Trends and challenges for stainless steel

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www.outokumpu.com
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1. Brief history of stainless steel
Milestones in the stainless steel development

- Discovery of chromium: Louis Vauquelin, 1797
- Inconsistent reports of the impact on corrosion resistance: Berthier, Stodard, Faraday, Boussingault, Hadfield, 19th century
- Aluminothermic reduction process for chromium metal: Goldschmidt, 1895
- Discovery of stainless steel constitution: Guillet, Giesen, Portevin, 1904 – 1909, Fe-Cr- and Fe-Cr-Ni- alloys
- Discovery of corrosion resistance: Borchers, Monnartz, 1910- 1911
- Discovery of industrial value: Harry Brearley, UK, martensitic steels, Christian Dantsizen, Elwood Haynes, USA, ferritic steels, Eduard Maurer, Benno Strauss, Germany, austenitic steels, 1911- 1913
- Expanding industrial applications in 1920’s, UK, USA, Germany, France, Sweden, Austria
- Duplex stainless steel grades, France, Sweden, in the 1920s
- Fe-Cr-Ni-Mo-Cu- stainless grades, in the early 1930s.
- Nitrogen as alloying element, in the 1950s
- "Superferritic, superaustenitic, superduplex- grades”, 1970-

Less impurities ⇒ full benefit from alloying
Milestones, process development, stainless steel

- **1890’s**
  - Low carbon chromium metal
  - Electric arc furnace
- **1920’s**
  - Hot rolling of strip
  - Cold rolling of strip
- **1940’s**
  - Oxygen decarburisation
  - Cluster mills, Sendzimir
- **1950’s**
  - Vacuum melting
- **1960’s**
  - Continuous casting
- **1970’s**
  - AOD- method, ladle metallurgy
- **1980’s**
  - New steckel- hot rolling
  - Hot charging
  - Direct rolling
  - Automation development
- **1990’s**
  - Thin slab casting
  - Strip casting
  - Integrated production lines

**Process automation, precise manufacturing**
Stainless steel production Western world
2. Industry consolidation in Europe 1976 - 2004
Intense consolidation among the European stainless steel producers (cold rolled)

1976 1 000 t
Outokumpu 50
Avesta Jernverk 70
Fagersta 40
Granges Nyby 50
Uddeholm 25
Sandvik 10
Stora Kopparberg 30
BSC 170
ALZ 40
Chatillon 70
Peugeot-Loire 40
Forges de Gueugnon
Ugine 200
Acerinox 105
Krupp 110
Südwestfalen 80
VDM
Thyssen 100
Ilssa-Viola 25
Fiat 80
Terninoss 110

Total 21 1 405

1986 1 000 t
Outokumpu 140
Avesta 150
BSC 210
ALZ 120
Chatillon 110
Ugine-Gueugnon 240
Acerinox 170
Krupp 225
Thyssen 125
Teksid 100
Terninoss 120

Krupp-Thyssen-Stainless 1 230
Krupp-Thyssen-Nirosta 750
AST 480

1998 1 000 t
Outokumpu 340
Avesta Sheffield 400
Arbed/ALZ 270
Ugine 580
Acerinox 500
Krupp-Thyssen-Stainless 1 350
TKN 800
AST 550

2001 1 000 t
AvestaPolarit 900
Outokumpu 1200
Arcelor 1050
Arcelor 1050?

2004 1 000 t
Outokumpu 1200
Arcelor 1050?
Acerinox 600?
ThyssenKrupp Stainless 1 350?
TKN 800?
AST 550?

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3. Capacity build-up
World stainless slab capacity (major units) 2002 - 2007

Source: CRU

2002, 1000 tons

Outokumpu Stainless, Avesta
Ugine, L'Ardoise
Nisshin Steel, Shunan
TKS-Nirosta, Bochum
Outokumpu Stainless, Tornio
ALZ, Genk
Yusco, Kaohsiung
Acerinox, Palmones
Posco, Pohang
TKS-ASTerni, Terni

2007, 1000 tons

Acesita, Timoleo
Acerinox, Palmones
Carinox, Carlam
Yusco, Kaohsiung
Baosteel, Shanghai
ALZ, Genk
AST, Terni
Outokumpu Stainless, Tornio
Posco, Pohang
Taiyuan, Taiyuan

Taiyuan, 2500 tons
Outokumpu, 2000 tons
World stainless cold rolling capacity (major units)  2002 - 2007

Source: CRU

2002, 1000 tons

2007, 1000 tons

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Global stainless steel cold rolled capacity and demand (2001 – 2010)

Source: ISSF
Global capacity utilization

Source: ISSF
4. Introduction of Outokumpu
Beginning of a new era!

International metals & mining house

~1990–2000

• Build-up of Copper through acquisitions
• Build-up of commercializing of technology
• Exit from metals chemicals and nickel
• Start of Exit Mining
• Establishing base for a focused European stainless player

2001–2004

• Formation of AvestaPolarit
• Tornio expansion
• Full ownership in AvestaPolarit
• Acquisitions to strengthen technology
• Formation of new Boliden
• New strategy including Copper exit

Towards global leader in stainless

2005–

• Major part of Copper exit completed

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Outokumpu’s vision statement

Outokumpu is an international stainless steel and technology company.

Outokumpu’s vision is to be the undisputed number one in stainless with success based on operational excellence.

Key strategic objectives:

• **Value creation** through building superior production and distribution capabilities in all major markets globally

• **Value realization** through commercial and production excellence
Being the undisputed number one means

• Best financial performance in the industry
• Operational excellence
  • Industry benchmark in managing customer relationships
  • Industry benchmark in production operations
• Preferred employer in the industry
Outokumpu’s operational structure – sales and distribution

- Logistics center in Terneuzen, the Netherlands
- Sales companies in 28 countries
- Own service centers in 9 countries
5. Stainless steel market
Global steel production

2004

1050 Mt Carbon steel

24 Mt Stainless steel

~1.9 Mt Outokumpu

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Stainless steel - fastest growing metal by demand

Index 1980 = 100

Source: CRU International

- Corrosion resistant
- Hygienic
- Low life cycle cost
- Excellent green credentials
- High strength

CAGR+5.5%
Historical Price Development German CR304

CR 304 2B 2mm sheet price to a large stockholder in Germany (EUR/t) and the Nickel price (USD/t)
Also showing European apparent consumption (CRU)

Price data quarterly
Consumption data yearly

304 prices source Outokumpu
Consumption source CRU (Aug 05)
Nickel price source LME

Germany Total Price (EUR/t)  Germany Base (EUR/t)
Nickel price (USD/t)  W Europe App. Cons
Size of market by selected region/market (Cold rolled flat products ‘000 tons)

Source: CRU Stainless Steel Flat Products Quarterly Aug 2004
6. Stainless steel applications
The properties of stainless steel

STAINLESS STEEL

- whole life cost
- corrosion resistance
- mechanical strength & formability
- energy absorption
- aesthetically fashionable
- hygienic
- 100% recyclable
- high temperature resistance

Source: Hatch Beddows
Stainless steel
An excellent choice in numerous applications

Main end use segments

- Process industry: 29%
- Catering and household: 25%
- Transport: 16%
- Welded tubes: 15%
- Construction: 10%
- Other: 5%

Source: CRU
The Apaté - bridge in Stockholm, DSS 1.4462
Stonecutters Bridge, Hong Kong
HyTens®- Light Constructions

Tensile strength MPa

Strength-ductility of HyTens in Comparison to carbon steel grades

DDQ = Deep drawing quality
BH-RP = Bake hardening/rephosphorized

HyTens 2000
Boron steel
TRIP
DP
HSLA
DDQ

HyTens X

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7. Production technologies
Currently dominating manufacturing route for austenitic stainless steel

Raw materials

- Scrap: carbon/stainless
- Ni
- Cr
- Others

1. Melting, EAF
2. Refining, AOD (VOD)
3. Continuous casting
4. Hot rolling, steckel/tandem
5. Primary annealing and pickling
6. Cold rolling, cluster mill
7. Final annealing and pickling
8. Skin-pass rolling
9. Finishing, slitting/CTL
Development of EAF- operation

- Oxygen injection
- Introduction of AOD- and VOD-process
- Water cooled panels
- High power capacity by electrode control
- Computer aided process control
- Water cooled roof, use of burner
- Use of high power transformer
- Spray cooling of electrodes
- Process control by computer and process-models

- Tap to tap time
- Specific power consumption
- Electrode consumption

- 180 min
- 630 kWh/t
- 6,5 kg/t
- 50 min
- 400 kWh/t
- 2,0 kg/t
Process development, new integrated Rolling- Annealing- Pickling line, RAP

- Line capacity 1.1 Mt per year, 350 kt cold rolled, 750 kt hot rolled
- Width range 950…1650 mm
- Incoming material 1.0…6.0 mm 300- and 400- series stainless steel
- Outgoing material 1.0..6.0 mm (Hot rolled) and 1.0…3.0 mm (Cold rolled)
- Finishes: No. 1, 1H, 2E, 2D, 2B and 2H
- Coil weight, max 30 t
Operating principle of RAP-Line

White HR coils → RAP5 → Skin-pass mill → 2B / 2D finish

Black HR coils → RAP5 → AP-process → Skin-pass mill → No. 1 / 2E finish

Second cycle material for 2B / 2D
Comparison: RAP and conventional process

Conventional process

Black hot coils

AP-line

Stock

Cold rolling mill (3)

Stock

AP-line (2)

Stock

Skin-pass mill

Stock

Tension-levelling line

Finishing lines, despatch

RAP-process

RAP-line, 1\textsuperscript{st} run

Stock

RAP-line, 2\textsuperscript{nd} run

Stock
8. Raw materials
Austenitic stainless steel eco-cycle

Use of stainless steel + 5.6 %/a

- 20% virgin CrNiMo invested in upgrading of steel scrap
- 60% steel scrap and other alloys
- 20% SS scrap recycled after using 30 years
Stainless steel value chain

Raw materials

- Stainless steel scrap
- Primary nickel
- Ferrochrome
- Other ferroalloys & slag formers
- Steel scrap

Melting by grade
Total 24.4 Mt, € 50 Bn

69% Austenitic
- AISI 300 series
  - 18% Cr
  - 8% Ni
  - 70% Fe
- 17 Mt
- € 40 Bn

22% Ferritic/Martensitic
- AISI 400 series
  - 12 – 17% Cr
  - 80 – 90% Fe
- 5 Mt
- € 6 Bn

- 8% Mn grades
- AISI 200 series
- 1% Special grades
- 2 Mt
- € 2.5 Bn
- 250 kt
- € 1.3 Bn

Source: CRU, Heinz Pariser, Outokumpu estimates
9. Conclusions
Trends

- Contracting margins
- Increased volumes (especially China)
- Increased efficiency
- Consolidation
- Increased unit sizes
- Total life-cycle thinking
- Environmental awareness (recycling, emission control)
Challenges

- Other, competing materials
- Correct selection of stainless steel grade to applications
- Threat of structural overcapacity
- Trade barriers, formation of trade blocks
- Health issues (Cr, Ni)
- CO₂ –emissions, CO₂ –trade in EU
- Availability / cost of raw materials
- Availability / cost of power
Final conclusion:
With stainless steel you drive your business further...

Ordinary Ford, model 1986

Stainless Steel Ford, model 1936