

# Collaboration to boost evolution and revolution in ironmaking and steelmaking

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Delft, The Netherlands

Bessemer Lecture

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# Background

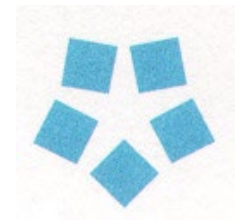
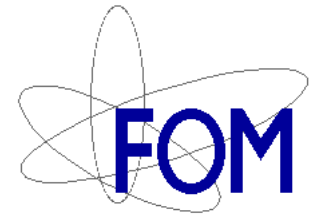
Physics, mathematics, astronomy

PhD

Heats of formation of solid and liquid alloys

1974

Research & Development Hoogovens Group



# International contacts

After one year Hoogovens

UK - 3 weeks Course at Sheffield University

Memberships

Germany - Arbeitskreis Sauerstoffmessungen VdEH

France - Comité Acierie ATS

ECSC - Expert Committees

- Basic Oxygen Steelmaking
- Theoretical Iron and Steelmaking

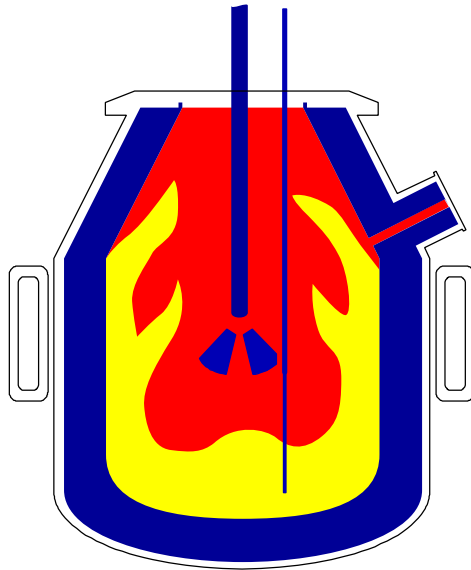


Ken Mills

2013

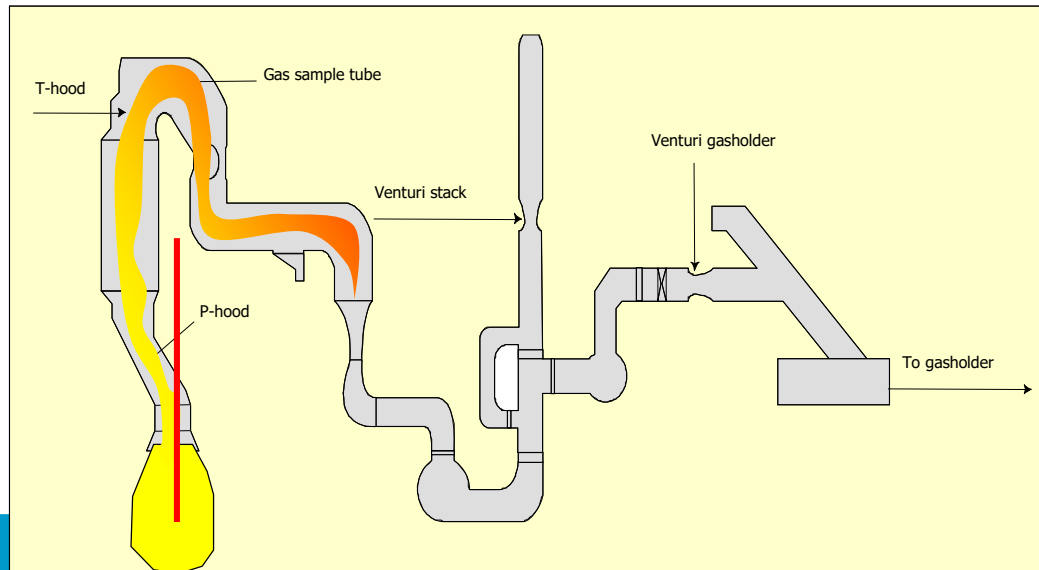
# Converter 23

- Introduction third converter in BOS No. 2 (1976)
- Japanese size
- OG gas recovery
- High oxygen blowing rate
- Sublance system?



# Waste gas analysis

- Converters 21 and 22 equipped with waste gas analysis
- Excellent tool for understanding process behaviour by determination of off-gas composition and volume
- Directly related to process dynamics
- Acceptable carbon end-point control proved possible



Dyrox system

# Waste gas analysis

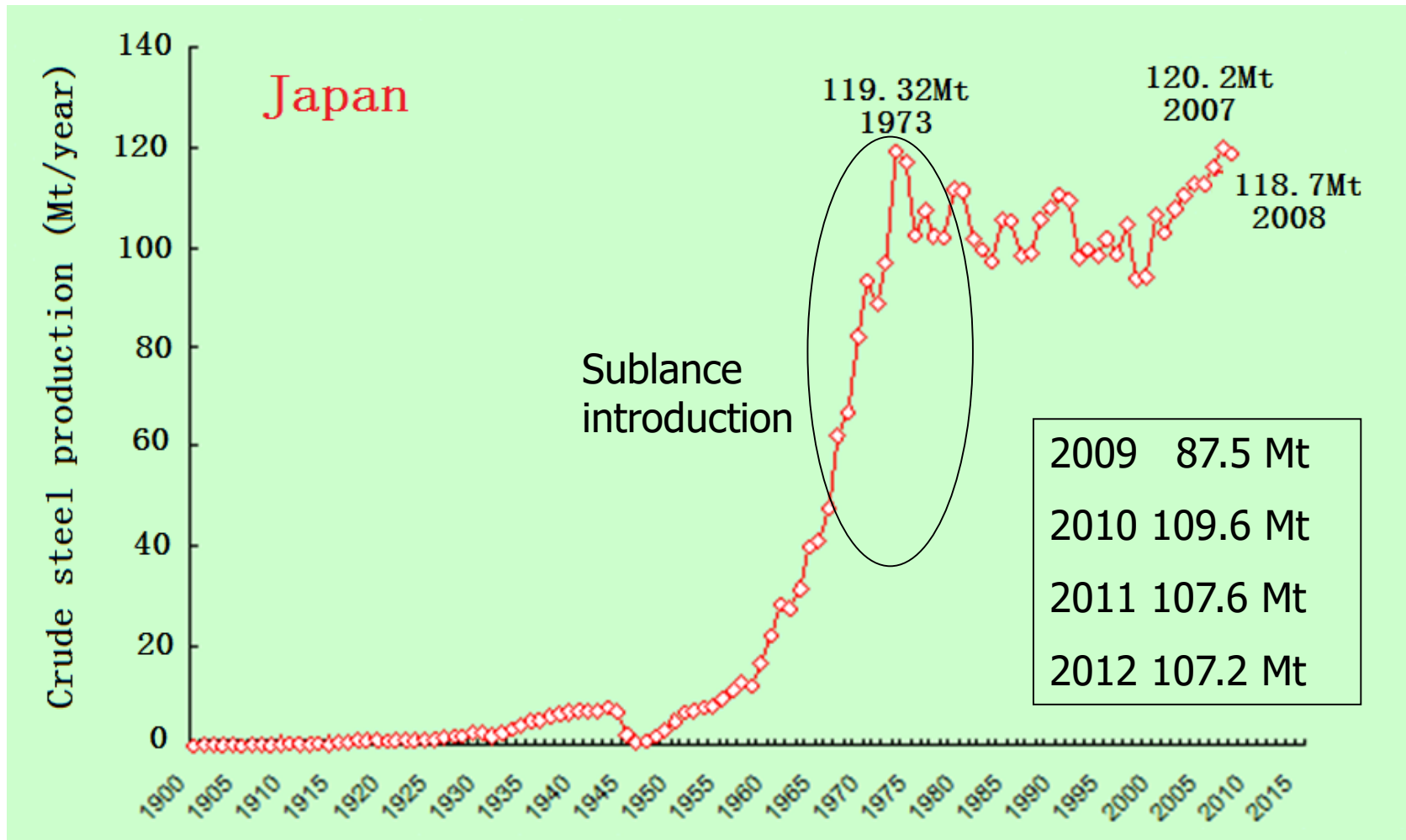
- Converters 21 and 22 full combustion vessels
- Converter 23 suppressed combustion OG system
- Problems with flow measurement and air inlet estimate
- Acceptable carbon end-point control not directly possible
- [C] and T control by intermediate stop
- Substance dynamic control attractive alternative
- Combined accurate carbon and temperature control

# Sublance measurement

- Invented in the nineteen sixties by Voest (Austria) and tried out by Bethlehem Steel (USA)
- Further developed and installed in the early seventies in new BOF's in Japan
- NSC: Muroran, Kimitsu, Nagoya, Oita, Yawata,
- Sumitomo: Wakayama, Kashima
- Kawasaki and NKK own developments
- Hoogovens decided to install an NSC-type sublance on Converter 23

**NIPPON STEEL**

# Steel production in Japan

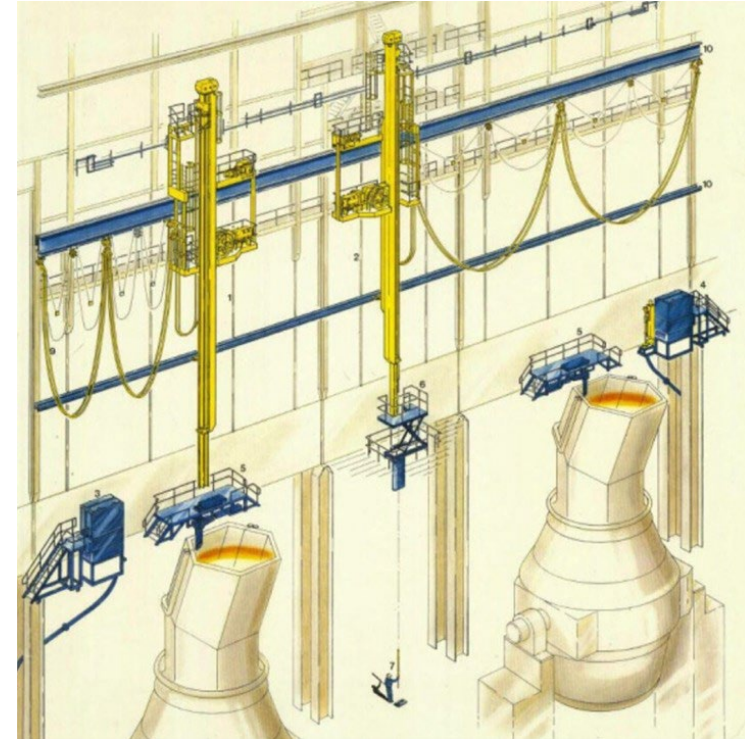






# Sublance license

- ESTEL Technical Services (ESTS) acquired license to sell NSC-type sublances in Europe
- NSC supplied sublances to AIS Port Kembla, Iscor Vanderbijlpark, Dofasco Hamilton
- ESTS delivery to Cockerill Seraing, Belgium, followed by Usinor Fos-sur-Mer and Usinor Dunkerque
- These were all existing plants, tailor-made solutions necessary



Courtesy of Danieli-Corus

# Start up subblance in BOS No 2

- Troublesome introduction subblance technology in IJmuiden
- Start of weekly Subblance Sensor Club in BOS No. 2
- Chairman and secretary, immediate report/action list
- Production, maintenance, ESTS and research represented
- Development sensors and digitizing equipment
- Dynamic control modelling
- Reliability of (parts of) installation
- Estimate project length 50 weeks
- Realization took 100 meetings



# First visit to Japan

- May 1980 first visit to Japan with ESTS engineer
- NSC plants Muroran, Kimitsu, Nagoya, Yawata, Oita
- Guide to assist us

35  
visits  
later



# International Sublance Sensor Club

- Troublesome introduction of sublance technology in Europe
- Hoogovens established International Sublance Sensor Club (ISSC)
- Members Hoogovens, Cockerill, Usinor, AIS, ISCOR, Dofasco
- Main emphasis on sensor development, measurement technique, reliability of sensitive parts of hardware
- NSC invited as member
- Every telex to NSC ended with same sentence:  
"I am convinced that organising a family conference would solve the sublance problems "



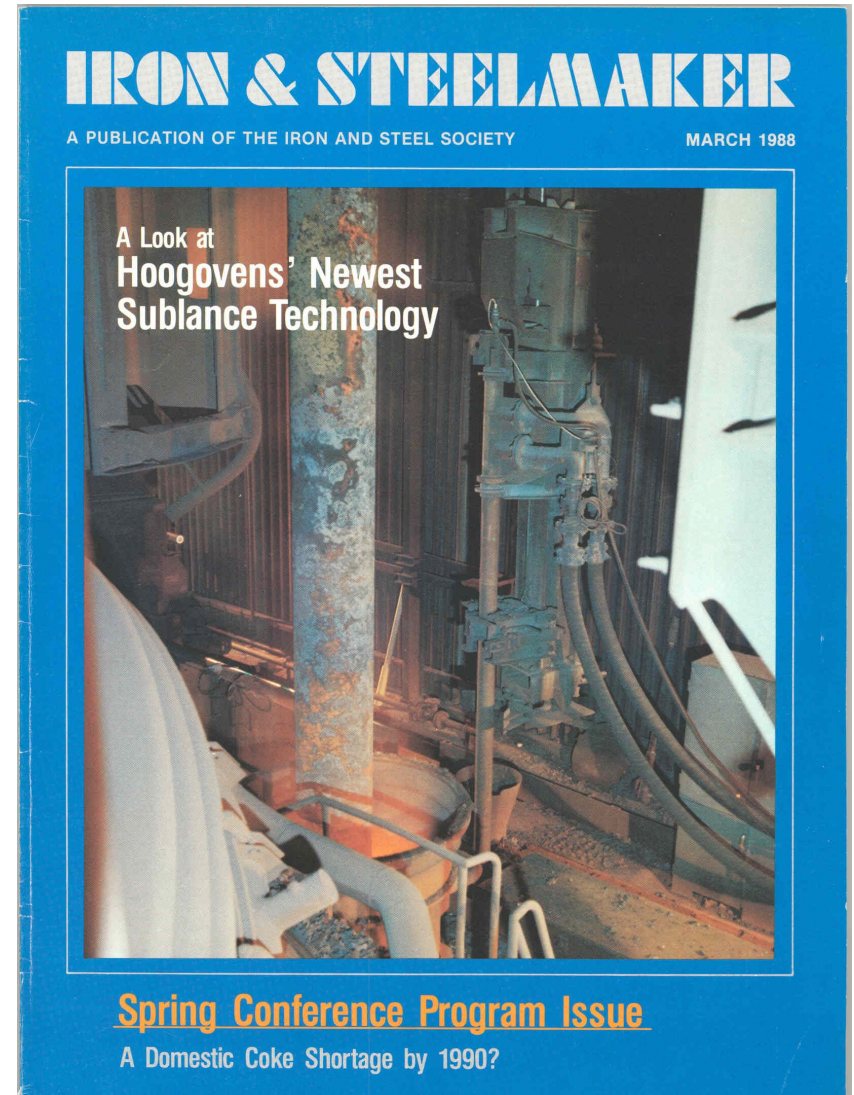
# Sublance family



5 December 1983 – Sublance Family Conference in Tokyo

# Sublance family

- Large family conference in IJmuiden in 1991
- Representation from Africa, Asia, Australia, Europe, North America and South America
- Most problems solved
- Sublance Dynamic Control accepted as standard process control system for BOF steelmaking
- Today Danieli-Corus is world market leader
- 125 systems delivered worldwide

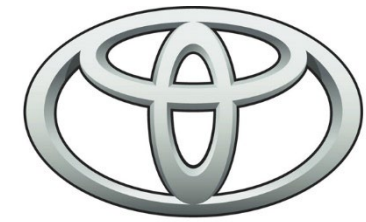


# NSC Hoogovens Sublance Family Conference 1991





# TiSulC family



**TOYOTA**

- NSC bilateral licenses for production galvanized/galvannealed Ti-stabilised ultra-low carbon steel grades for ultra deep drawing applications for automotive

**NIPPON STEEL**



**British Steel**



**Inland Steel**



**Koninklijke  
Hoogovens**

- Technology covers production from steelmaking to coating
- Hoogovens founded TiSulC family
- Technology had to be denipponised
- Outcome: Production TiSulC outside Japan successful

# 1996 Ti-SulC and Galvanneal Family Conference in IJmuiden

Ti-SulC bulletin is een interne uitgave van Hoogovens Staal.  
 Redactie: Projectteam Ti-SulC  
 tel: 96145, fax: 70069  
 Teksten: Bart Stam  
 Vormgeving en Productie:  
 Mark & Remark Communications BV.

*Dit bulletin bevat vertrouwelijke informatie over de interne verbeteringsprogramma's op het gebied van Ti-SulC. Dringend verzoek hierin contacten met derden terughoudend mee om te gaan!*



## Ti-SulC Bulletin

### Family conference krijgt vervolg

De eerste 'Family Conference on Galvanneal Technology', die medio februari in IJmuiden werd gehouden, krijgt een vervolg. In mei 1997 zullen Nippon Steel, Inland Steel, British Steel en Hoogovens in Chicago bij elkaar komen om over de voortgang van de Ti-SulC productie te praten. Tevens zullen dan de resultaten bekend worden gemaakt van de gezamenlijke projecten die na de eerste Family Conference van start zijn gegaan. Daarbij gaat het onder andere om het uitwisselen van plakken en foutmonsters.

Organisator Rob Boom, werkzaam bij Hoogovens Research & Development, is tevreden over deze eerste internationale Ti-SulC bijeenkomst. "Het algemene beeld is voor mij de grote openheid tussen de vier staalbedrijven. Er is uitgewisseld kennis uitgewisseld over technologieën, productiefaciliteiten en maatregelen tegen afkeur en dat was het hoofddoel van deze bijeenkomst.

*Druck overleg tijdens Workshop 2*



Bovendien is er veel ervaring op het gebied van galvanneal-technologie gepresenteerd, waarvan Hoogovens veel heeft geleerd." Hij illustreert dit aan het feit dat zo'n 10.000 kopieën zijn gemaakt van lezingen en sheets. De Family Conference in De Schouw trok circa 80 vakmensen, waarvan 25 vertegenwoordigers van NSC, Inland Steel en British Steel. Boom vindt dat vooral Inland Steel

zich goed had voorbereid. "De Amerikanen kwamen met zeer uitvoerige informatie over de verzinktechnologie en de produkt-aspecten van 'Ti-SulC'."

**DRIE WORKSHOPS**  
 De conferentie kende drie workshops voor de echte fijnproever. De onderwerpen



*Rob Boom (links) in gesprek met Yoshio Matsuda van Nippon Steel.*

waren staal maken en gieten (workshop 1), warmwalsen, beitsen en koudwalsen (workshop 2) en galvanized/galvannealed dampelverzinken (workshop 3). Boom vat de belangrijkste conclusies samen. "In workshop 1 bleek verrassend dat niet alleen Nippon Steel met zijn rechte gietvorm maar ook British Steel met zijn extreem kromme gietvorm weinig last heeft van gasbelen. Hoogovens (zonder EMBR) en Inland blijken daar meer moeite mee te hebben."

In de tweede werkgroep was de conclusie dat er grote onderlinge

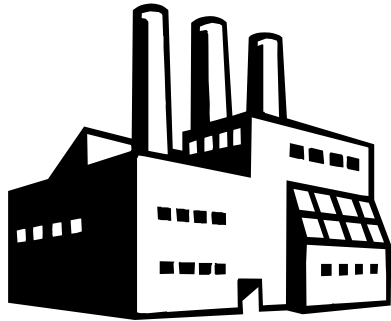
*(vervolg op blz. 2)*



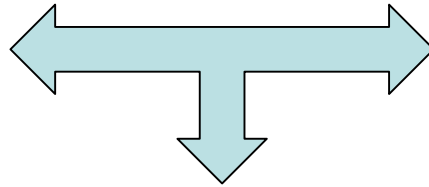
### International team

Greg Ludkovsky	Inland Steel
Tony Jones	British Steel
Yoshio Matsuda	Nippon Steel
Rob Boom	Hoogovens

# Collaboration and alliances



Industry



Academia



Government

# Drivers for alliances

Something in common:

- enemy
- problem
- challenge
- opportunity
- friendship
- funding
- region



[dreamstime.com](http://dreamstime.com)

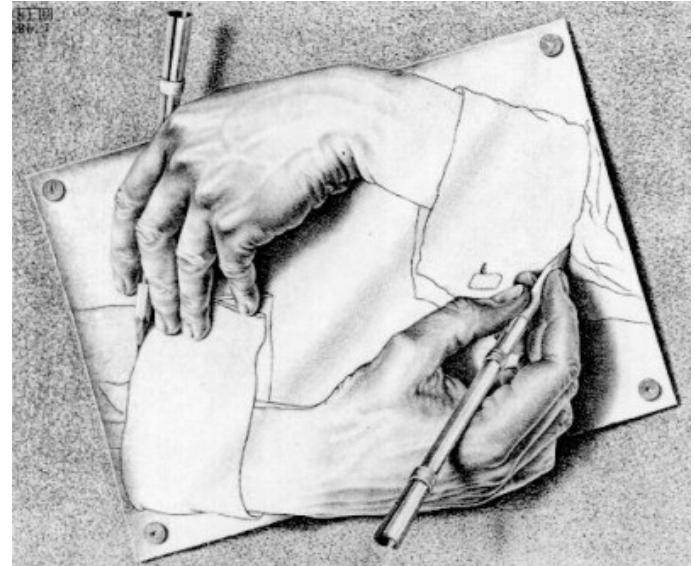
# Output of alliances

Knowledge (know how + know why) and experience on

- Processes
- Products
- Product applications
- Market expectations
- Society interaction

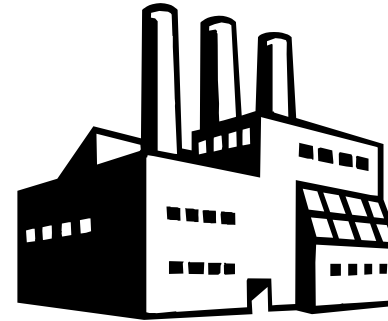
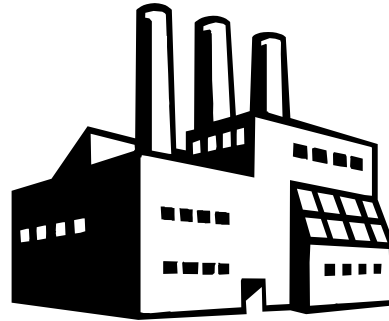
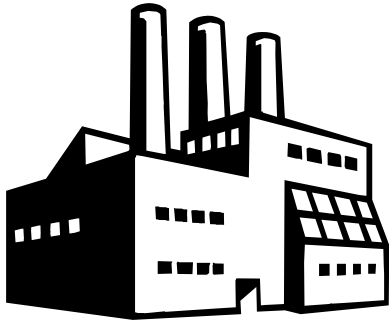
Not on

- Prices
- Sales volumes



Artist M.C. Escher

# Alliances between iron and steel industries



ISSC  
RH-OB  
Concast  
TiSuIC  
CRM

International Substance Sensor Club  
Licensees  
Family of users of Concast technology  
Family of licensees  
Centre for Research in Metallurgy

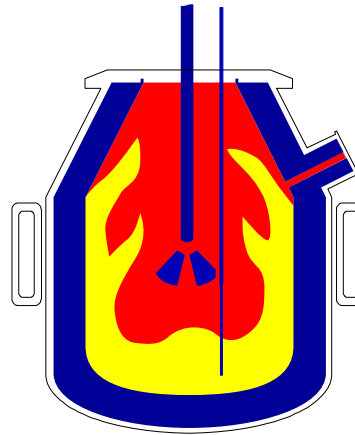
# Drivers for alliances - sublance

What did we have in common for sublance development?

- enemy
- ✓ problem
- ✓ challenge
- ✓ opportunity
- ✓ friendship
- funding
- region





ESTS/HTS/Danieli-Corus



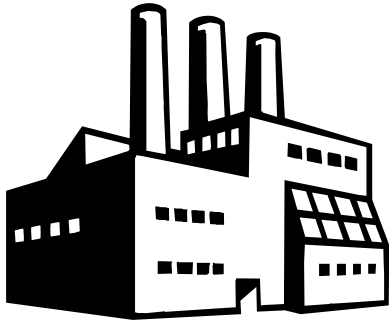
# Drivers for alliances - TiSulC

What did we have in common for TiSulC development?

- ✓ enemy  slivers and blowholes
- ✓ problem
- ✓ challenge
- ✓ opportunity  same license supplier
- ✓ friendship
- funding
- region

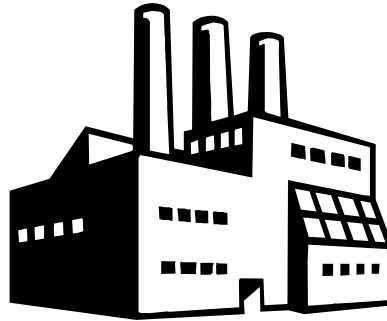


# Alliances between industries



Hoogovens

Corus/Tata

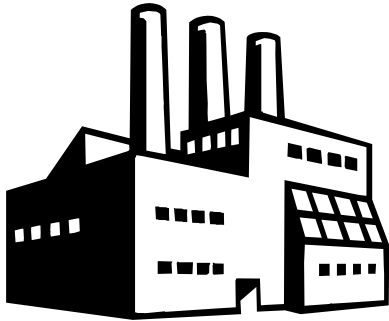


Kobe Steel  
British Steel  
Usinor  
POSCO

Sumitomo Metal Industries  
Salzgitter Stahl und Technologie

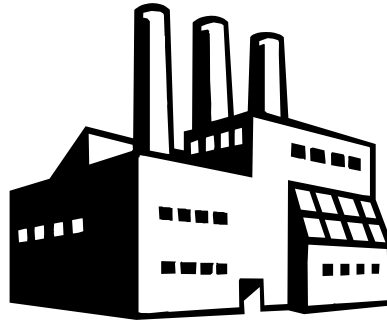
Asea/ABB  
Electronite

# Alliances between industries



Hoogovens

Corus



Kobe Steel

US Steel

British Steel

Usinor

POSCO

Sumitomo Metal Industries

Salzgitter Stahl und Technologie




# Bath Agitation Process

- British Steel Teesside Labs developed inert gas bottom stirring for oxygen steelmaking converter at Teesside (now MPI)
- Industrial test at Consett works prior to closing down plant
- No interest by superintendents of other BOS plants within BS
- Friendship between BS Research and Hoogovens R&D
- Continuation BAP development in IJmuiden BOS No. 1
- Less than 20 years later British Steel and Hoogovens merged into Corus

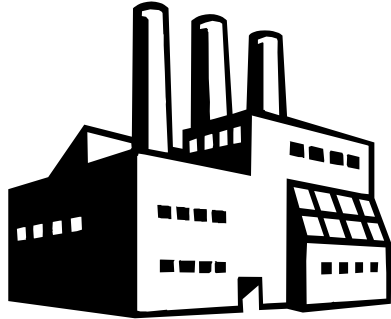


# Drivers for alliances - BAP

What did we have in common for BAP development?

- ✓ enemy  BS BOS plant management
- ✓ problem
- ✓ challenge
- ✓ opportunity  connection Teesside-Amsterdam
- ✓ friendship
- ✓ funding  ECSC project
- ✓ region

# Alliances between industry and academia



CISR Centre for Ironmaking and Steelmaking Research USA  
MMPC McGill Metals Processing Centre Canada

# CISR

- Center for Iron & Steelmaking Research
- Carnegie-Mellon University
- Pittsburgh (Pennsylvania) USA
- Founders profs Richard Fruehan and Alan Cramb
- Winners Bessemer Gold Medal in 2004 resp. 2016



2004



2016

# Drivers for alliances

What do we have in common in MMPC and CISR?

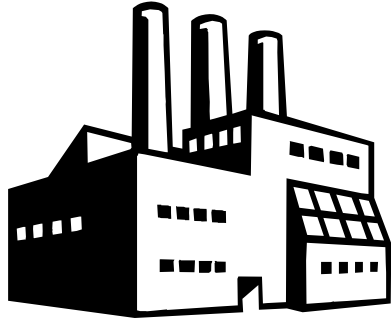
- enemy
- ✓ problem
- ✓ challenge
- ✓ opportunity
- ✓ friendship
- ✓ funding
- Region



Boom

Guthrie

# Alliances between industry, academia and government



ECSC/RFCS

Research Fund for Coal and Steel Research

ULCOS

Ultra Low CO<sub>2</sub> Steelmaking

M2i

Materials innovation institute



# Project funding

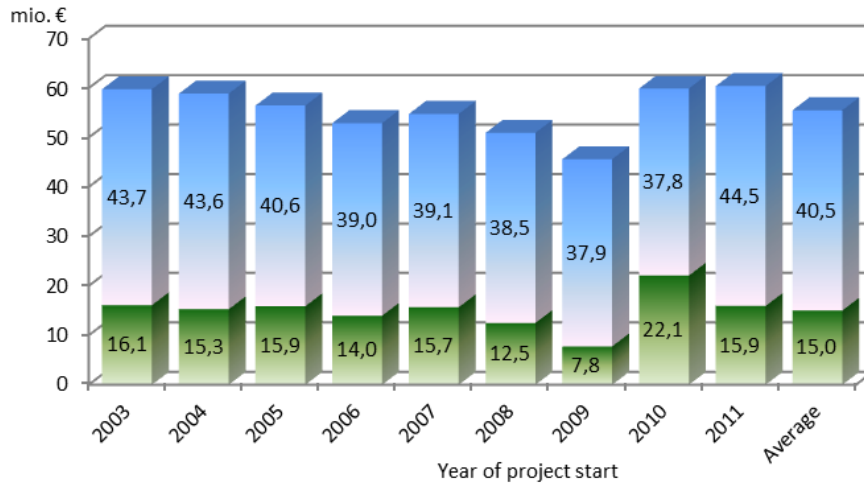
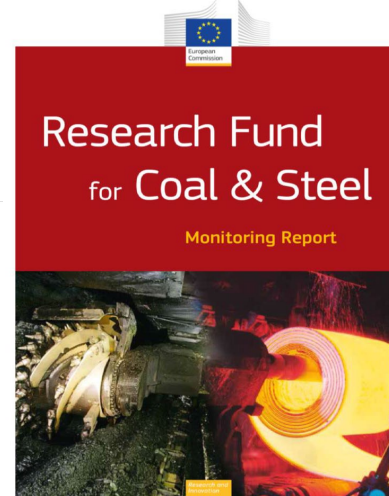


Figure 2.7 RFCS funding

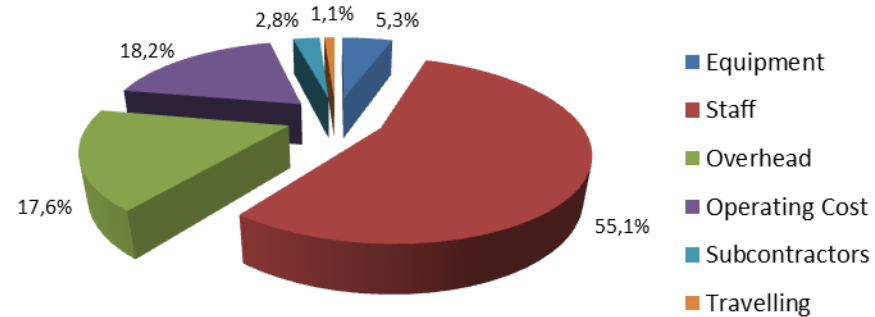


Figure 2.9 Expenditure breakdown

Total expenditure  
500 M€

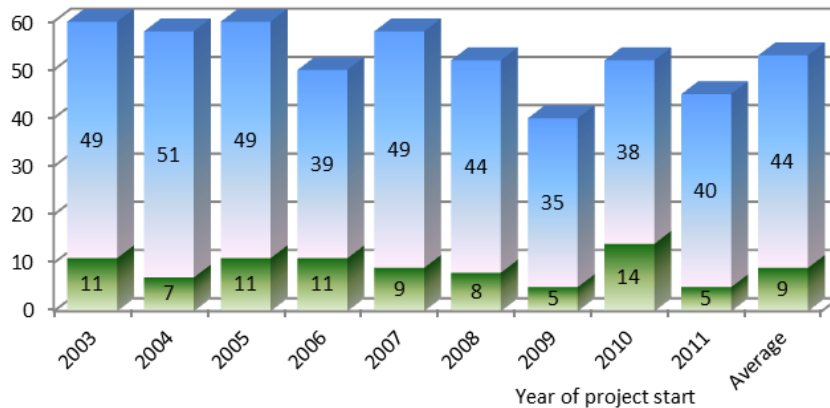
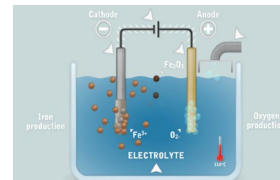
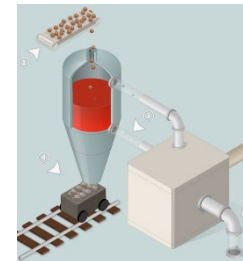
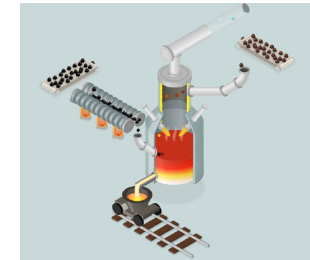
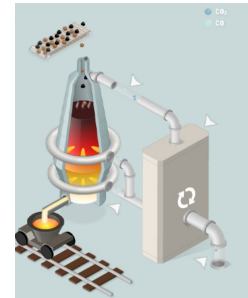


Figure 2.8 Number of funded projects



# New technologies selected

- Blast Furnace top gas recycling
- Smelting reduction (HIarna)
- Advanced direct reduction
- Iron ore electrolysis



# Drivers for ulcos

Something in common:

- ✓ enemy →
- ✓ problem
- ✓ challenge
- ✓ opportunity
- ✓ friendship
- ✓ funding
- ✓ Region

CO<sub>2</sub>, climate change



Birat



2003

# Orchestrated follow up of Ulcos?

- Iron and steel industry must get rid of carbon
- Most companies follow individual H<sub>2</sub>-route
- Global collaboration would have been better
- It is not too late



# Conclusions

- Alliances in iron and steel exist in different format
- Drivers are diverse and differ with the type of alliance
- Sharing knowledge and experience only has winners
- Key is personal involvement of partners
- Dealing with different cultures needs special skills
- Outcome of common projects not always feasible
- Setting up alliances is a joy in life

# The end

- Thank you for your attention
- Questioning time

