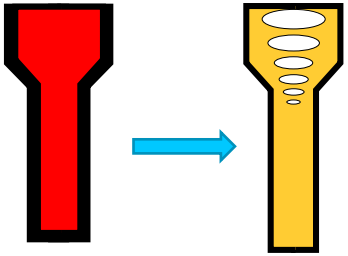
Engineering

Agenda

- ✓ **Refractory**
  1) Quality assurance for reliable AZS fused cast refractory
  2) High-insulation monolithic refractory with RCF free

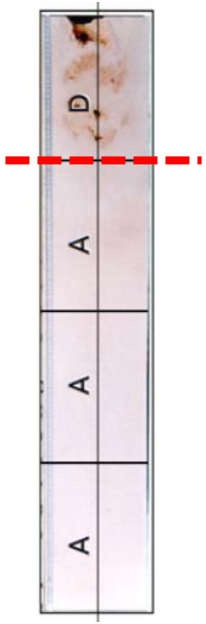
- ✓ **Engineering**
  3) Actual energy saving performance of container furnace
  4) Operation data analysis system to prevent furnace trouble.

Casting process of AZS (Al_2O_3-ZrO_2-SiO_2)



Shrinkage void

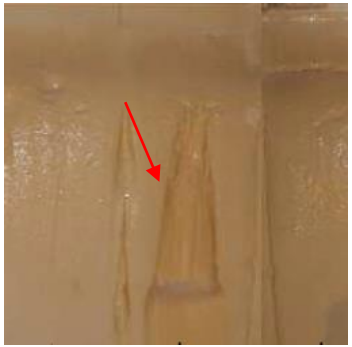
Shrinkage during solidification



Cutting

Void free

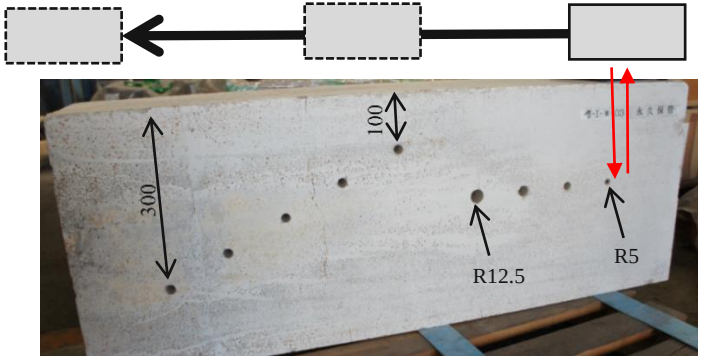
Is it possible to assure that all refractories has no internal void?



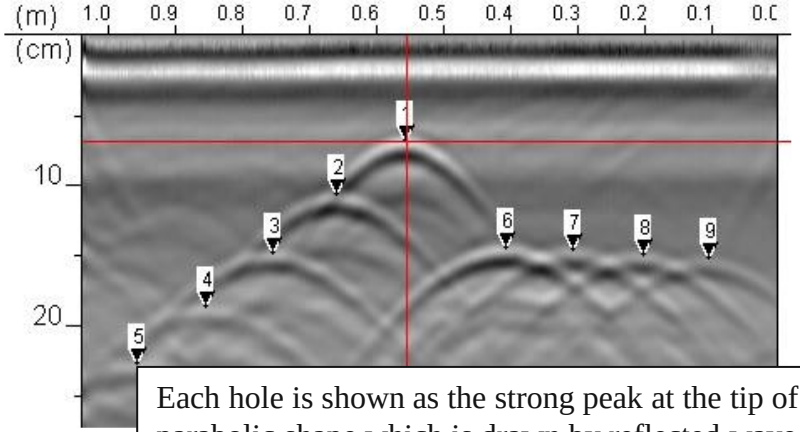
Unusual heavy corrosion of side wall due to internal void, which was manufactured before 1990.

Non destructive internal inspection, developed in 1991

Electromagnetic radar device



AZS Block Size 1250×450×250
Artificial Holeφ10-φ25mm, Depth 100-300mm



Each hole is shown as the strong peak at the tip of parabolic shape which is drawn by reflected wave.

All holes can be measured at the tip of parabolic shape correctly.
Based on this theory, non destructive internal inspection has been developed in 1991, and as one of our quality assurances before shipping, we have carried out this inspection for all important large blocks since 1992.[1)]

1) Pat.5363106,FR , Pat.2689245,IT, Pat.1287883,JP, Pat.3262606

Actual results of internal quality assurance

Non inspected block

before

1992y

after

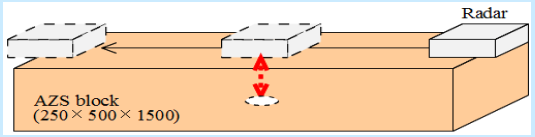
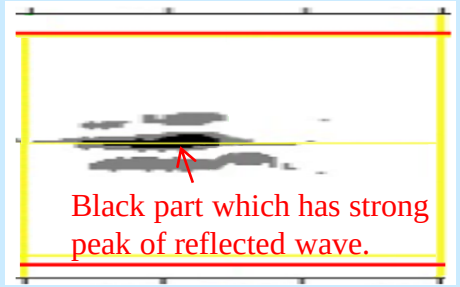
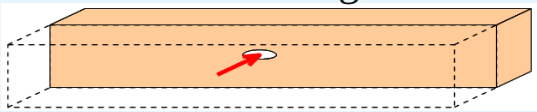
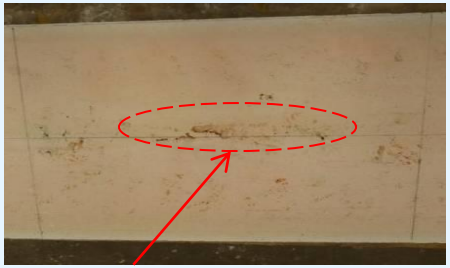
Inspected block

Unusual corrosion

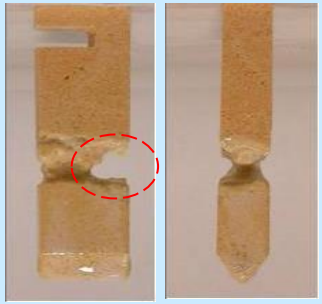
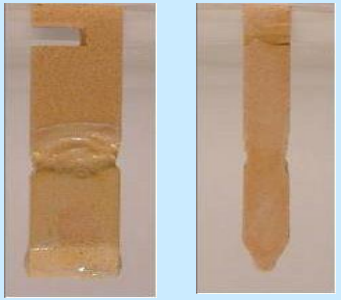
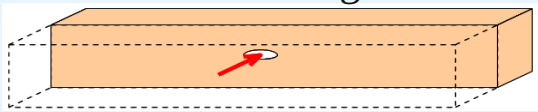
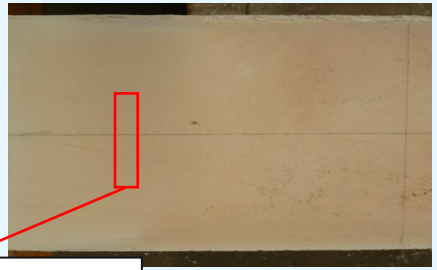
19%
18/95 blocks
(2 furnaces)

0%
0/340 blocks
(10 furnaces)

Detected internal micro void inside side wall block

	Sample-A (Rejected)	Sample-B (Good)
The result of non destructive inspection. 		
Confirmation of the cross section after cutting 		

The example of detected internal micro void

	Sample-A (Rejected)	Sample-B (Good)
TC-11 corrosion test 		
Confirmation of the cross section after cutting 		

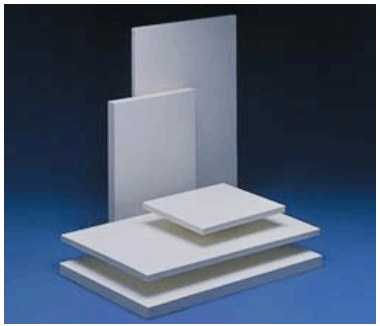
Corrosion test in laboratory.

Agenda

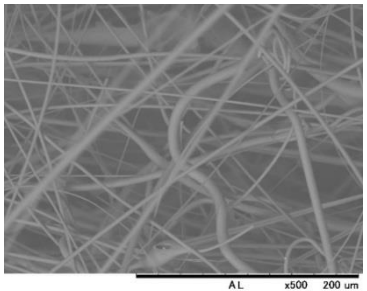
- ✓ **Refractory**
  1) Quality assurance for reliable AZS fused cast refractory
  2) High-insulation monolithic refractory with RCF free

- ✓ **Engineering**
  3) Actual energy saving performance of container furnace
  4) Operation data analysis system to prevent furnace trouble.

Insulation material with Refractory Ceramics Fiber



Insulation material with RCF



RCF

Refractory Ceramics Fiber
(Limitation on using)

BSF

Bio Solube Fiber,
which has solubility inside human body

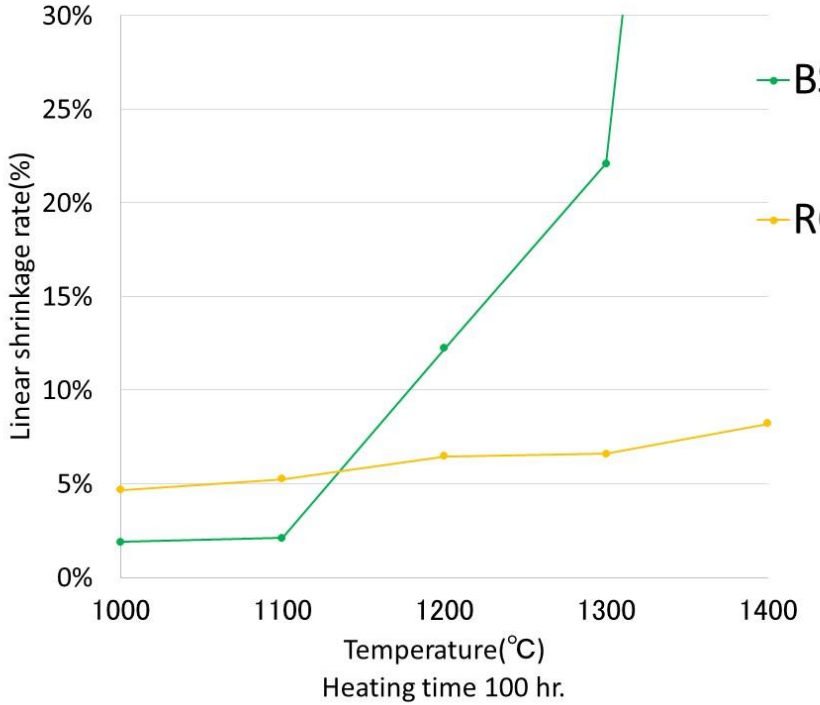
■ Carcinogenicity possibility

Limitations on using RCF has been started internationally because of its carcinogenic possibility. So the use of BSF is increasing as an alternative to RCF.

But these material included non crystal fiber, has deterioration problem at high temperature.

2) The energy conservation center Japan,
Ceramic fiber and how to design insulating structure, 2007, 45p.

Shrinkage Test with 100 hr heating

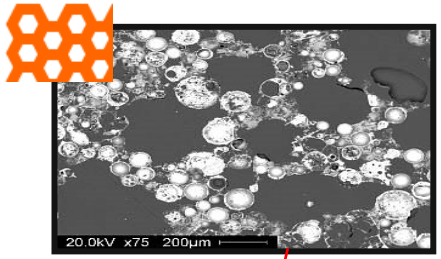


BSF (Bio Soluble Fiber)

RCF (Refractory Ceramics Fiber)

- BSF shrank remarkably at over 1200 °C.
- RCF shrank by 5~8% at over 1000°C.

Solution) Monolithic Insulation Material with RCF Free



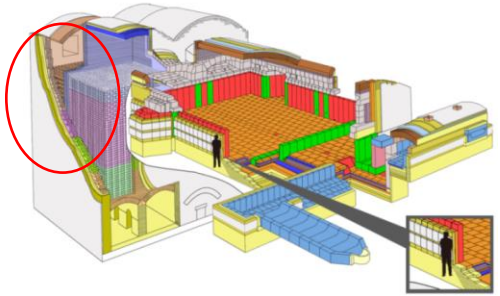
High Thermal Insulating Ceramic Materials
THERMOTECT WALL®

- ✓ High insulation performance
- ✓ Low deterioration at high temperature for long time
- ✓ RCF free

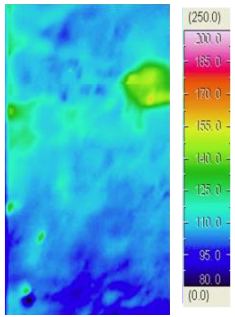
ENERGY CONSERVATION GRAND PRIZE

In 2015, It got the grand prize for excellent energy solution in Japan.

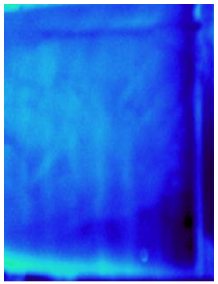
The comparison of deterioration in actual furnace

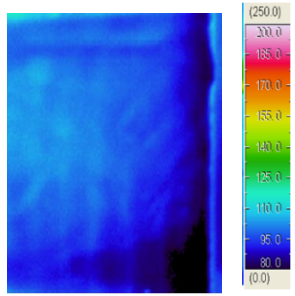


Regenerator wall



Conventional fiber cast（After 5 years）





ThermoTect Wall just after installation

After 2.5 years

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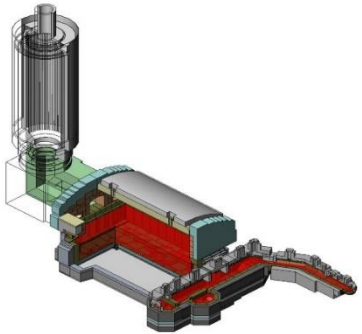
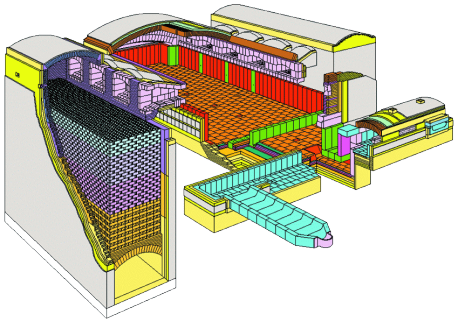
  4) Operation data analysis system to prevent furnace trouble.

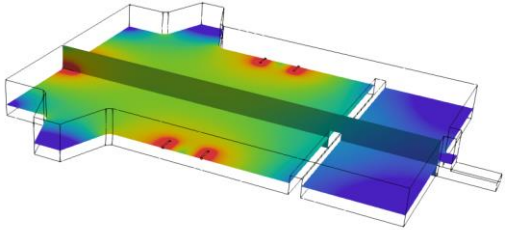
Various type of furnace container, table-ware, and sodium-silicate

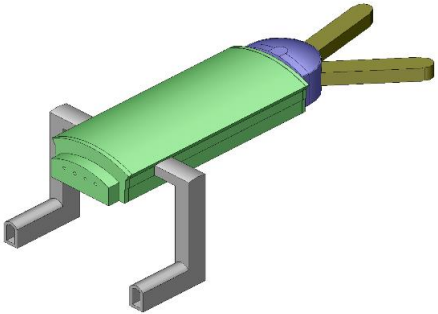


Recuperator

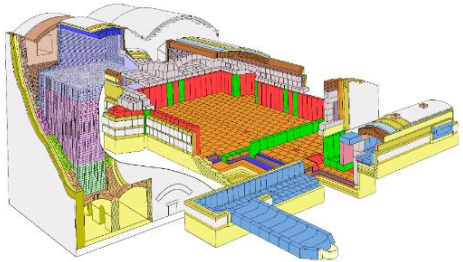


Side Port

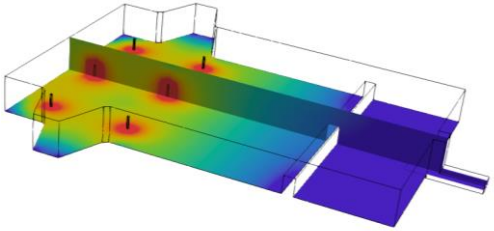




Oxy-fuel Combustion

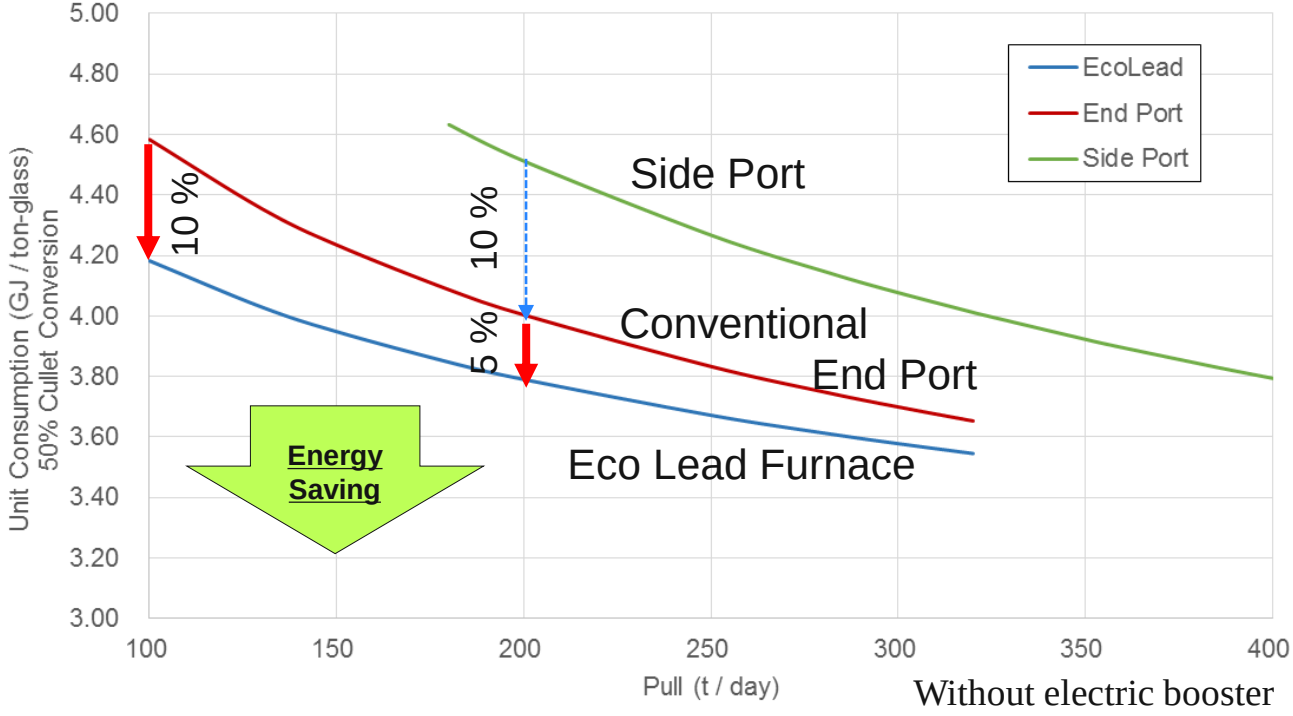


End Port



Electric booster

Actual performance of EcoLead furnace



EcoLead Furnace

Improvement of

- Heat recovery
- Insulation

Agenda

- ✓ **Refractory**
  1) Quality assurance for reliable AZS fused cast refractory
  2) High-insulation monolithic refractory with RCF free

- ✓ **Engineering**
  3) Actual energy saving performance of container furnace
  4) Operation data analysis system to prevent furnace trouble.

Significant furnace trouble

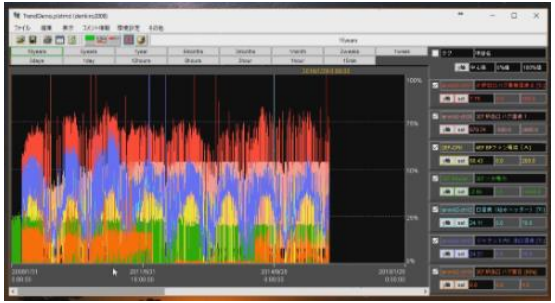
Our goal is trouble free furnace.

ZERO

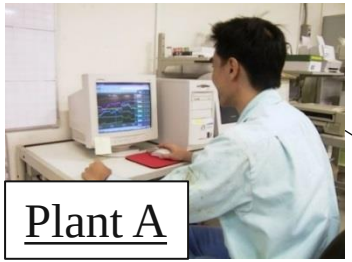
It is important to find unusual state of the furnace at early stage during operation.

Remote trend analysis example with Company LAN in AGC

10 years scale



Quick displaying software, called PLEASURE.
(40 times faster displaying speed than conventional trend system)



Plant A

Plant B

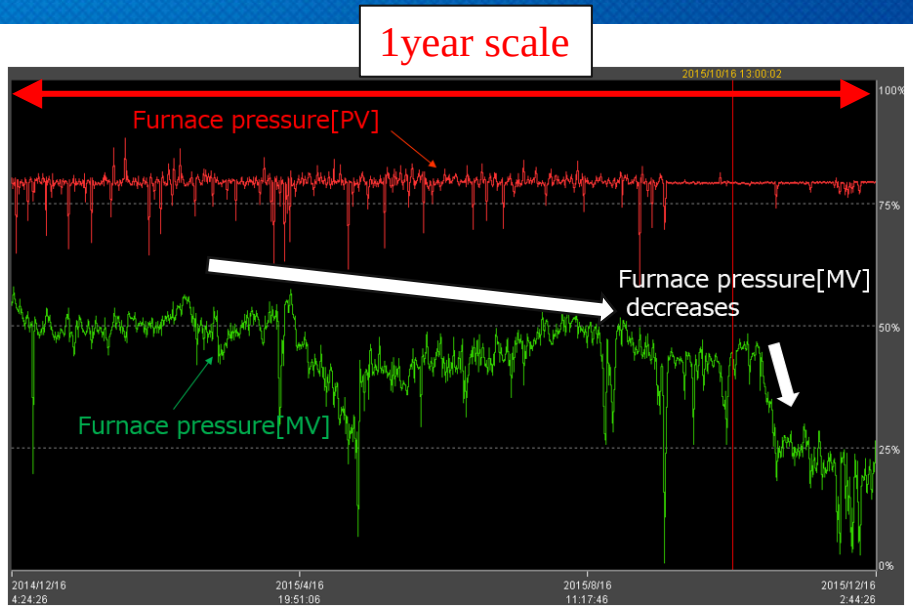
R & D Center

Plant C

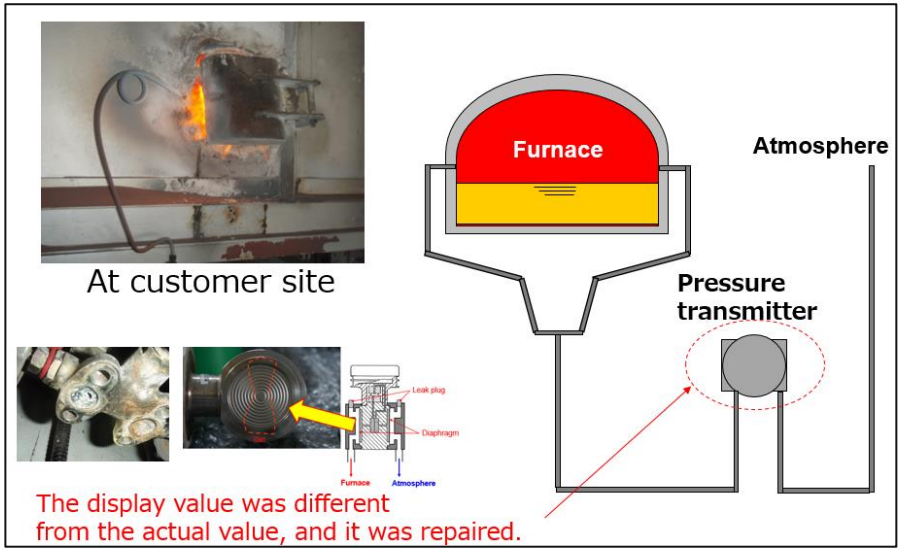
Plant D

High speed trend data processing software is developed for big data analysis around 2000y.
So data was shared with skilled engineer and analysis staff, using Company LAN.

The example of unusual furnace trend data

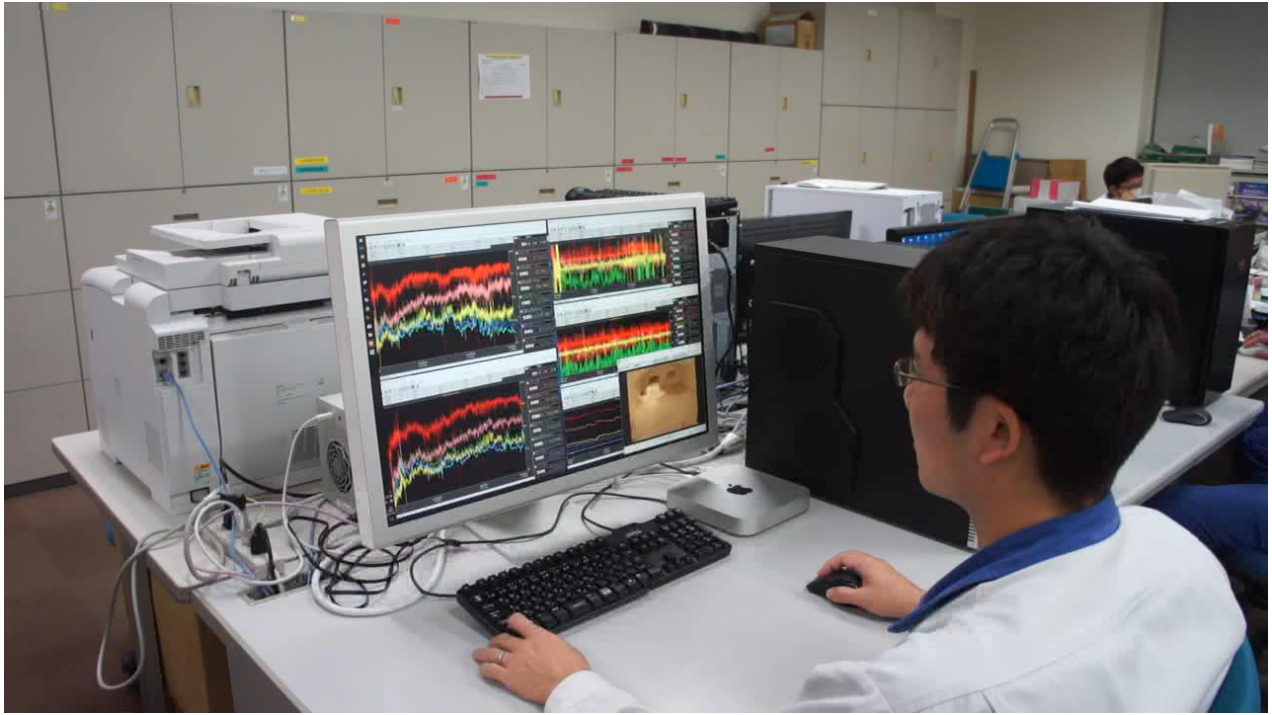


Gradual progress of Pressure meter trouble



- In this case, pressure meter had problem and doesn't show correct value. It is important to find such unusual situation and be improved ASAP.

Remote trend analysis of container furnace with secured communication



Remote big data analysis example through secure internet

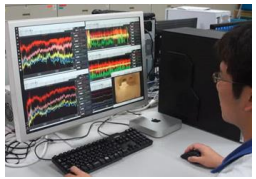
docomo 4G 17:49 72%
agc-soft.com

DateTime	15:12-25/10/2017
Furnace Pressure[PV]	6.7
Combustion Air Flow[PV]	6456
Glass Level[PV]	-0.2
Gas Flow[PV]	648
ME Crown1 Temperature[PV]	1543
ME Crown2 Temperature[PV]	1519
ME Crown3 Temperature[PV]	1457
Main Gas Pressure[PV]	0.3
Primary Gas Pressure[PV]	116.1
Burner Cooling Air Pressure[PV]	0.5
ME Crown R/P Temperature[PV]	1513
Flue Left Draft[PV]	-73
Flue Right Draft[PV]	41
Flue Stack Draft[PV]	-123
Cooling Water Pressure[PV]	0.3
ME Bottom 1 Temperature[PV]	1174

WEB monitor function

Summary

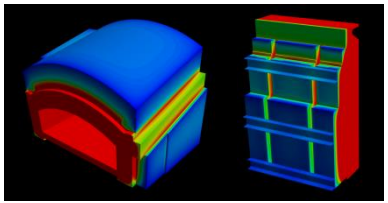
- ✓ **Refractory**
  - 1) Quality assurance of AZS fused cast for reliable internal structure
  - 2) Stable insulation monolithic refractory with RCF free
- ✓ **Engineering**
  - 3) Better energy saving performance of EcoLead furnace.
  - 4) Remote trend analysis of the furnace



Conclusions

Examples of refractory and engineering technologies have been introduced in this presentation. Challenge for energy saving and long life furnace should be continued for global environment, and good refractory performance, well-balanced design, and operation support technology can contribute to it.


Refractory

Design and Engineering

Your Dreams, Our Challenge

Thank you!

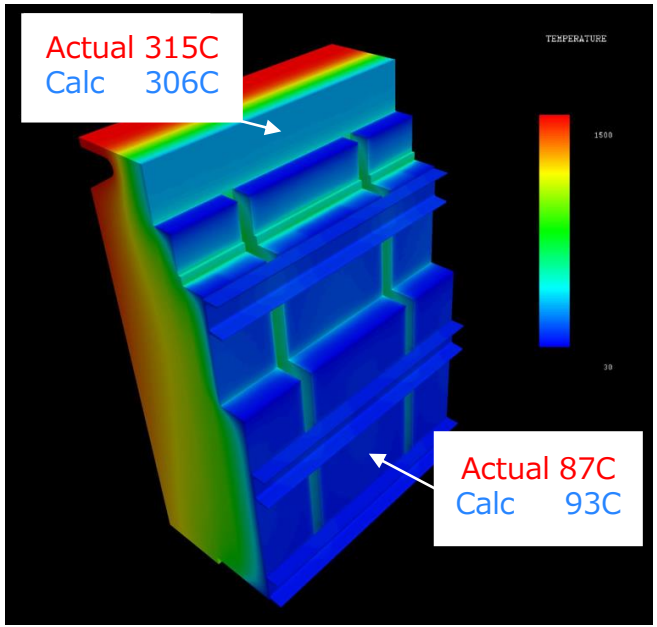
Hyper Regenerator System

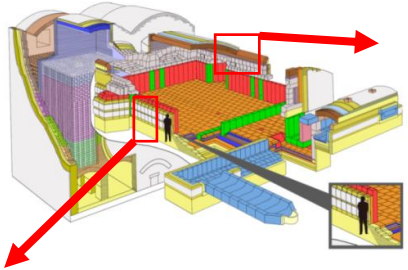
Supply records

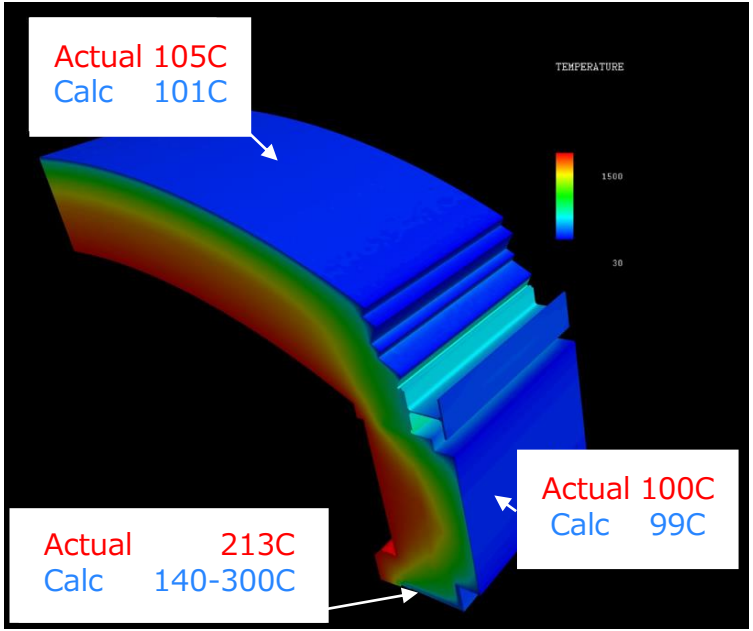
Period	1960's	1970's	1980's	1990's	2000's	2010's
Number of Multi-REG	**2**	**5**	**10**	**6**	**7**	**14**
Glass type						
Cullet	2	4	6	1	2	1
Container	0	0	2	4	5	13
Table Ware	0	0	1	0	0	0
Boro-Sil	0	1	1	1	0	0
Purpose						
Save Energy (A)	0	0	3	4	6	14
Checker Trouble (B)	0	0	0	0	0	0
(A)+(B)	2	5	7	2	1	0
Improvement of the technology	1-st Generation(Challenge)	2-nd Generation (Solve Problem and Expand)			3-rd Genaration (Reliability with Simulation)	4-th Gen. (with TMT)

*Furnaces in AGC Group and designed by AGCC

Temperature distribution of refractory

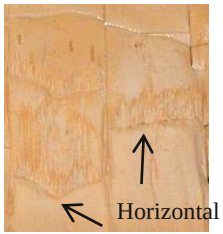
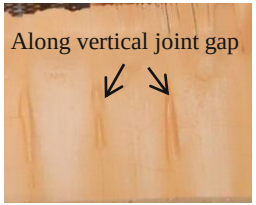
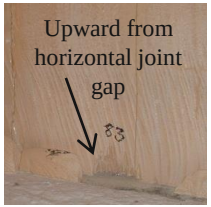
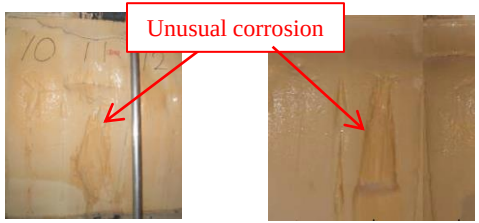




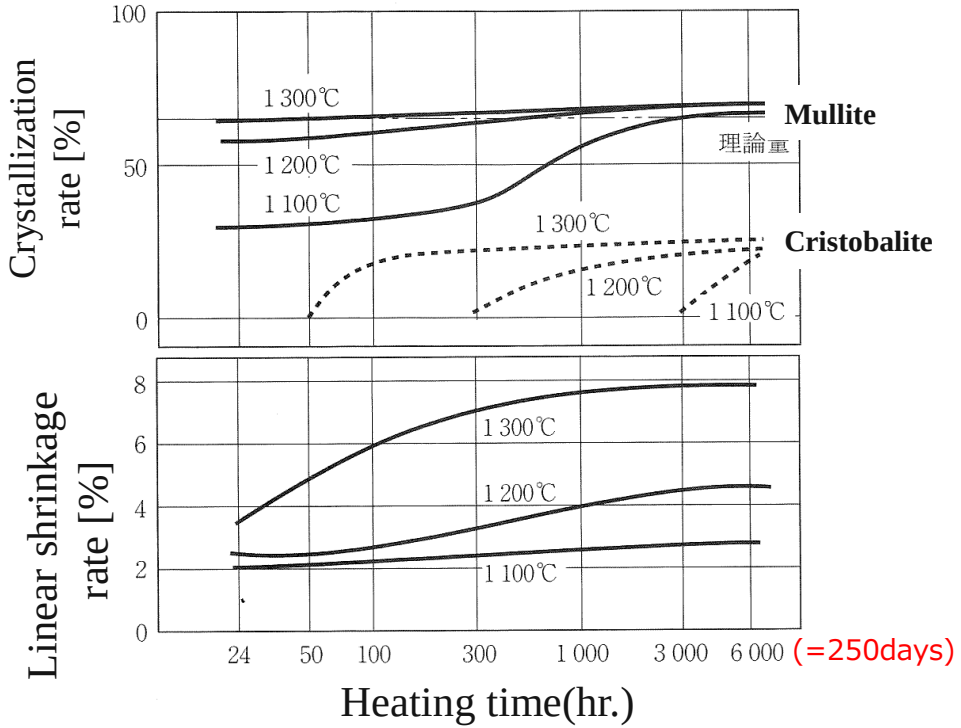


It is helpful tool for heat loss reduction study

3-1 How to count unusual corrosion of side wall refractories.

1) Upward drilling from horizontal crack.		These corrosions are influenced by cracks and have no relation with internal defect.
2) Corrosion from gap.	 	These corrosions may be influenced by condition of joint gap and design concept.
3) Unusual corrosion without joint gap and clear crack.		Internal defects may influence these type of unusual corrosion .

Deterioration mechanism



Heating test of RCF[1] (SiO_2:Al_2O_3=53:47, Max service temperature:1260 °C)

■ Deterioration

It can be seen that crystallization increasing, and shrinkage progress for 250 days even under the max service temperature

Crystallization gives the material a dense structure. As a result, it is expected that thermal conductivity of the material will increase.

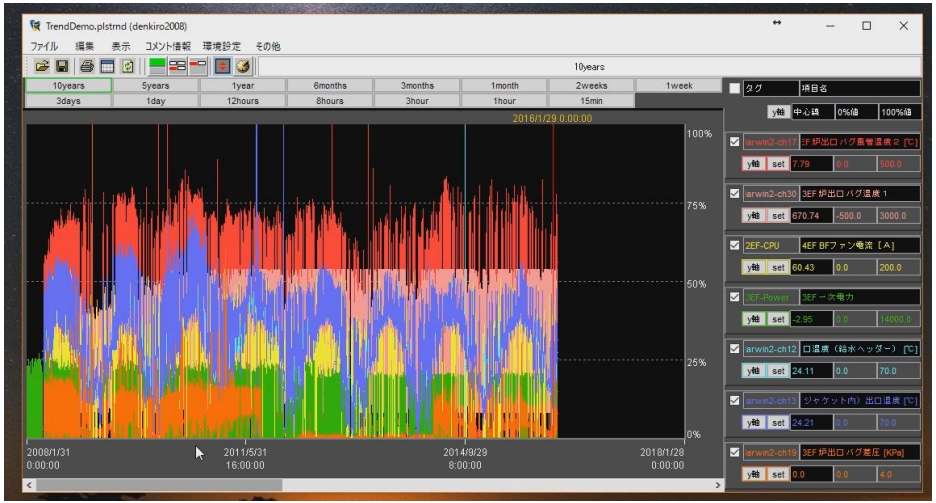
1) The energy conservation center Japan, Ceramic fiber and how to design insulating structure, 2007, 45p.

High speed trend data processing technique

The comparison of graph displaying speed between Excel and PLEASURE on laptop PC

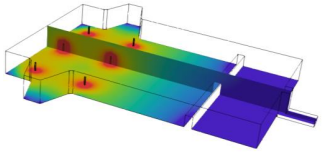
	Row number of data	Graph display time (sec)
Excel	1,050,000	13
	40 times larger	43 times faster
PLEASURE	31,500,000	0.3

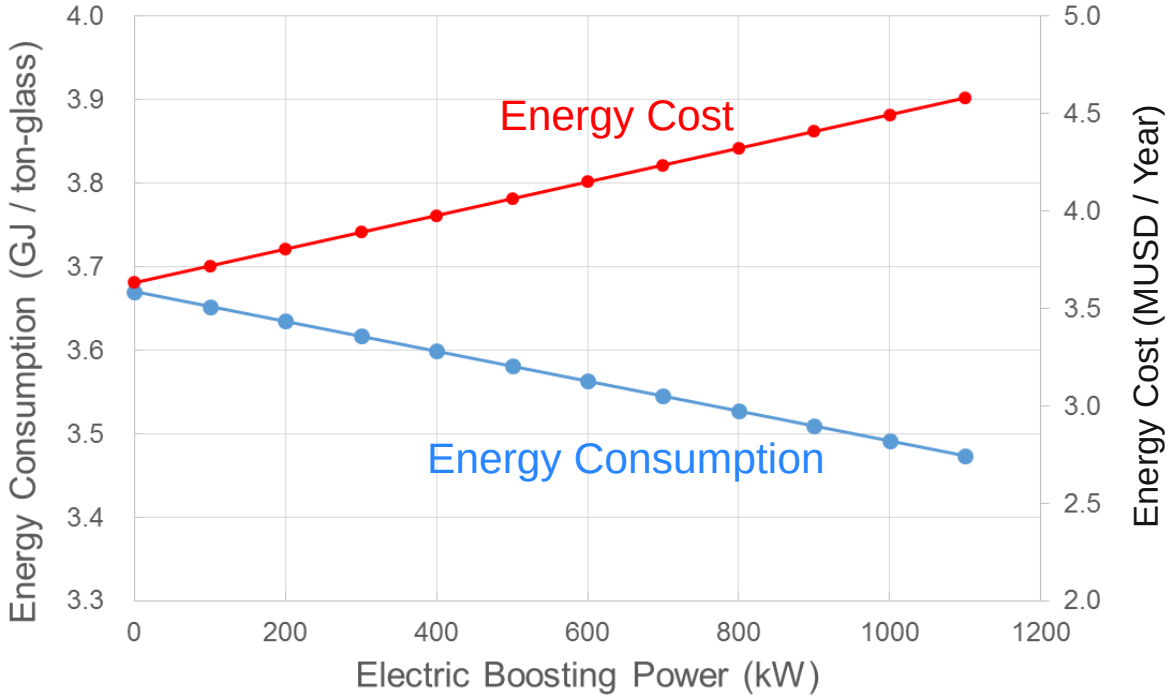
Every 10 sec sampling through 10 years



High speed data processing technique was developed around 2000y.
It becomes easier to understand the data in any time, any scale immediately.

Electric booster





*250 t/day, 50% Cullet
**1 USD = 112 JPY

Problems of Fiber Added Insulating Materials

■ Carcinogenic classification

	Carcinogenic to human	Probable human Carcinogen	Possible human Carcinogen	Not classifiable
WHO	1	2A	2B	3 or 4
	Asbestos Crystalline Silica	Ultraviolet irradiation Benzo[a]pyrene	**RCF** MF	GF, RW, SW ,GW Others
EU	1	2	3	0
	Asbestos	**RCF**, MF	RW, SW, GW	GF
Germany	Ⅲ 1	Ⅲ 2		Ⅲ 3 B
	Asbestos	**RCF**, Aluminium RW, GW		SW, others
USA	A	B2	C	D or E
	Asbestos	**RCF**		

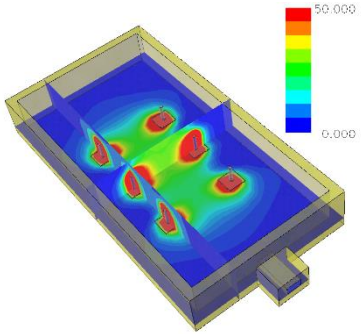
【Mark】

RCF : Refractory Ceramics Fiber
GF : Glass long Fiber
GW : Glass Wool
MF : Micro glass Fiber
RW : Rock Wool

In Japan, limitations on using RCF has been announced.

Ref. Refractory Ceramics Fiber Association (JAPAN) WEB Site
http://www.jhiwa.jp/index.html

Comparison of CO_2 Generation



$$C_xH_y + (x+y/2)\ O_2 \rightarrow x\ CO_2 + y/2\ H_2O$$

In Japan (Using the emission factor of Japan):

CO_2 Generation by city gas combustion:

0.050 t-CO_2/GJ / 40% = **0.12** t-CO_2/GJ

* Efficiency

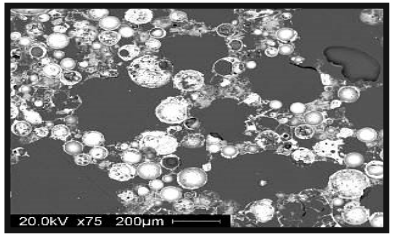
CO_2 Generation by fuel oil C combustion:

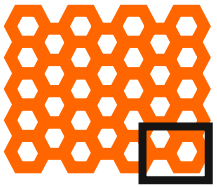
0.072 t-CO_2/GJ / 40% = **0.18** t-CO_2/GJ

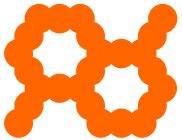
CO_2 generation by power generation: 0.000518 t-CO_2/kWh

0.144 t-CO_2/GJ / 85% = **0.17** t-CO_2/GJ

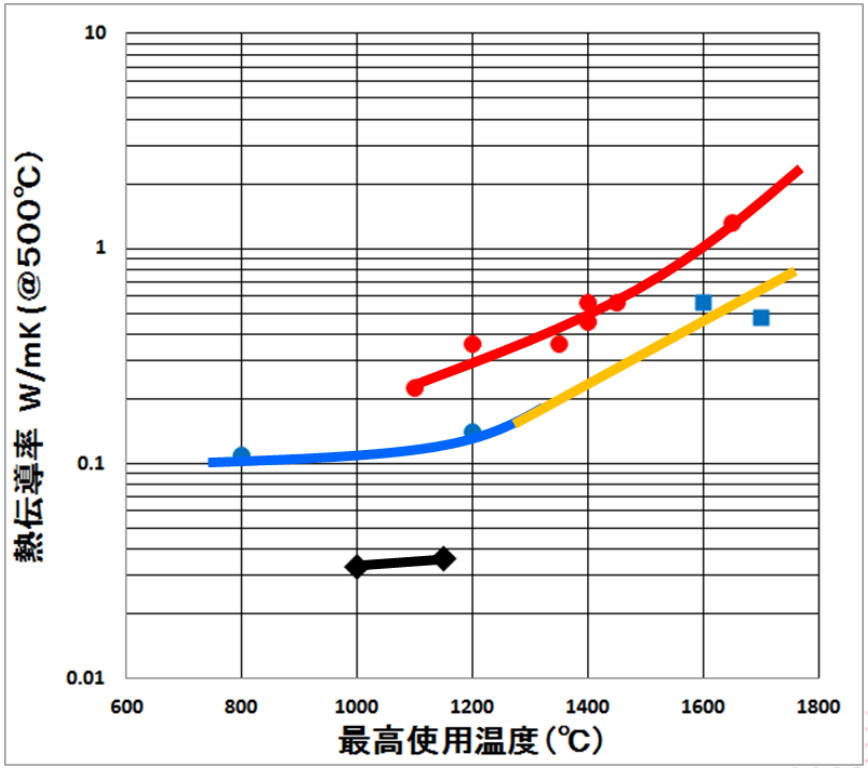
Monolithic Insulation Material with RCF Free







High Thermal Insulating Ceramic Materials
THERMOTECTWALL®



Conclusions

- 「Low energy consumption」「Long life」「High quality glass」are important topics for glass manufactures.
- Refractory and Engineering technologies must contribute to realize well-balanced design for their needs.
- Moreover, it is important to find unusual state at early stage during operation over 10 years in order to realize stable and long life furnace.

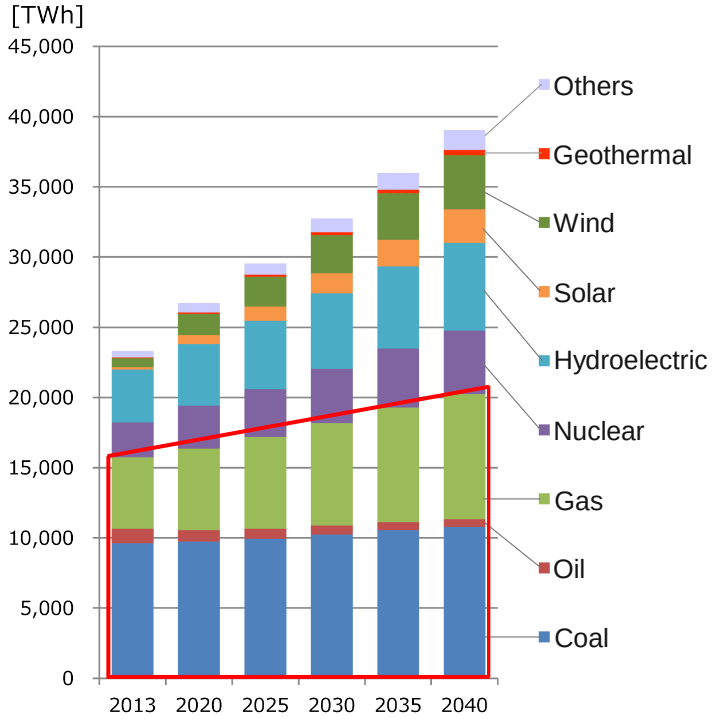
Maintain insulation performance in actual furnace

材料と水を混練

型に流し込む

硬化させ脱型

Outlook of global energy demand

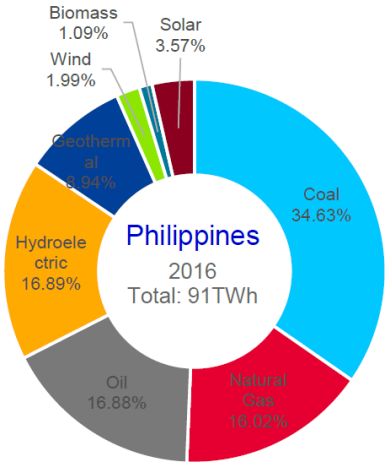


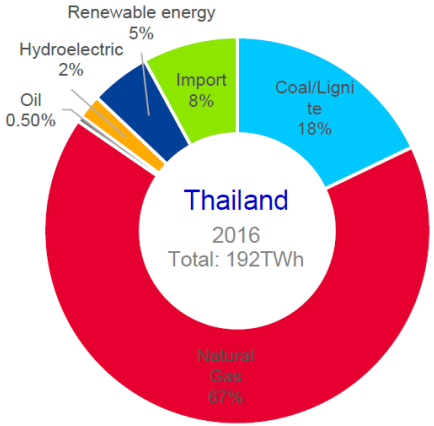
- Energy demand is expected to increase in the future.
- Reduction of energy consumption and CO_2 emission is important topics for all manufactures.

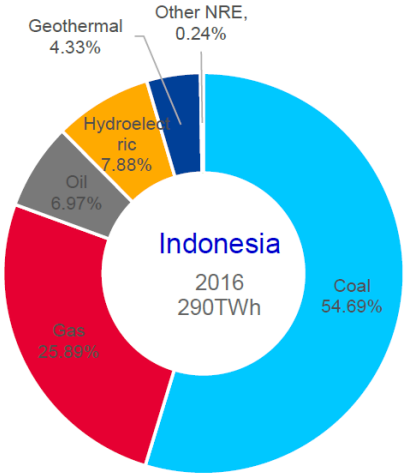
Approach

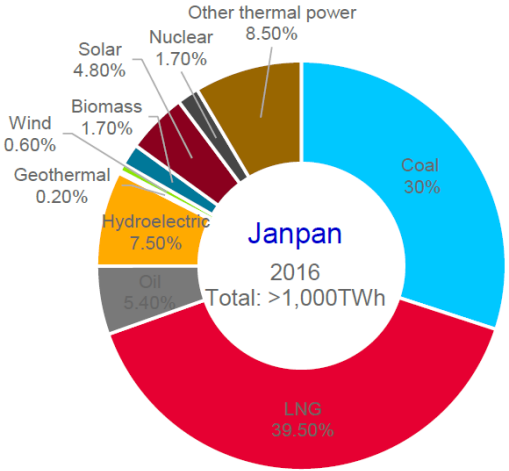
Perspective of electricity demand of the world:

Power generation





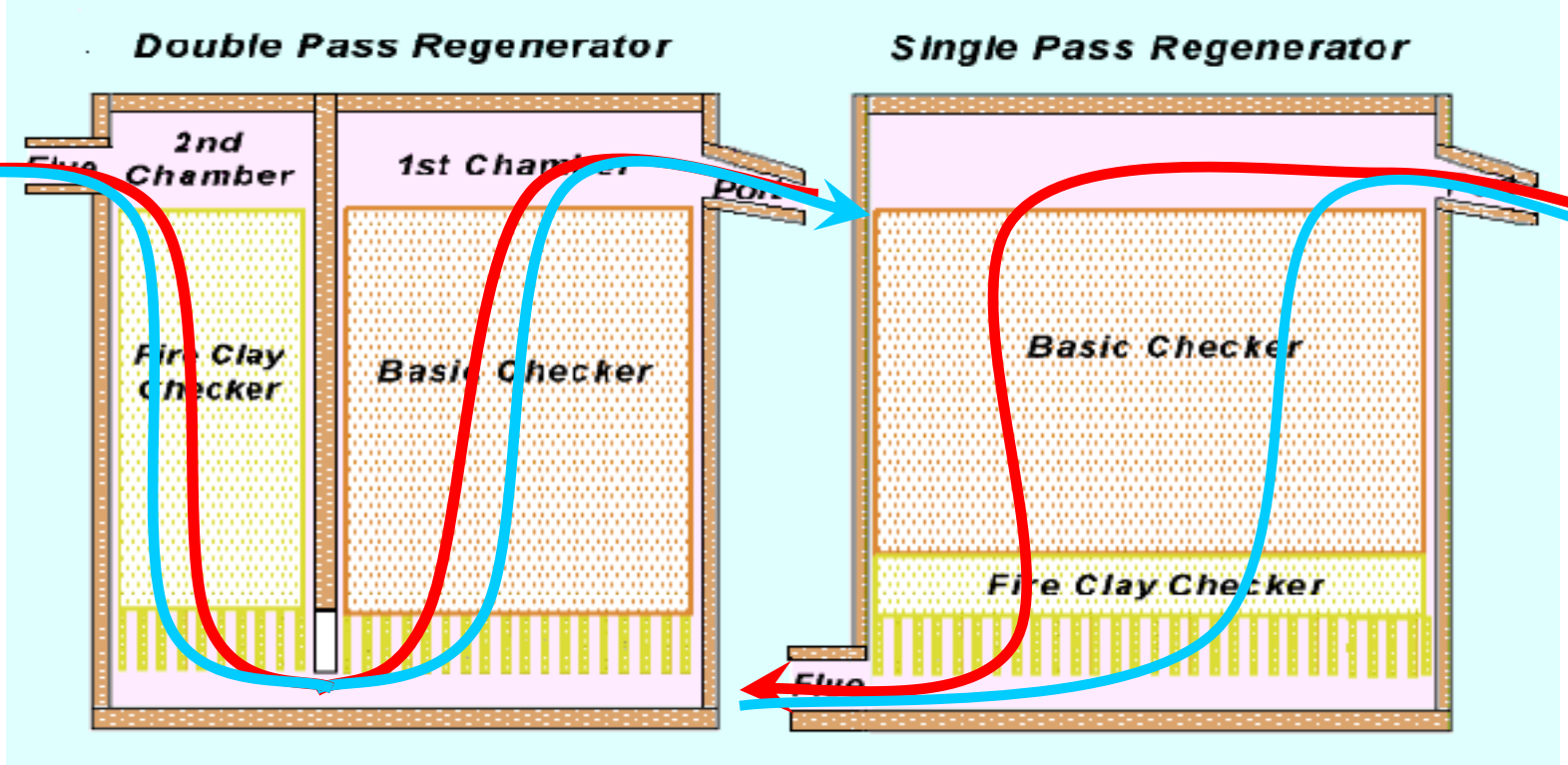




Institute for Sustainable Energy Policies
https://drive.google.com/file/d/0B72dHL3q3jybU2JscXJsQi10elk/view

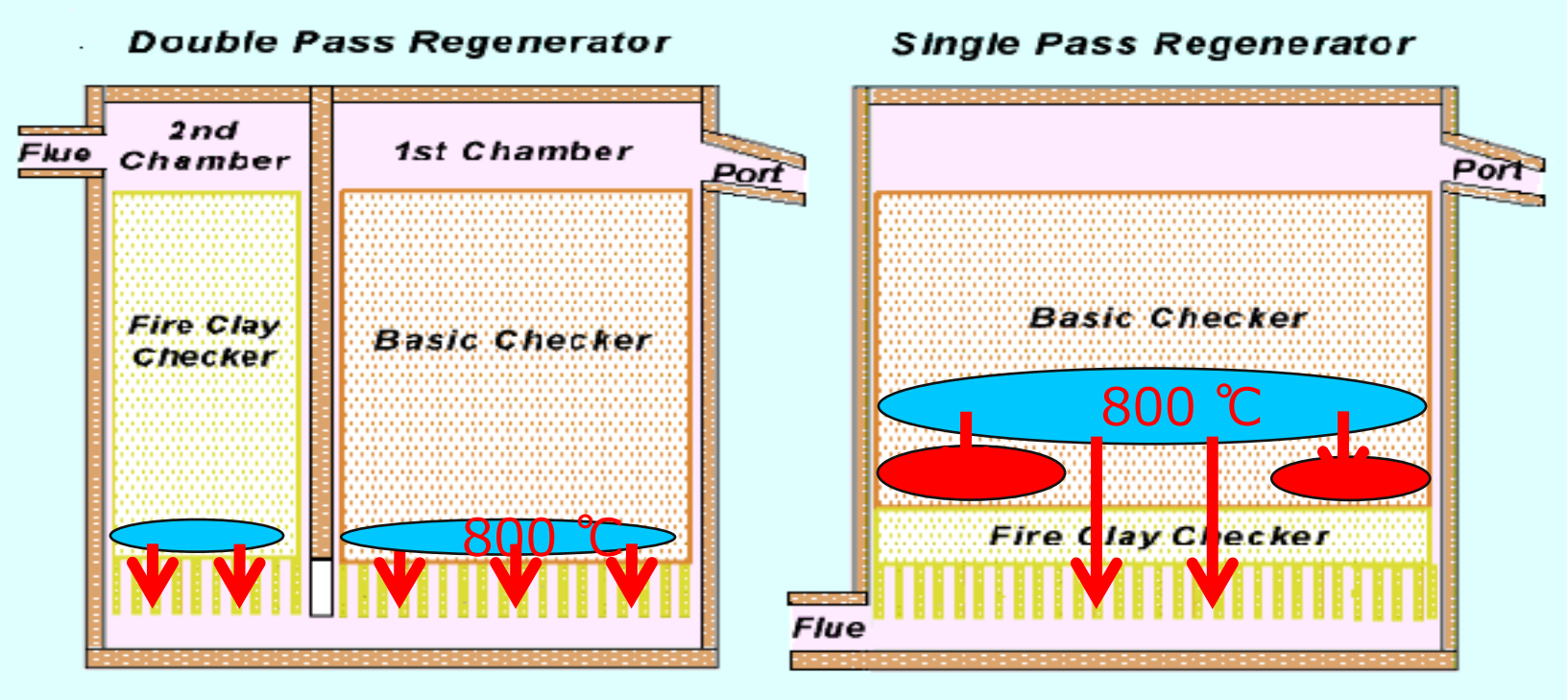
Hyper Regenerator System

Prevention of unbalanced air-flow & gas-flow



Hyper Regenerator System

Prevention of checker clogging



1. はじめに

生体溶解性繊維とは、生体内での溶解性を付与した新しい人造非晶質繊維(Man Made Vitreous Fiber；MMVF)の総称であり、1990年頃EU(European Union)で開発され、海外ではBio-Soluble Fiberと呼ばれている。日本で発売される際に日本語に翻訳されたものであり、最近その利用が広がるに従い、日本でも認知されている。世界で販売されている主要な生体溶解性繊維の構造は、シリカをネットワークとするSiO_2-CaO-MgO系の無機質のガラス(無機高分子)であり、その組成から、別名AES Fiber(Alkaline Earth Silicate Fiber)とも呼ばれている。本稿では、セラミックファイバー[1](アルミナ·シリカ系耐火断熱繊維)代替品として開発された「生体溶解性繊維(商品名 スーパーウール；SUPERWOOL「SW」)」[2),3)]について紹介する。

2. 人造非晶質繊維(アスベスト代替製品)のヒトへの影響(発がん性)について

人造非晶質繊維とは、その名の通り人工的に生産された非晶質の無機繊維であり、天然の結晶質の鉱物であるアスベストとは区別されている。住宅の断熱材として使用されるグラスウール、プラントの断熱材として使用されるロックウール及び高温度領域(1000℃以上)の断熱材として使用されるセラミックファイバーが代表的な製品であり、形状及び組成がアスベストに良く似ていることから、アスベスト代替製品として古くから使われてきたが、2005年6月のアスベスト疾患による工場作業者や周辺住民の死亡報道以来、産業分野での利用が急激に増えている。しかし、人造非晶質繊維のヒトへの影響については、安全性が確認されたとは言えない[4)]。2006年にこれまでアスベスト代替製品として幅広く使用されていたセラミックファイバーが、写真週刊誌に「第二のアスベスト」として取り上げられたこともあり、アスベスト代替製品のヒトへの影響が問題化