Characteristics of Amorphous metal and Energy Efficient Amorphous metal Distribution Transformer

Hitachi Metals, Ltd.
Soft Magnetic Materials and Components Business Unit
http://hitachi-metals.co.jp

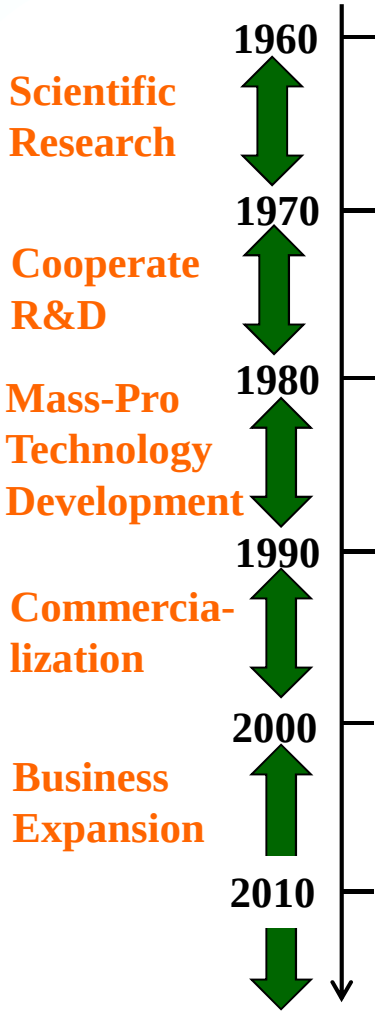
Outline

1. Introduction of Amorphous metal, Core and Transformer
2. Energy Loss and Efficiency in Transformer
3. World Wide Situation of AMDT
4. Recycle of Amorphous Core
5. Conclusions

*AMDT: (AMorphous metal Distribution Transformer)

1. Introduction of Amorphous metal , Core and Transformer

History of Amorphous metal



1960 — **Discovery of amorphous metal** (Au-Si alloy):
Klement, Willens & Duwez., Nature 187, 869 (1960)

Discovery of the stable ferromagnetic $Fe_{80}P_{13}C_7$ **amorphous metal:**
Duwez & Lin., J. Appl. Phys. 38, 2267 (1965) (1967)

1970 — Developed amorphous metal, **METGLAS® by Allied Signal** (1973)

Developed **amorphous metal for distribution transformer by Allied Signal** (1976)

1980 — **1st amorphous distribution transformer** (USA) (1982)

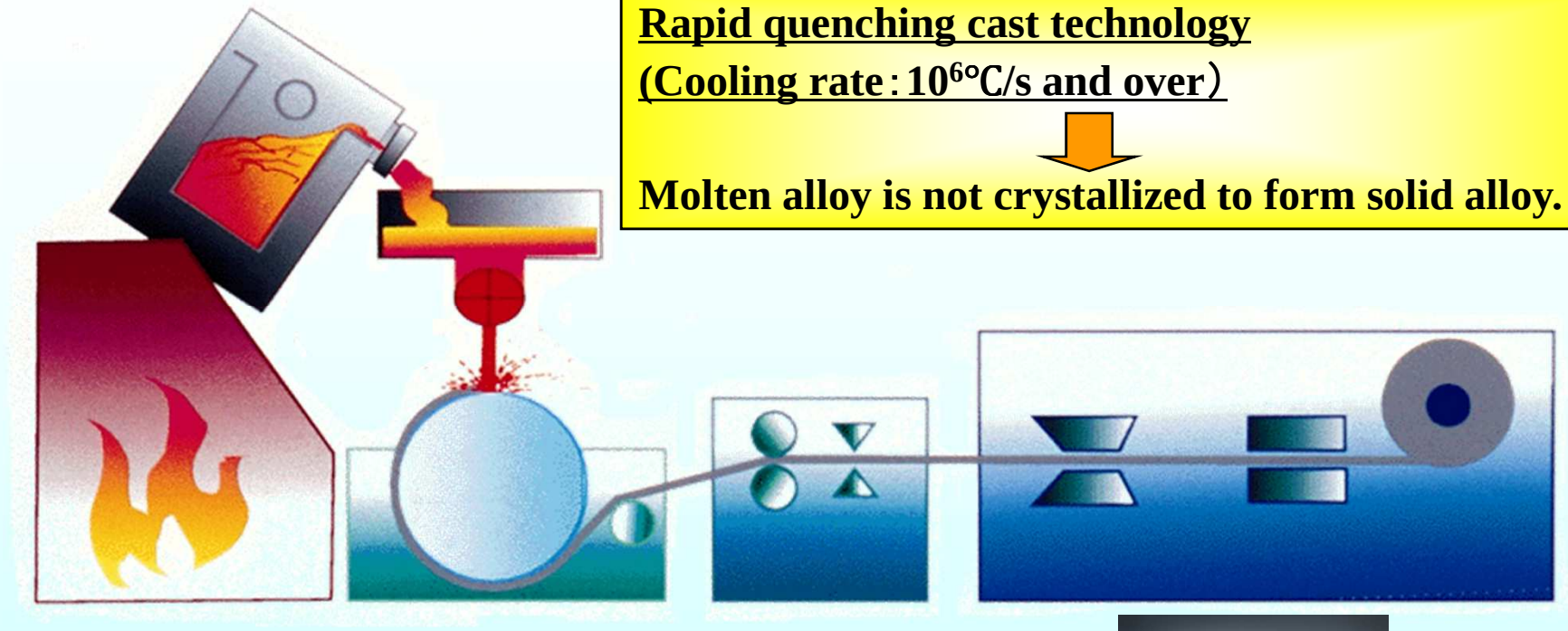
Mass production of amorphous metal **(Metglas® 2605SA1)** in Conway, SC, USA (1989)

1990 — Started to produce **amorphous pole transformer in Japan** (1991)

2000 — Acquisition of amorphous metal business unit by **Hitachi Metals** from Honeywell (2003)

2010 — Developed high permeability grade of amorphous metal (**Metglas®2605HB1M**) (2011)

Amorphous metal Casting Process



Rapid quenching cast technology
(Cooling rate：10^6℃/s and over）

Molten alloy is not crystallized to form solid alloy.

Metglas® 2605SA1 & 2605HB1M

Chemical composition: Fe, Si, B

Nominal thickness： 25 μm

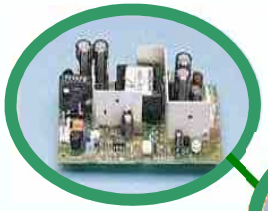
Standard width： 142 mm, 170 mm, 213 mm

Materials Mag!c

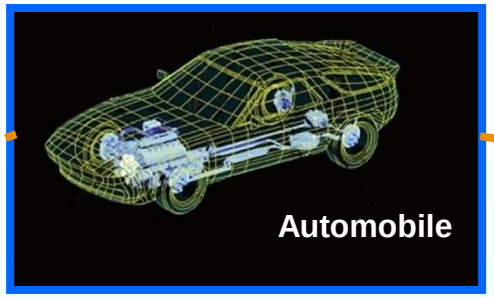
Uses of Amorphous Metal Alloys

Metglas®

Switched-mode Power Supply



Choke Coil



Powerlite® C-Core
(Cut Core)

High Efficiency Inverter
(Wind or Solar Generator)

Fe-based

Fe-based or
Co-based

Current Sensor

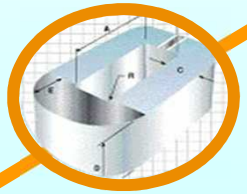
Wound Core

Fe-based

Axial Gap
Motor Stators
(Future)

Ni-based

Ni-based or Co-based



Wound Core

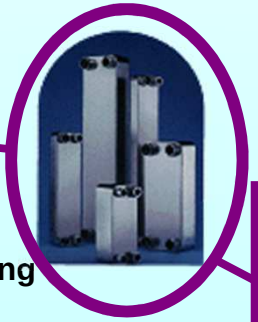
Distribution Transformer

Ribbon

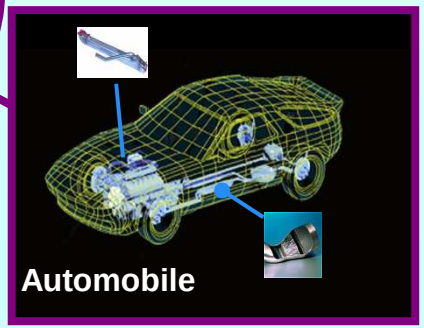
Marker for Electronic Article
Surveillance

Ribbon

Metal Joining

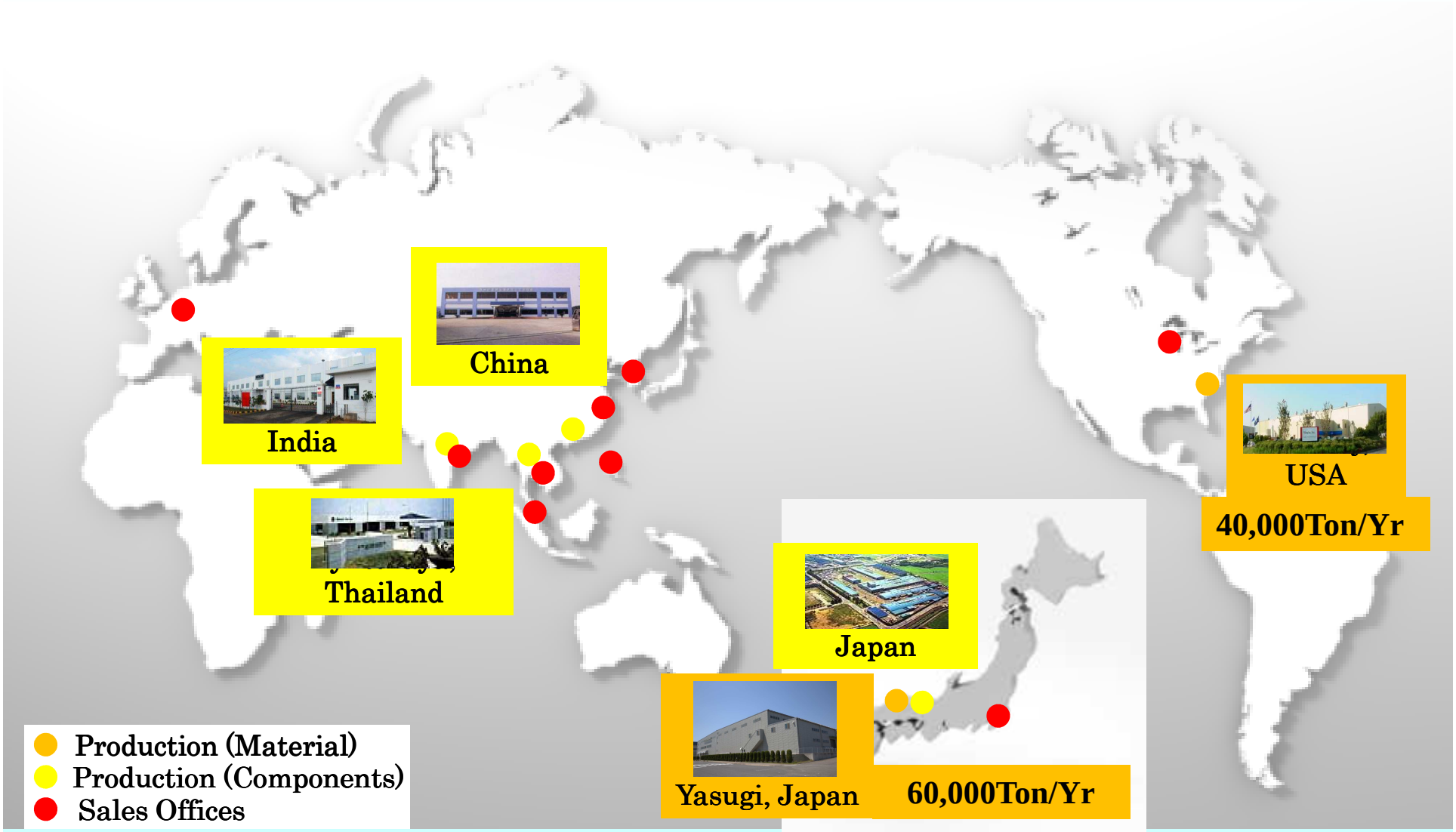


Brazing Foil



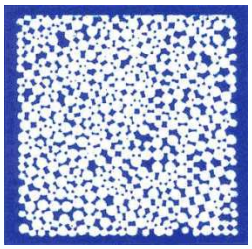
Transformer Segment is Highest Volume

Geographical Locations of our Business Unit

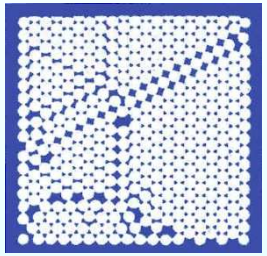


Features of Amorphous metal

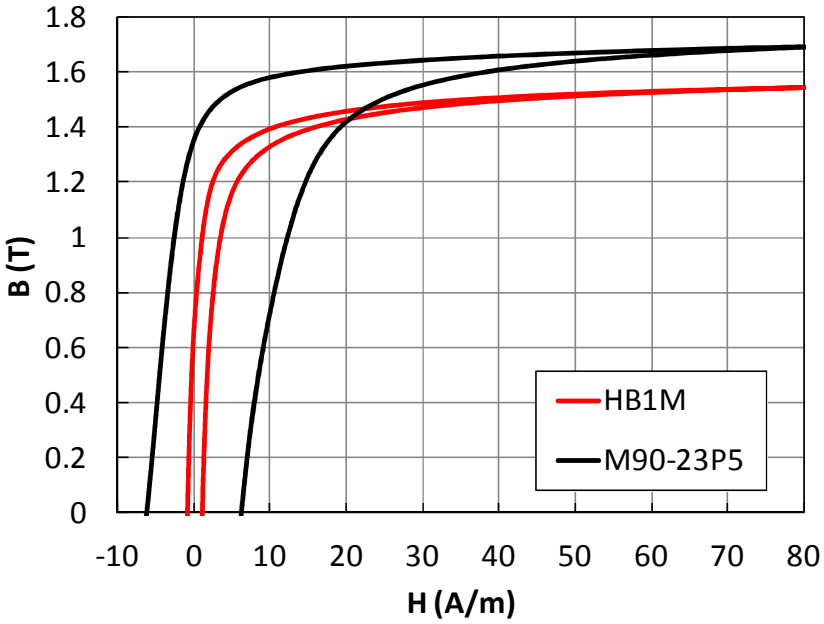
Amorphous metal



Crystalline metal (CRGO)



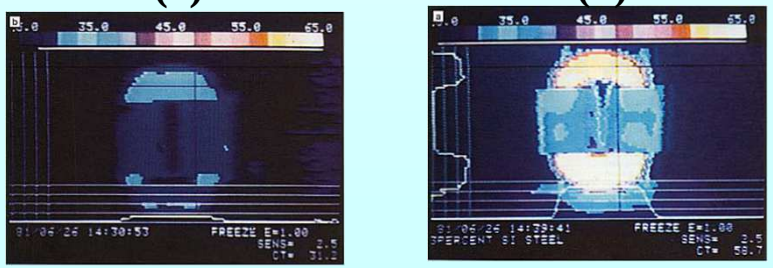
- **Random Atomic structure**
  - **•Lack of crystalline anisotropy**
    - **⇒ Lower hysteresis loss**
  - **•Higher resistivity**
    - **⇒Lower eddy current loss**
- **Small thickness (0.025 mm)**
  - **⇒Lower eddy current loss**



1/3 of core loss compared to CRGO

Less heat from core

(a) **(b)**

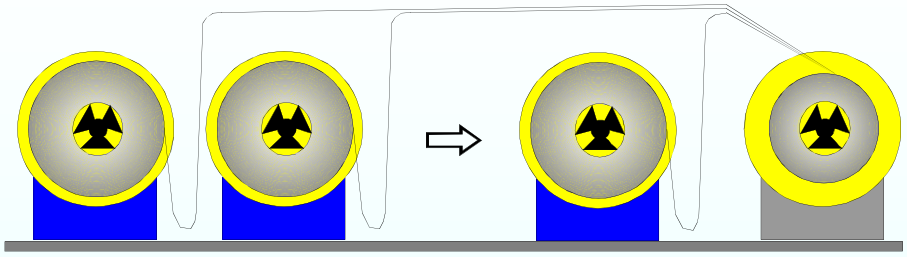


Infrared Photographs of (a) Metglas® Amorphous metal& (b) Grain Oriented Steel Distribution Transformer Core

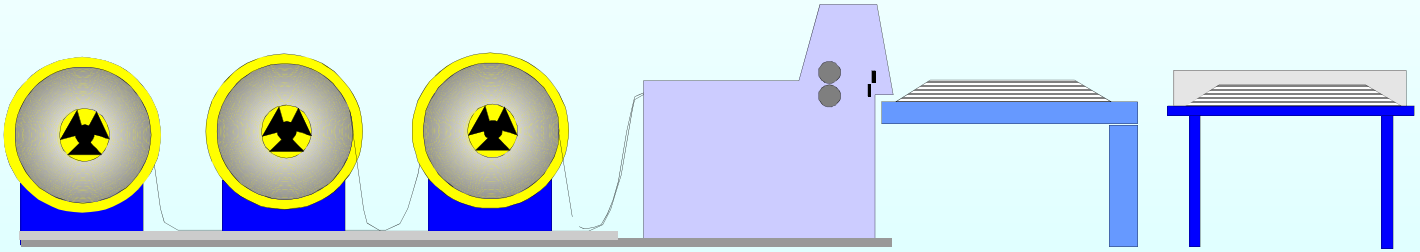
*CRGO: Cold Rolled Grain Oriented Electrical Steel

Amorphous metal Transformer

Core Manufacturing

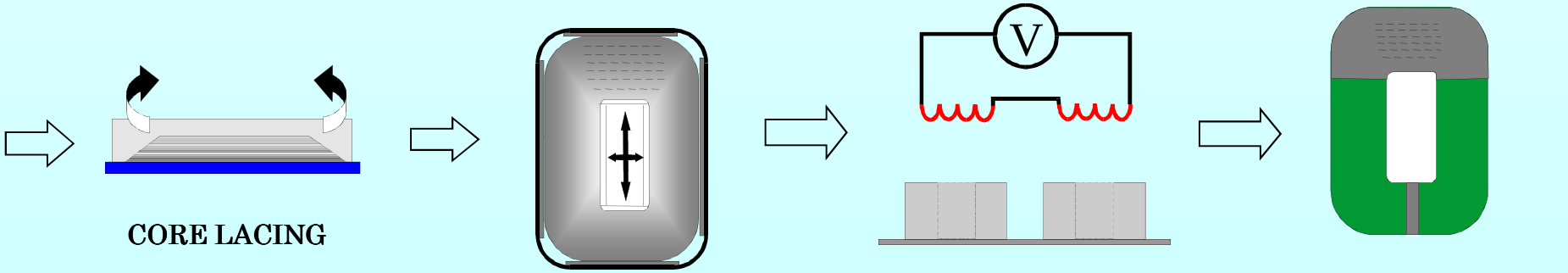


PRESPOOLING



CUTTING

STACKING



CORE LACING

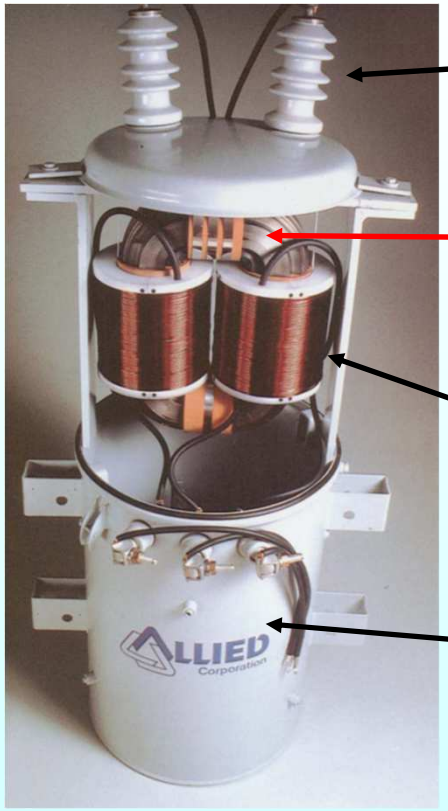
CORE FORMING

ANNEALING

EDGE FINISHING

2. Energy Loss and Efficiency in Transformer

Amorphous metal Distribution Transformer (AMDT)



Example: Oil-Immersed Single Phase DT

Bushing

Core

Winding

Oil Tank

◎ Difference of parts in DT between AMDT and CRGO-DT is just a core.

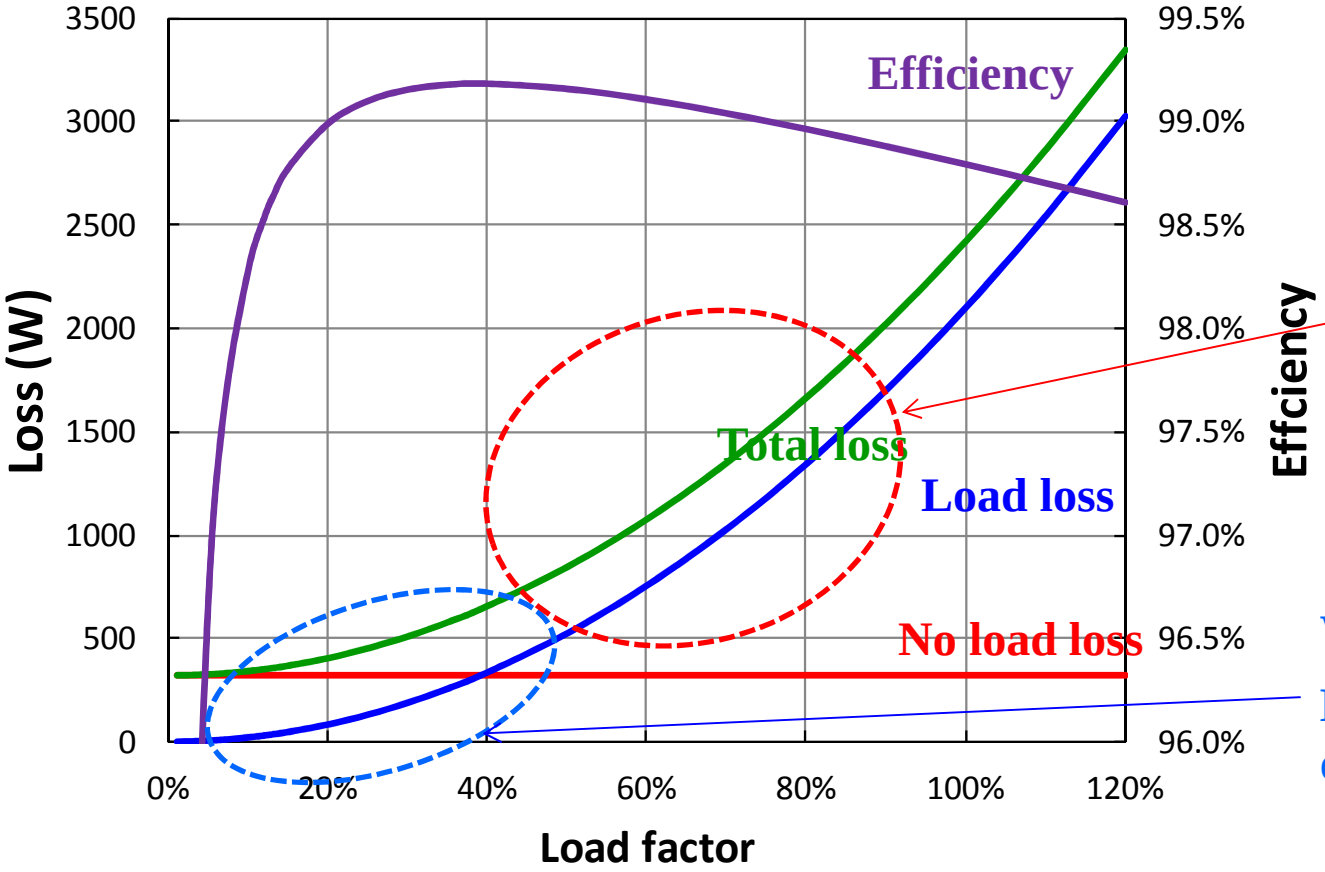
◎ You can produce AMDT using traditional technique.

◎ Many people are worried that AM-core is very difficult to handle. But handling of AMC becomes easy after they have some experience.

◎ Hundreds of AMDT makers have mastered its production.

Energy Loss in Transformer

Loss	Site	Major reason	Feature
No load loss	Core	Hysteresis loss & Eddy current loss	Constant at all times
Load loss	Coil	Electric resistance	Increase as square of load factor



When LF is high :
Load Loss (LL) is dominant in total loss

When LF is low :
No Load Loss (NLL) is dominant in total loss

Example of loss and efficiency vs. load factor*

*Load factor=(Output)/(Rated capacity)

Load factor in Distribution Transformers (DTs)

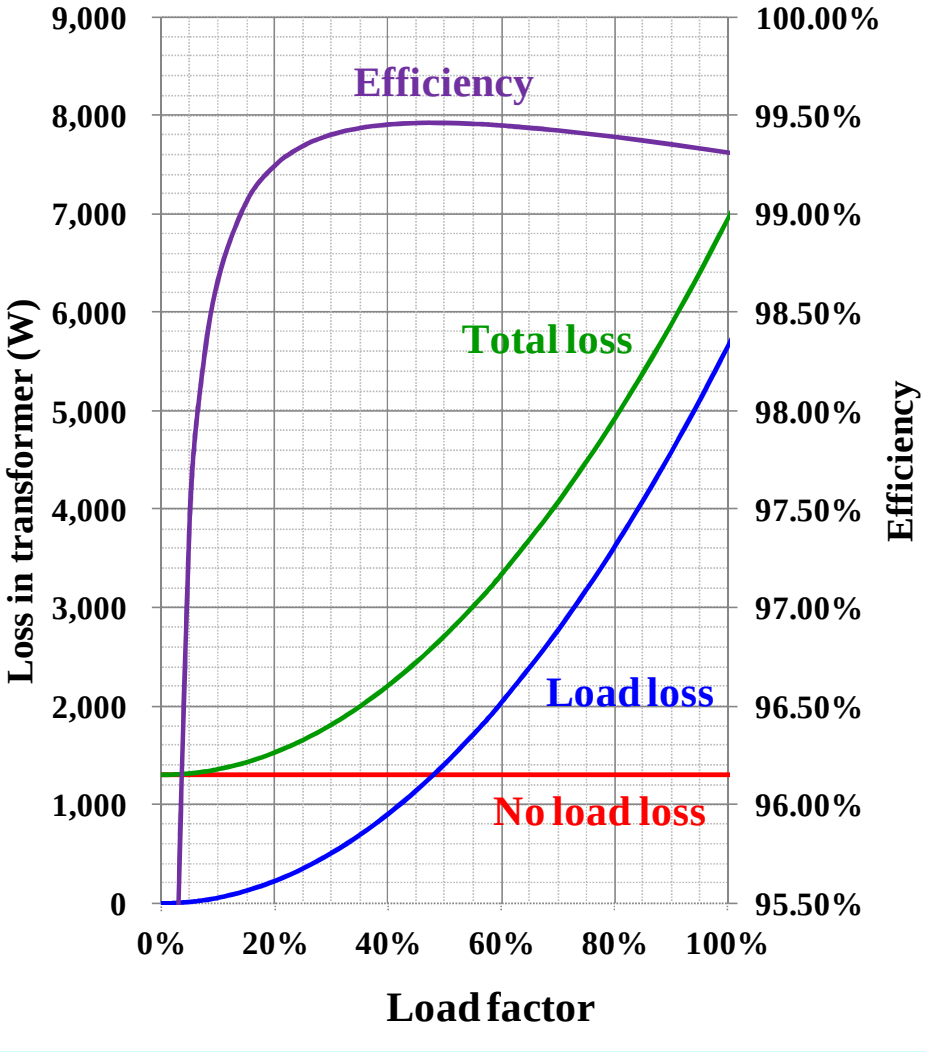
Measured load factors of DTs in Vietnam

Test site	Rated capacity (kVA)	Number of households	RMS load factor (%)	Max. load factor (%)	Min. load factor (%)
1	400	300	16.6	35.9	5.9
2	400	320	35.2	107.7	4.5
3	1500	Hotel	28.4	57.2	5.3
4	560	factory	29.8	130.2	1.1
5	25	50	22.3	80.3	1.5
6	50	45	44.9	129.8	16.7
7	25	20	33.2	86.8	9.6
8	50	63	31.9	72	12.3

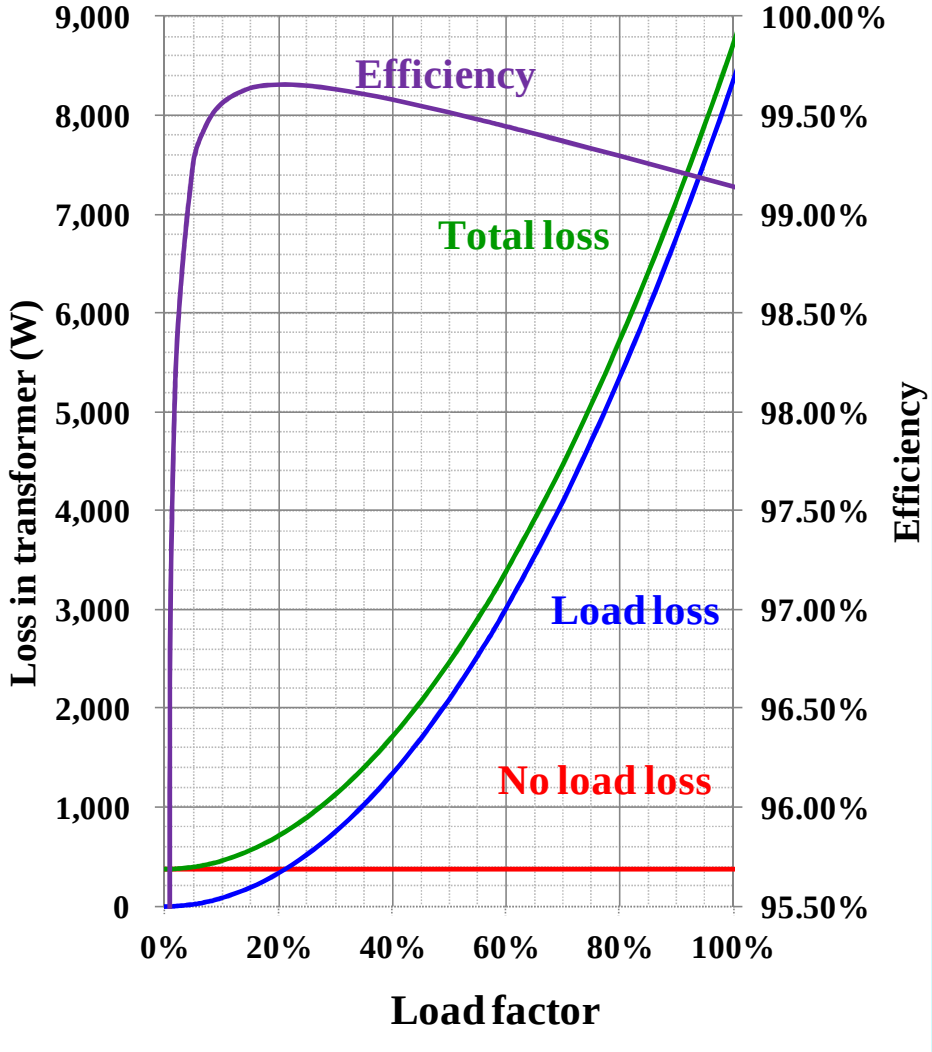
1.Residential area in suburbs of Hanoi, 2. Residential area near industrial park in suburbs of Hanoi, 3 Hotel in Ho Chi Minh City, 4. Factory in Dong Nai, 5-6,Residential area in Binh Duong The data measured from Oct to December 2011 as a part of project supported by NEDO.

RMS load factor: 20~40% should be considered to choose an adequate transformer

Transformer Loss Comparison



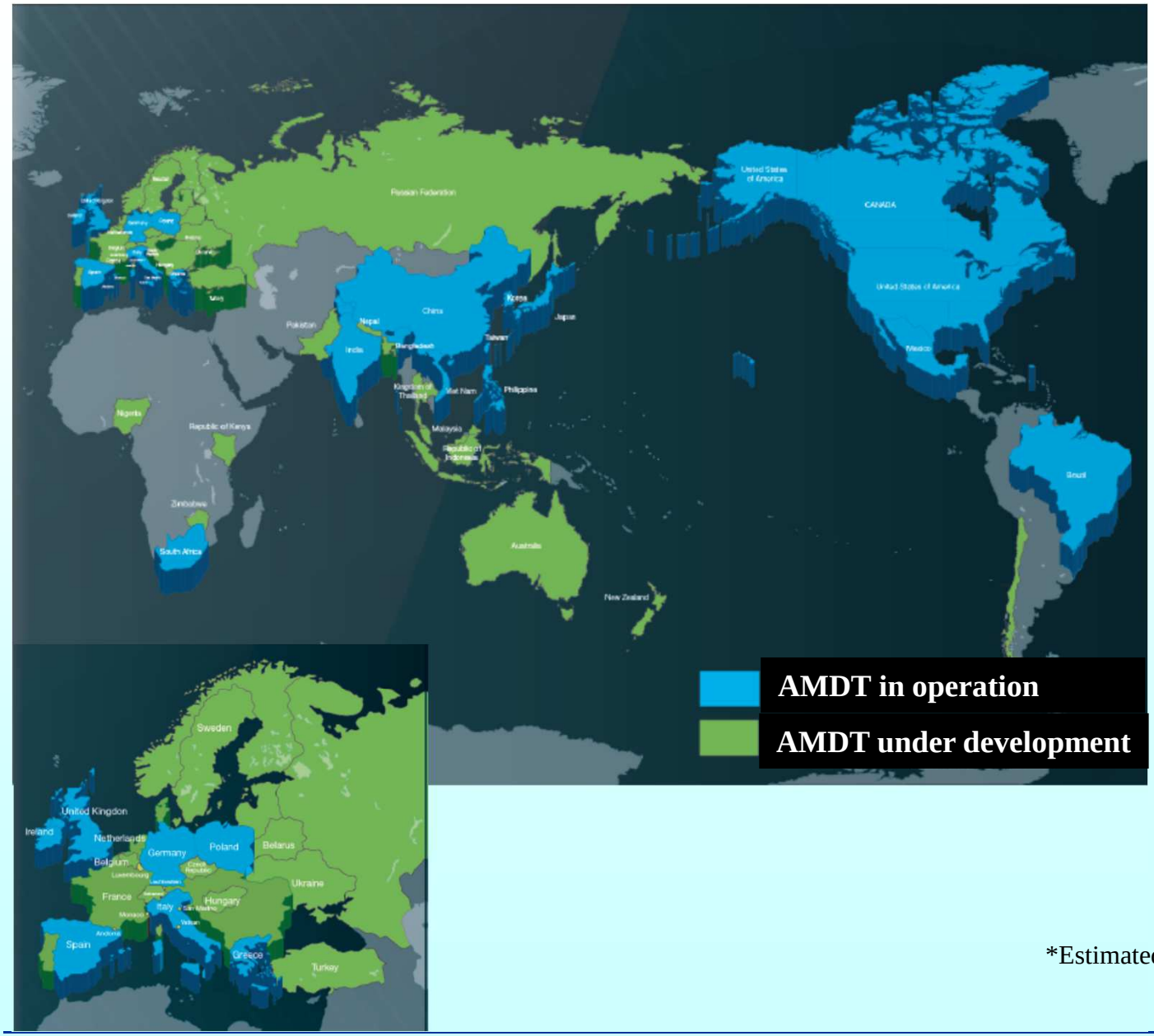
CRGO-DT



AMDT

2nd Top Runner DT in Japan 1000kVA 50 Hz

3. World Wide Situation of AMDT



Unit: MVA

China	230,000
USA	61,500
India	57,000
Japan	24,000
Mexico	17,000
South Korea	13,500
Taiwan	7,000
Canada	6,000
Philippines	4,000
EU	4,000
Brazil	1,800
Vietnam	1,800
Thailand	16

*Estimated by Hitachi Metals in Mar. 2016

4. Recycle of Amorphous Core

AMDT

Discard AMDT

Recycle process
Capacity：50 MT/mo
（April, 2013～）

Retrieve AM core from AMDT

Crush and Screen

Wash and Dry

Crushed AM core

AM ribbon

AMDT core

Energy saving and
Resource circulation

Recycle Flow of AMT（2013～）

5. Conclusions

1. Amorphous alloy has been used in transformer more than 25 years

2. Manufacturing process of amorphous core and transformer are well-established under proven technologies.

3. Amorphous transformer is suitable for low RMS load factor area because of its low no load loss.

4. Amorphous transformers are installed in many countries.

5. Amorphous core recycling process has been established.

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