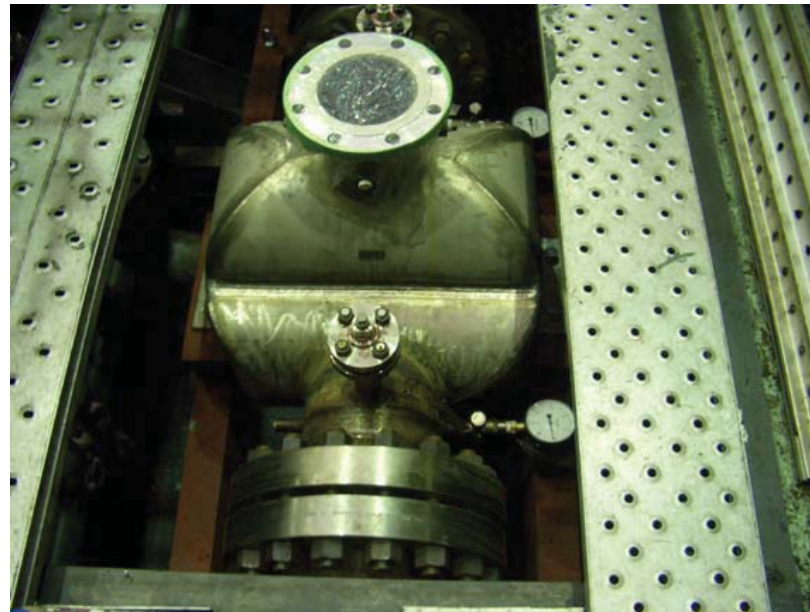


Modeling of Kobe's High Performance heat exchangers and Microchannel reactors



KOBE STEEL, LTD

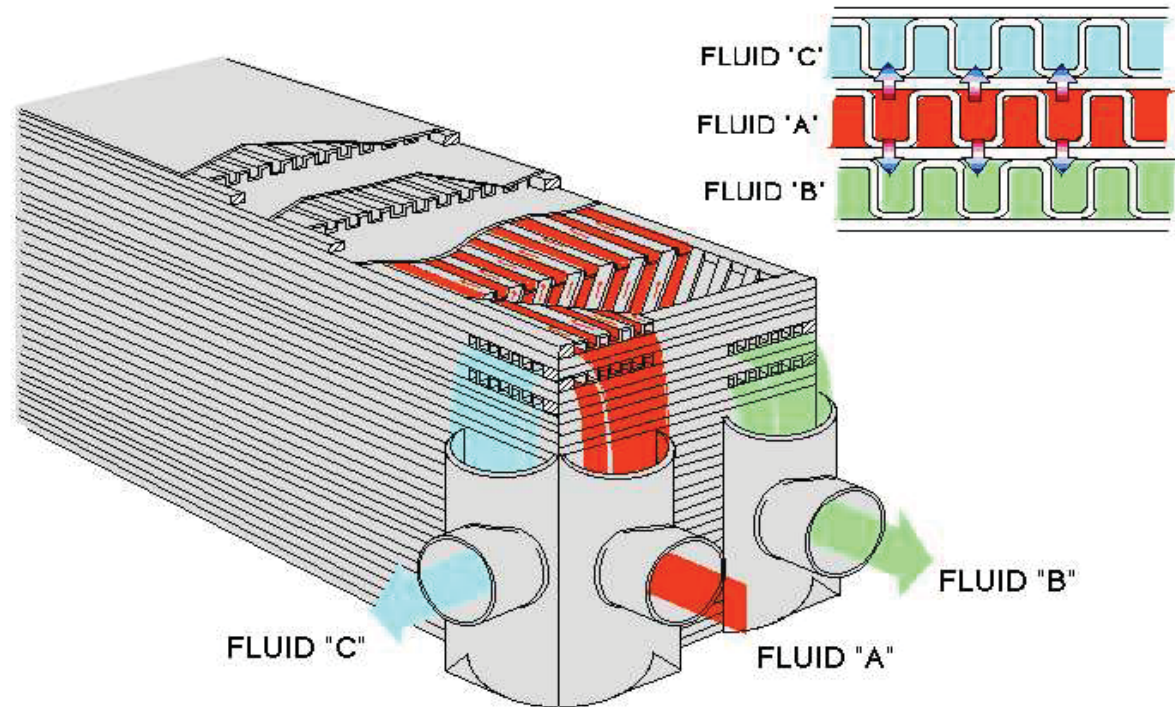
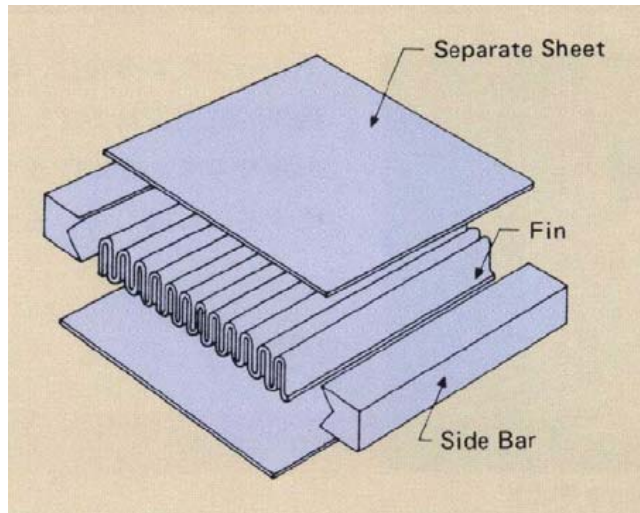
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(ALEX: Brazed Aluminum Plate fin Heat Exchanger)
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(SMCR: Stacked Multi-Channel Reactor)

Kobe Steel, Ltd Background to technology



Over 50 years experience as major manufacturer of compact heat exchanger (ALEX=Brazed Aluminum Plate-fin type).

Extensive range of technologies to design and fabricate heat exchangers of this type.

Has now developed the micro or milli channel heat exchanger (like PCHE (Printed Circuit Heat Exchanger) and MCR (Microchannel Reactor) based on this technology.

Printed Circuit Heat Exchanger (PCHE)

Micro channel Heat Exchanger (PCHE: Printed Circuit Heat Exchanger)

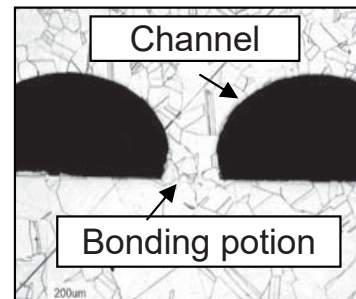
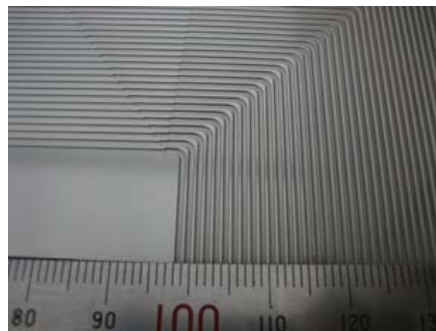
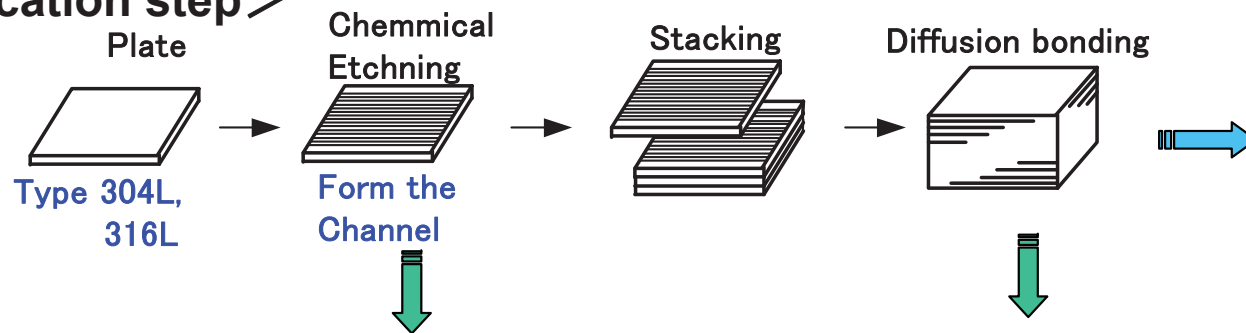
<Application>

- a) Gas cooler for offshore use
- b) Special use for high pressure, high temperature or large temperature difference

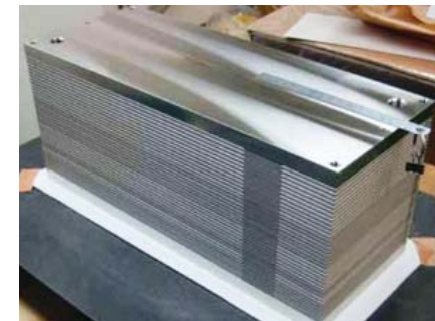
<Features>

- a) can withstand high pressure (up to 100MPaG)
- b) High thermal performance (approximately 1/10th of Shell & Tube type)

<Fabrication step>



Cross sectional view of diffusion bonding



Outside view of core block
with header
& nozzle



Note: KSL can fabricate this equipment based on ASME code with stamp, PED and ship classification.

Design and rating software for heat exchanger

<Design Software>

KSL's own software and technique

<Rating software(Aspen PlateFin)>:

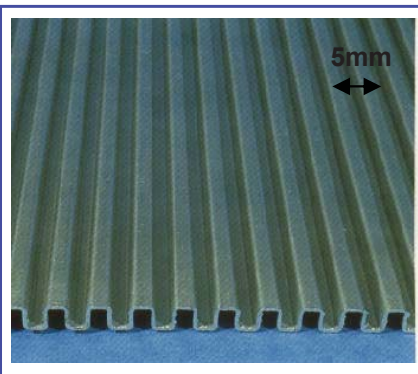
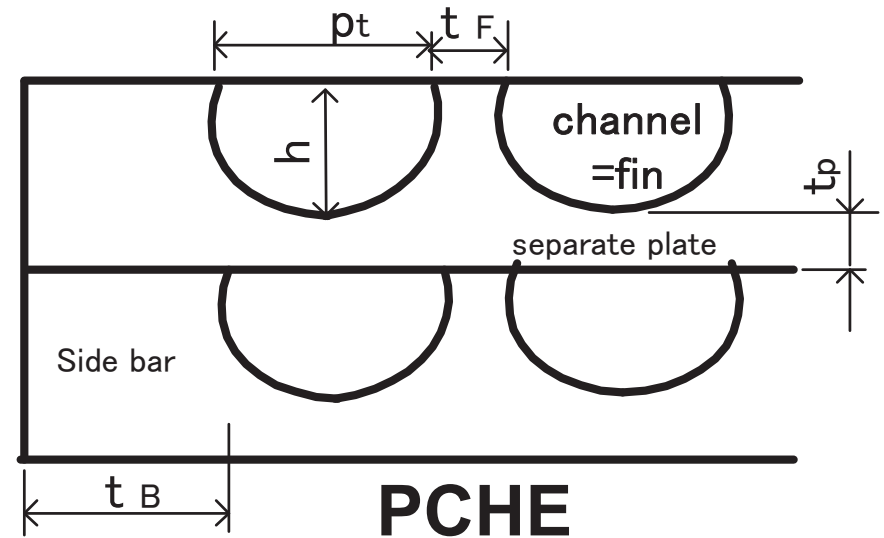
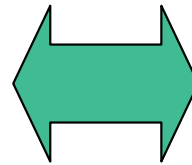
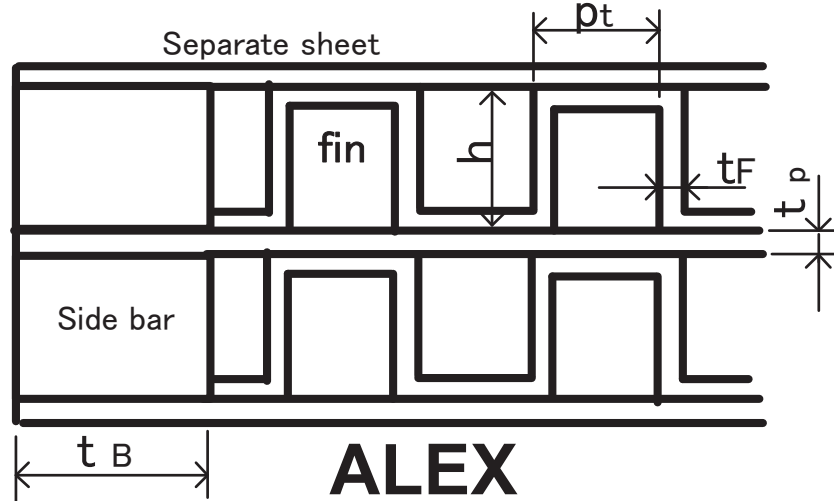
- Stream by stream simulation and thermosyphon
- Detailed layer by layer simulation
(including stacking arrangement)
- Crossflow exchanger simulation (single or multi-pass)

Note- Fin performance or channel data were measured by KSL.
and the data are linked to Aspen PlateFin.

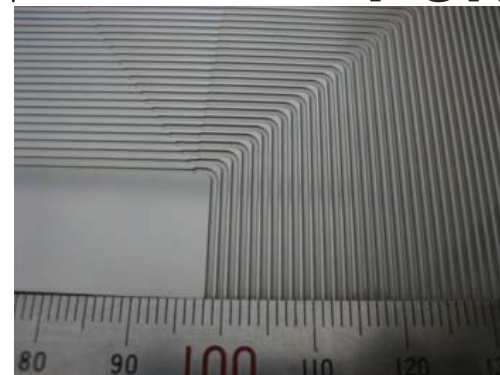
Comparison between ALEX and PCHE for PlateFin

All design parameters for ALEX and PCHE are basically the same.

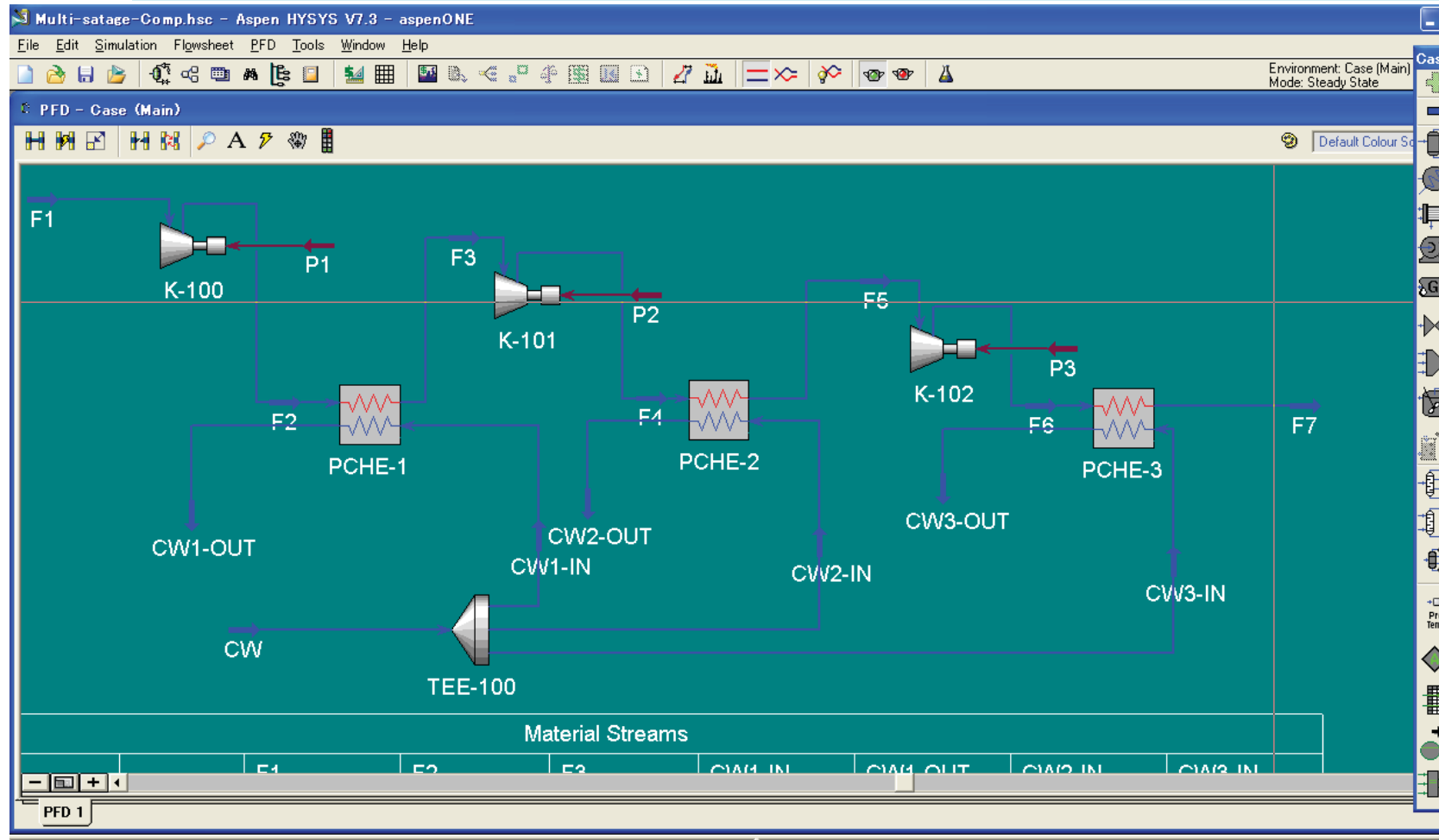
Hence heat transfer and pressure drop performance will be calculated using the same design tool as for ALEX.



Fin = Channel,
pt: pitch of fin
h: height of fin,
tF: thickness of fin
tB: thickness of side bar



Link between Aspen Hysys and PlateFin

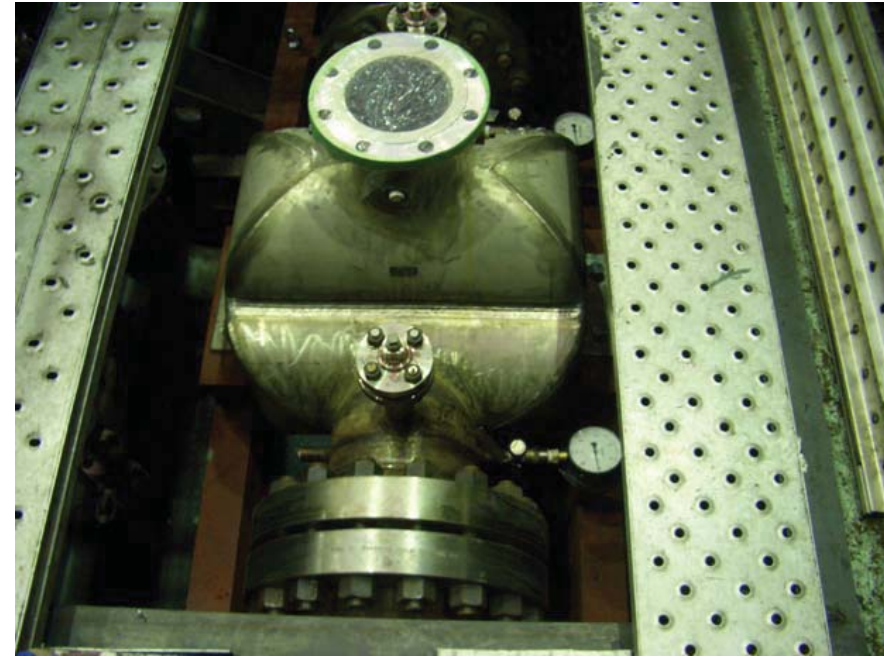
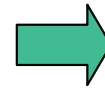


Operation condition for Multi-Stage Compressor is simulated by HYSYS. The some operation condition are checked by the link between HYSYS and Aspen PlateFin.

Performance check of PCHE (After cooler for Compressor)



Shell&Tube
Φ 650 × 4200TL-TL (5500kg)



PCHE
330X350X650 (700kg)

Design Pressure: 8MPaG (Hydrostatic test: 12MPaG)

Code: Japanese High Pressure Gas Safety Law (with stamp)

KSL tests confirm the mechanical and thermal performance of this PCHE to be superior to S&T.

***Performance calculation & Rating : KSL's own software and technique
(PCHE:S&T) Volume: 1:10, Weight: 1:8**

**Microchannel reactor
(Stacked Multi-channel reactor)**

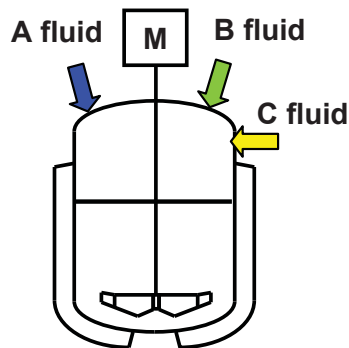
Microchannel Reactor

(**SMCR**: **S**tacked **M**ulti-**C**hannel **R**eactor)

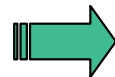
SMCR is the stacked multi-channel reactor for the large capacity use, it is very easy to built the numbering-up (multi-channel of one unit) by using the channel arrangement of third dimension .

→ Improve batch operation to continuous operation for large capacity

Mixer type (batch operation)

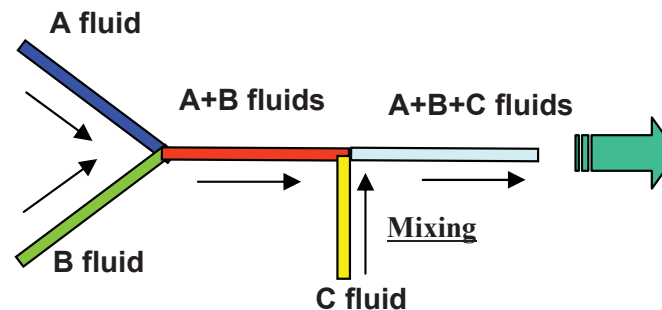


Continuous



<2 dimensional>

Y shape tube (Existing MCR)



<3 dimensional>

Plate type (SMCR)

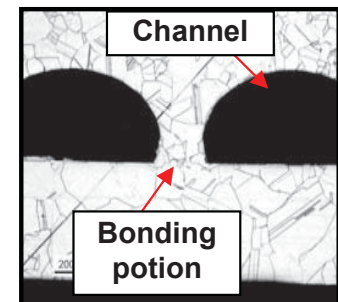
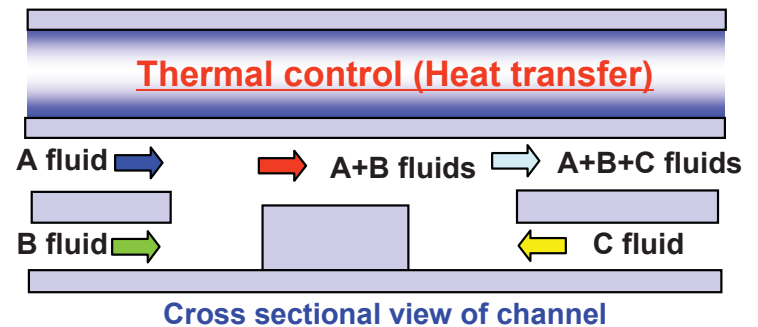


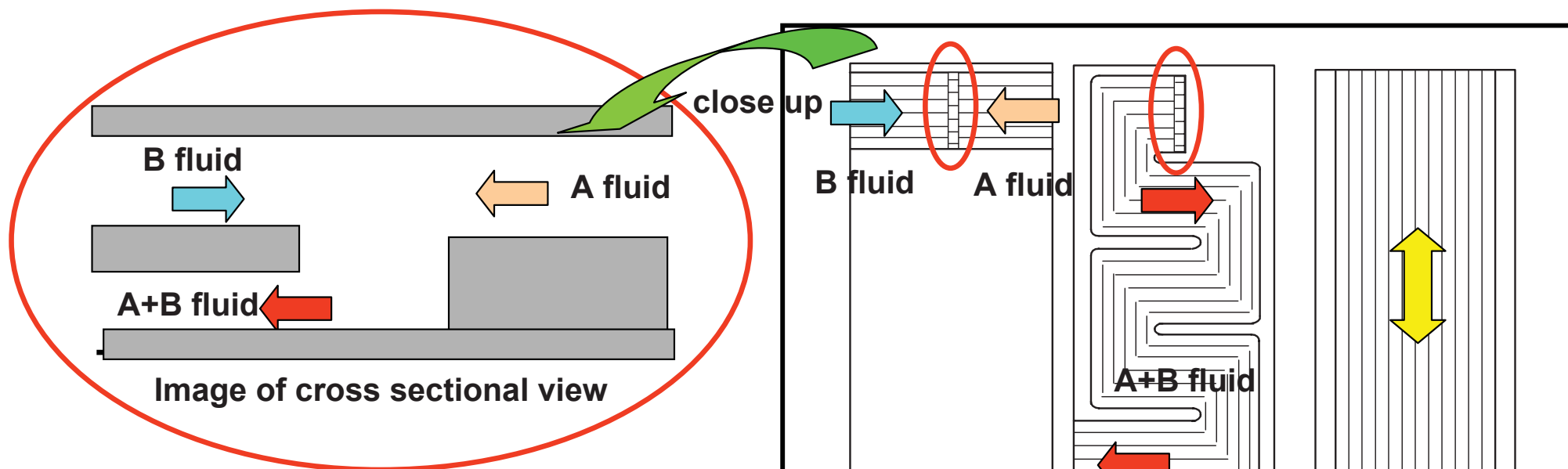
Photo of bonding area

<Application>

- a) Extraction
- b) Polymerization (Highly exothermic reaction)
- c) Reaction (liquid & liquid, liquid & gas and others)

⇒ It will be very important to estimate thermal performance of each reaction.

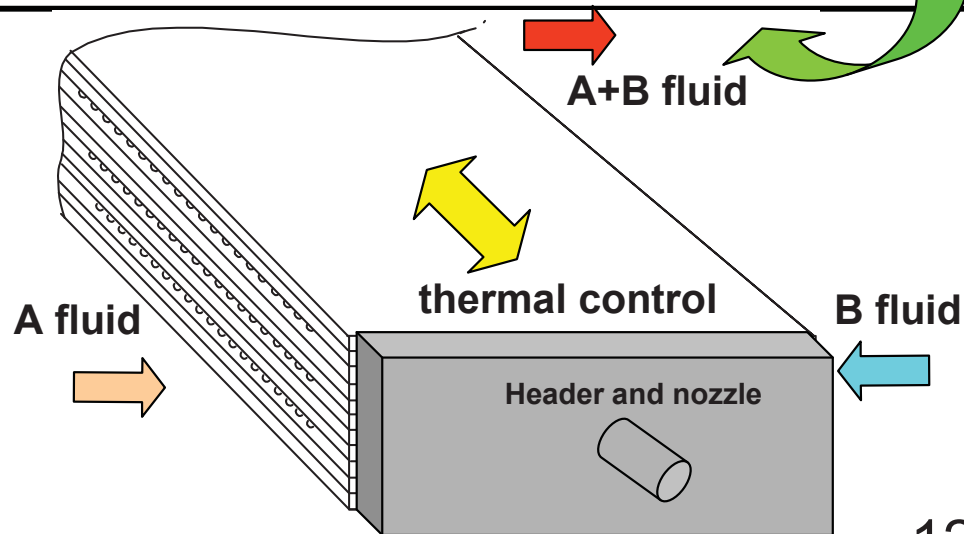
Conceptual design - Large capacity Microchannel Reactor



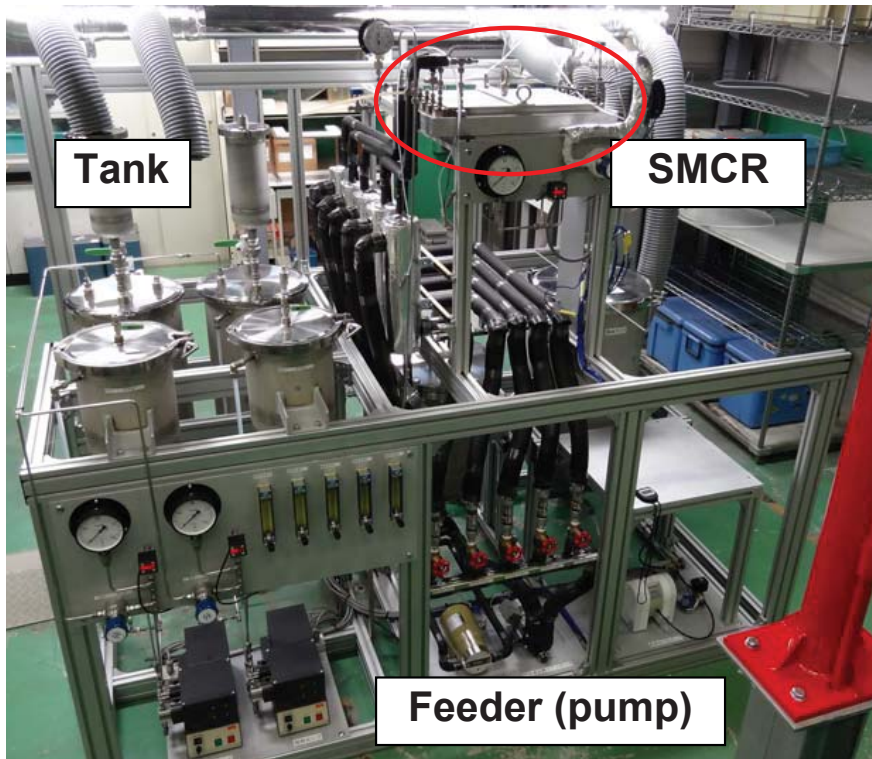
Stacked plate (b+a+b+a+b: plate and thermal control) will be bonded to one block.

Chanel number
 = channel / plate × stacked number

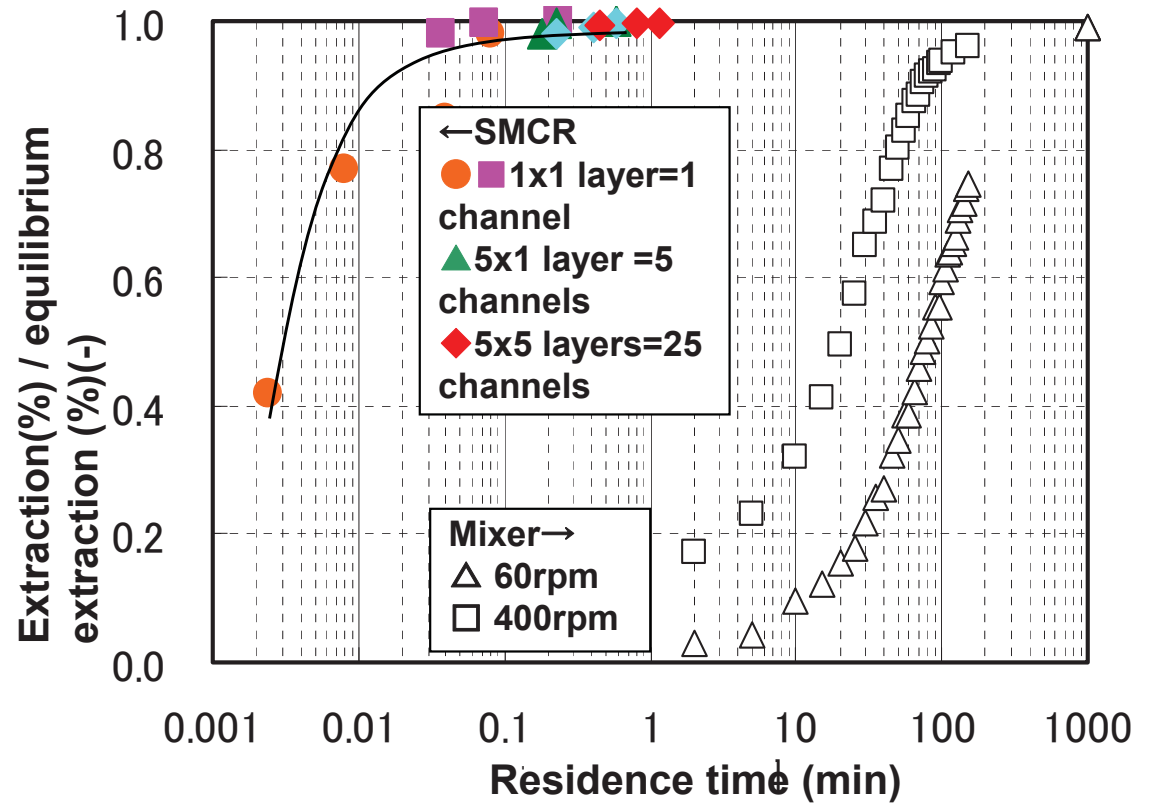
(Feature)
 Each stream has uniform pressure drop,
 so maldistribution is minimized.
 Due to this, a large capacity Micro channel
 reactor can be designed and fabricated.



Testing results for extraction use of SMCR



Testing device



Test results (extraction from phenol 0.1wt%/dodecane to water)

- a) No deterioration of extraction ratio by using SMCR
- b) Residence time of SMCR can reduce 1/100 of Mixer type

⇒ KSL will use HYSYS and Aspen PlateFin to simulate the thermal performance and mass-transfer of SMCR by same concept of PCHE.

Conclusion

- Based on BAHX technologies, Kobe steel is now developing Microchannel heat exchangers and reactors for some applications such as cooler for compressor, extraction and reaction use.
- The heat transfer is most important issue for design of these equipment.
- The channel shape information of PCHE can be changed to the fin shape by using same hydraulic diameter and free flow area.
- Kobe steel presented the design method for the Microchannel equipment by using PlateFin.
- The process data such as some stage compressor or extraction process from HYSYS are linked to Aspen PlateFin.
- We reported the design result by PlateFin and the operation test results of this compressor cooler.
- And also, we introduced Large capacity Microchannel reactor and the importance of HYSYS and Aspen PlateFin to simulate the thermal and mass-transfer performance.