OVERVIEW OF CURRENT DEVELOPMENTS IN STEELMAKING AND CONTINUOUS CASTING

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Summary

Steel production is based on the converter process and electric steelmaking. For both process routes one common development goal is the increase of productivity.

In EAF steelmaking a trend to higher shell design is used to increase heat size and productivity. For maximized energy input not only the electric power supply is increased but also chemical energy is added via fixed installed burners.

In AOD steelmaking the main development direction is the increase of the hitting rate for temperature and chemical analysis and the reduction of the tap to tap time. Process automation is one mayor means to move towards these targets. Static and dynamic process models in combination with in-line measurements were developed for fully automatic and precise process control. For automatic tapping of the converter the dynamic adjustment of the tilting angle is adjusted based on bath level measurements and the ladle car position is adjusted accordingly.

The shape of AOD converter, which is used for the production of stainless steel, was unchanged over decades. Recently both the requests of mechanical engineers as well as process engineers resulted in a basically new shell design with symmetric converter these improvements during the design phase and guaranteed successful start-ups.

Machines for continuous casting of slabs were and are developed in all directions of flexibility. Automatic and model based adjustments to non-steady state casting conditions are well known for secondary cooling and casting width. Later developments include the dynamic adjustment of the roll gap profile and for the latest installations the adjustment of the spray area by means of adjustable spray headers to maximize operational range and product quality.

Examples of new equipment installations including background information will be given during the presentation.

6th European Stainless Steel Conference

Stainless steel in household products : how to serve « the many people »?

IKEA

- IKEA overview
- Stainless at IKEA
- IKEA stainless vision
- Conclusions

IKEA®

Purchasing and distribution

- **1,350 suppliers in 50 countries**
- **45 trading service offices in 31 countries**
- **31 distribution centers and 11 customer distribution centers in 16 countries**
- **38 Swedwood factories and sawmills in 11 countries**

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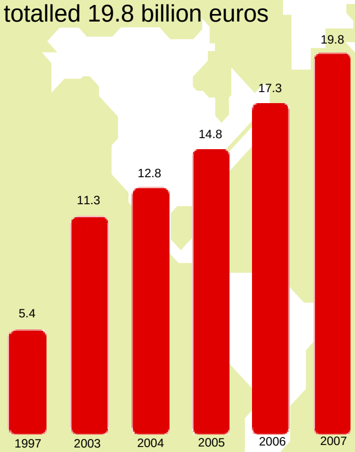
IKEA at a glance

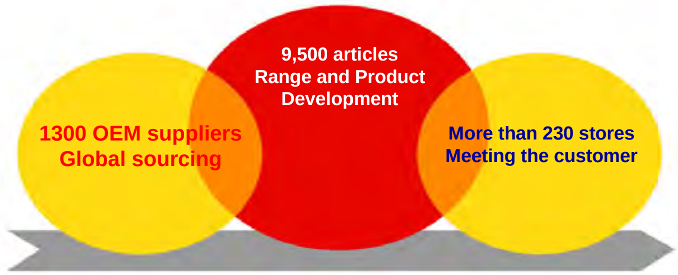
IKEA Group sales FY2007 totalled 19.8 billion euros



Sales 1997 – 2007 (in billions of euros)

- **231 stores in 24 countries**
- **522 million store visitors**
- **450 million web site visits**
- **191 million IKEA catalogues**

Total co-workers (employees) 2007
118.000



The unique way we ***create value*** for our
520 million Visitors

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The business idea

We shall offer a wide range of ***well-designed***, ***functional*** home furnishing products at prices ***so low that as many people*** as possible will be able to afford them.

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IKEA of Sweden - Business Areas

IKEA

Our catalogue

The IKEA catalogue is our most important marketing channel.

- 175 million copies
- 55 editions
- 27 languages

Top five sales countries

Germany	17%
USA	12%
United Kingdom	9%
France	9%
Sweden	8%

Top five purchasing countries

China	18%
Poland	14%
Italy	8%
Sweden	7%
Germany	6%

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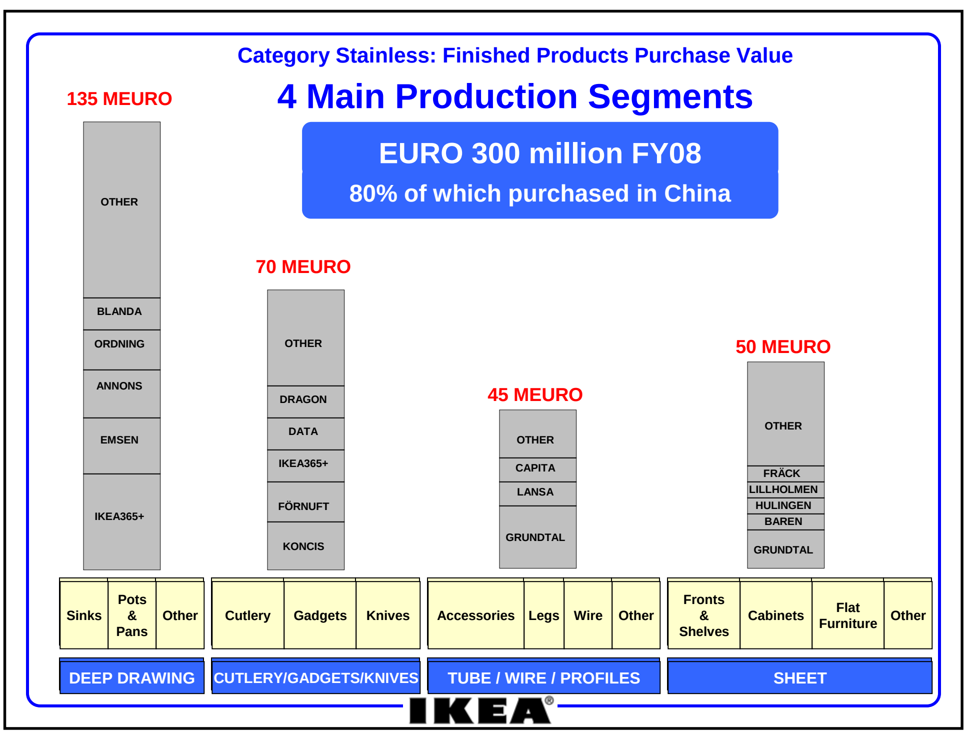
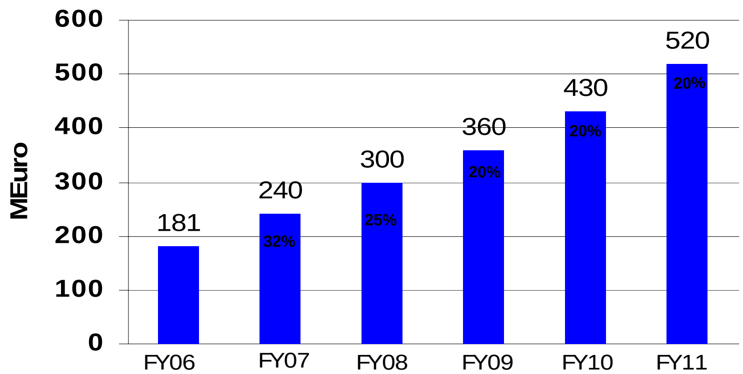


Cost Development – Purchasing Process

Moving IKEA’s stainless business toward a more industrialized purchasing approach

Capacity Development

IKEA’s capacity need for finished stainless articles will double within the next 4 years



Competence Development – Global Organization

Shanghai Raw Material Stainless Competence Centre

Move toward more industrialized purchasing approach

- 4-pillar raw material strategy
  - Separate follow-up of raw material cost from other costs
    - Use bill of materials and average weighted cost concept
  - Material supply agreements with IKEA OEM suppliers
  - Set-up of coil cutting center

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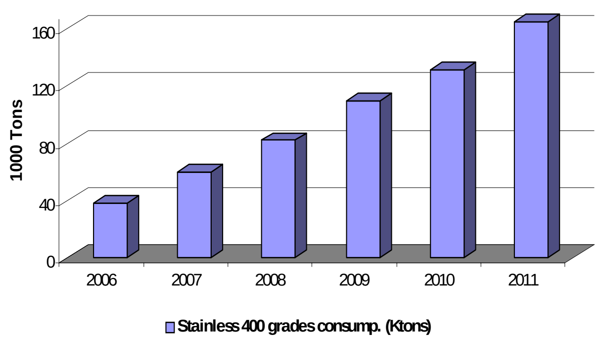
5 years IKEA stainless steel businees development

	2006	*2007*	*2008*	*2009*	*2010*	*2011*
Finished articles purchase value mill€	**182**	**245**	**295**	**350**	**420**	**500**
430 articles share on total (%)	**60%**	**70%**	**80%**	**90%**	**90%**	**95%**
Stainless 400 grades consump. (Ktons)	**38**	**59**	**82**	**109**	**131**	**165**



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For people and environment

- IWAY code of conduct
- Climate – energy & transport
- Raw materials
- Forestry
- WWF
- UNICEF & Save the Children

Read more in the IKEA Social & Environmental Report on **www.IKEA-group.IKEA.com**

A mature technology offers wide range of options….

Martensitic

Ferritic

400 Series

Magnetic

444, 439, 4??

Formability

Duplex

J1, J2, J4???

Austenitic

Corrosion

200 Series

4% Ni / 1% Ni

Lean Duplex

….that demand competence for adequate selection

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Retail business golden rule: offer to customers what they really need

IKEA customers consider stainless because of

- Corrosion resistant
- Hygienic
- Low life cycle cost
- Aesthetic appeal
- Fully recyclable
- Biologically neutral

All above characters relate to Chromium. Nickel is just a manufacturing processes facilitator

Consumers only value end-use and function: fabricating implications do not belong to them

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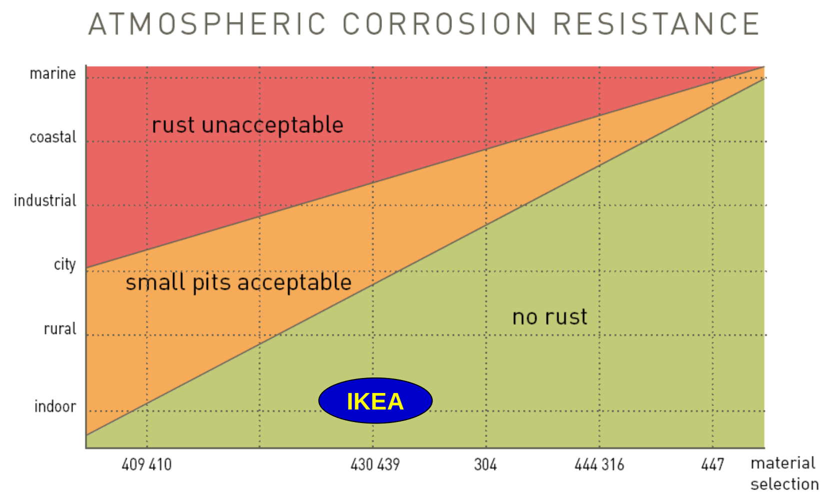

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Corrosion first

Consumers pay for Aesthetic and Hygienic properties, hence *corrosion resistance*

A close and realistic matching of corrosion requirements versus grades properties is the essential factor

Fabrication (forming and joining) processes shall (and can) be adjusted by relying on manufacturing skills and not by ***over-specifying materials***

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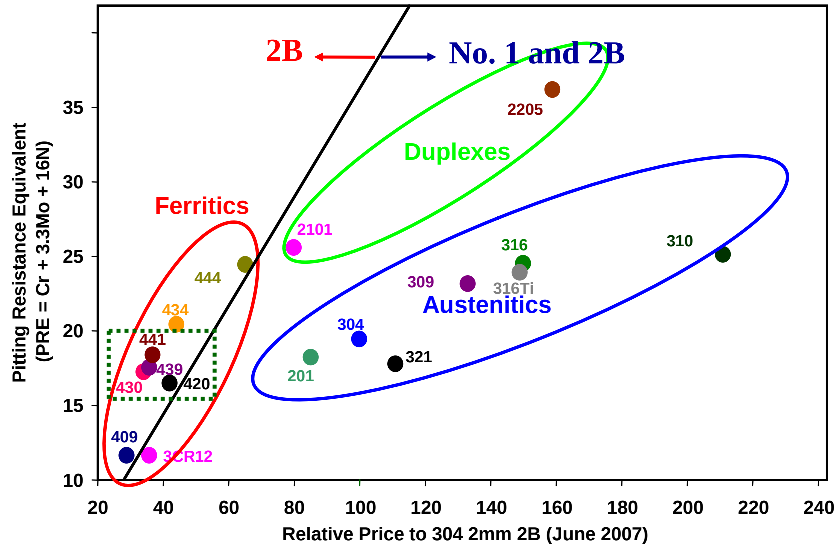
Price vs. Performance



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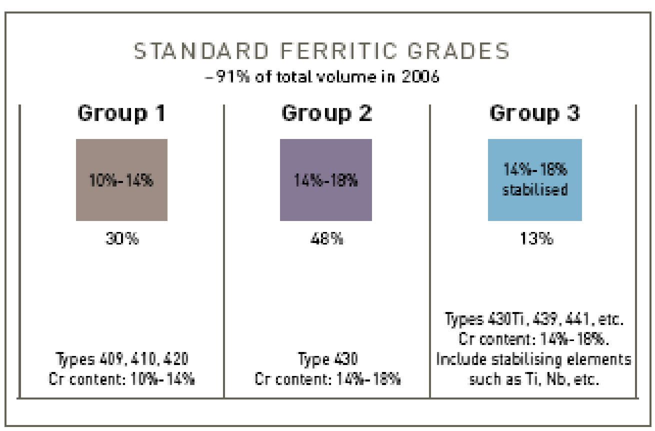

Groups 1 to 3 as defined by the recent ISSF brochure « The ferritic solution » are fully adequate to cover 90% of household applications

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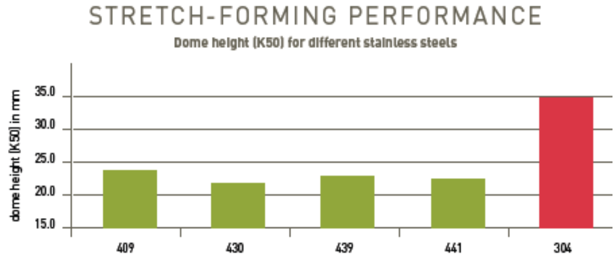
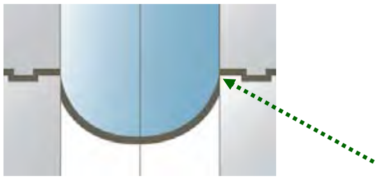
About forming ferritic grades





In strech forming the drawn area becomes thinner

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Ferritic grades: made to measure for IKEA articles

Cost Predictability

Selling price fixed 18 months in advance: Millions of catalogues shall be distributed 1 year in advance

Material Cost

IKEA started substituting austenitic with ferritic grades end of year 2003. At that time Ni was at level of 14000 USD/t and ferritic grades proved to be competitive even versus 200 series 4% Ni

Economies of scale

Total adoption of ferritics allows *optimal mother coils usage* as well as *standardization* of manufacturing practices and tooling

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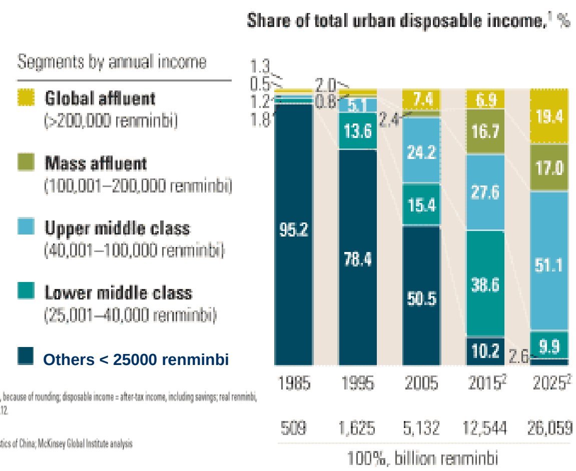
Household products and stainless development in China



[1] Some figures do not sum to 100%, because of rounding; disposable income = after-tax income, including savings; real renminbi, base year = 2000; 1 renminbi = $0.12.
[2] Base case forecast, Q1 2006.

Source: National Bureau of Statistics of China; McKinsey Global Institute analysis

In 1995, 77 percent of urban Chinese households lived on less than 25,000 Renminbi a year; by 2025 that figure should drop to 10 percent

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Adequate grade selection calls for competence on understanding actual end users expectations

In our world where natural resources are progressively lacking and where knowledge is exponentially accessible

Over-specifying

It is economically disadvantageous as well as ethically inconsistent

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Thanks a lot for your attention!

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STAINLESS STEEL FROM A CUSTOMER PERSPECTIVE - CHALLENGES FOR THE FUTURE IN THE MACHINERY INDUSTRY

J.T. Mäkinen

Metso Paper, Finland

Stainless steel is one of the fastest, if not the fastest, growing basic materials with 6.6% growth in 2007 and the growth estimate for 2008 is some 6.3%. The consumption has increased in many industry sectors including machinery industry, architecture and construction industries.

The industry investments and development of the infrastructure all over the world are affecting the material costs. The impact of production processes and labour costs are not that big by comparison. Significant impact on the material costs has come from financial speculation in base metals and alloys.

The machinery industry needs to find new ways to meet the challenges posed by customer demands and increasing raw material prices. Obviously there are options like reducing the raw material usage by changing structures, standardization, substituting materials to other alternatives and compound structures. Stainless steel is not irreplaceable and the possibilities are explored in the machinery industry.

The production efficiency within the paper industry has set new targets to machinery suppliers. The increase in the annual production leads to increased speed, or wider machines, or both increased speed and width. The increase in machine width and speed also requires different composite materials like glass-, carbon- and aramid fibers.
These materials are known to be resistant to corrosive environment and they can also stand large temperature variations without deformation. On the other hand, there are also applications where it is possible to reduce the overall weight of the machine by using new manufacturing technologies. Also the standardization is a solution to get an improved cost efficiency although it is not that easy task to achieve.

The paper making machinery industry has a lot of new challenges due to the growing markets all over the world. New lines and rebuilds both have different applications and need different approach from the engineering and materials point of view.

THE STAINLESS STEEL INDUSTRY'S RESPONSE TO NEW CHALLENGES: GRADE SELECTION AGAINST THE BACKGROUND OF THE ALLOYING ELEMENT MARKET

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Abstract

Fluctuations in the price of alloying elements have led users to reconsider grade selection. The European stainless steel industry has responded to changing purchasing behaviour. Innovation has made it possible for the European producers to keep material substitution trends within the stainless steel family. Beyond that, the stainless steel industry is taking advantage of the renewed interest in lower-alloyed grades to conquer fields of application previously associated with other (metallic and non-metallic) materials, in applications such as building (HVAC, plumbing, solar energy use, cladding, fasteners) and transport (road, rail).

Alloying-element price development

While technical development determines a material's potential, economic factors often decide its market success. The most relevant economic factor over the last ten years has been the volatility of raw-material prices – especially that of nickel (Figure 1). In applications with strong inter-material competition, where several materials can qualify for the same end-use, price factors usually tip the balance. There has therefore been growing concern that the cost of alloying elements – which is reflected in the alloy surcharge – and the availability of scrap could limit the development of stainless steel use.

Figure 1. LME Nickel prices development (Source: Metalprices / TKL)

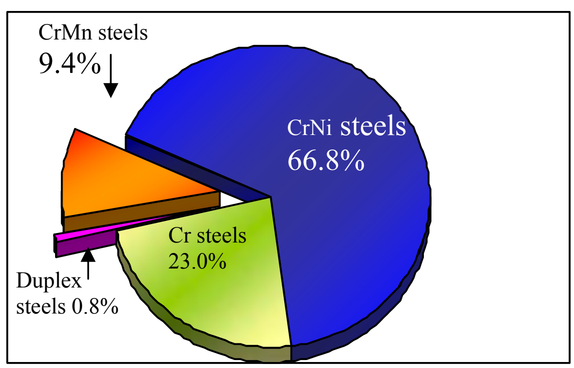

Figure 2. Share of stainless steel types in world world stainless steel melted production 2006 (Source: ISSF)

Changes in the austenitic/ferritic balance

On a world basis, the austenitic share has long remained stable, at around 65%. Looking at recent statistics, alloying-element price fluctuations do not seem to have changed the overall picture significantly (Figure 2). It should be remembered, however, that the peak in alloying-element prices coincided with a period of strong buildup of capacity, particularly in China. This mainly increased the production of austenitic commodity grades and made up for a drop in the production of austenitics in other parts of the world, such as Europe. Growth of the petro-chemical industry - a classic end-use sector for austenitics – compensated for the swing to ferritics in other applications.

Because of the long investment cycles in the steel industry, changes in the austenitics-ferritics balance can only be implemented over a longer period of time. However, European stainless steel producers have decided to strengthen their ferritics business. Significant investments are being made. The resulting shift of focus towards the ferritics will have long-lasting effects.

While the total ferritic/austenitic balance has not changed much, it is clear that the share of low-nickel, manganese-alloyed austenitic grades has risen quite substantially, to reach, currently, about 10% of world production. The potential risks of undiscerning use of these 200-series grades have been extensively discussed [1]. The European answer to this trend has been, on one hand, a focus on ferritic grades. Notably, stabilized ferritic grades now play a more important role in volume applications. Mo-containing ferritics widen the range of applications of this stainless steel family “upwards”. On the other hand, duplex options have extended “downwards” into non Mo-alloyed grades. There is now a wide area of overlap between austenitic, ferritic and duplex grades of comparable levels of corrosions resistance, from which the customer can make his choice [2].

New trends in the application of ferritics

The stronger focus on ferritics is not primarily a defensive action. On the contrary, at the lower end of the scale, 10.5% to 12% Cr grades are making inroads into markets traditionally dominated by coated carbon steel (Figure 3). The bus and rail industry, where painting is generally required, are cases in point (Figure 4).

Figure 4 (above). Bus body in stainless steel (Source: Centro Inox / De Simon)

Figures 3a and b (left). Prefabricated housing units made of laser-welded wall segment in grade 1.4003 stainless steel

Beyond that, applications in which aesthetic considerations are less important, such as cable trays and electrical cabinets, will provide further opportunities.

Commodity austenitic grades are often used for their ease of fabrication. As just a handful of grades can serve a wide range of purposes, they can also be selected for non-technical reasons, such as ease of stockholding. From a corrosion point of view, they are often over-specified. Producers have revived an interest in ferritics, such as 1.4016, in applications such as interior cladding, kitchen equipment and large domestic appliances, by making available cost-effective rolled-on surface finishes that closely resemble the well-known polished austenitic products (Figure 5). In an effort to reduce fingerprint sensitivity, progress has been made in both transparent organic and nanotechnical coatings. Colour-coated ferritic sheet is increasingly used where the reflectivity of bare stainless steel can be a disadvantage (Figure 6).

Figure 5 (above). Grade 1.4016 with a rolled-on satin finish applied in lift construction (Source: ThyssenKrupp Stainless)

Figure 6 (above). Colour-coated stainless steel used as tunnel liner, to avoid reflections (Source: ThyssenKrupp Acciai Speciali Terni)

Figure 7 (above). Stainless steel roofing material used as cladding in the building envelope (Source: ArcelorMittal Stainless Europe)

Stabilised ferritics, especially grade 1.4509 (441) are now widely accepted and can be an alternative to grade 1.4301 (AISI 304) in a number of applications, including professional kitchens or cladding and roofing (Figure 7). Grade EN 1.4521 (AISI 444) has a pitting-corrosion resistance similar to (and even better than) that of EN 1.4401 (AISI 316). It has now also been recognised in sensitive applications such as plumbing (Figure 8) or hot-water boilers.

There is growing awareness among users of the good formability of ferritic grades. The fact that their limit drawing ratio (LDR) is even higher than that of austenitics means that complex shapes can be produced by deep drawing [3] (Figure 9). However, as forming operations often involve both deep drawing and stretchforming, an in-depth analysis of the forming process may be required.

Figure 8. Drinking-water installation in grade 1.4521 (Source: Nussbaum)

As the forming behaviour of ferritics is similar to that of carbon steel (and especially springback is less marked than in austentics), the threshold for carbon steel users to start fabricating stainless steel is lowered.

The quest for energy from renewable sources is one of the driving forces of present and future technologies. Ferritic stainless steels are increasingly applied in gravity solar water heaters, which are popular in sunny climates. Due to their good thermal conductivity, these grades can also replace other metallic materials in solar panels. Besides black chromated panels, organically coated solutions have also been suggested. These can even be used to fully replace conventional roofing – with roof and solar panel integrated into a single component [4] (Figure 10).

Figure 9. Deep drawn decorative caps for automotive locknuts (Source: ArcelorMittalStainless Europe)

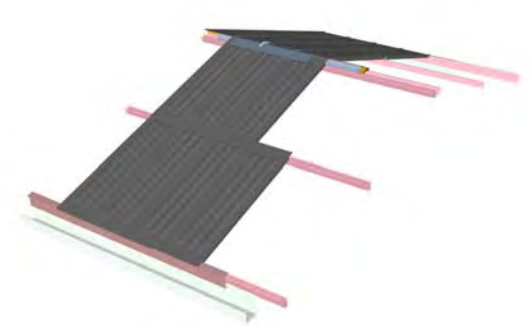

Figure 10. Lightweight solar thermal panel made from coated ferritic stainless steel, used as roofing element (Source: Acerinox / plou i fa sol)

Duplex Stainless Steels

Duplex stainless steels such as EN 1.4462 were previously known as heavy-duty grades for applications such as the offshore or pulp and paper industries. As a lower-alloyed variant, grade 1.4362 has demonstrated its ability to compete with Mo-bearing austenitic grades such as EN 1.4401/1.4404, for example, in fasteners (Figure 11). Duplex grades are increasingly found in the construction of bridges (Figure 12). The “lean duplex” grade 1.4162, whose pitting-corrosion resistance is superior to that of commodity grade EN 1.4301, has been used succesfully in benign environments.

Figure 11. Fasteners made of grade 1.4362 Duplex stainless steel (Source: Modersohn)

Figure 12. Bridge structure in grade 1.4162 Duplex stainless steel (Source: Outokumpu)

Low-nickel manganese-alloyed stainless steels

During the nickel-price peak in mid-2007, interest in the AISI 200 series revived. While some poorly-defined manganese-alloyed stainless steels were a source of concern in many markets, the European stainless steel industry decided to define a new grade: 1.4618. In many environments, this grade is close to EN 1.4301 in terms of corrosion resistance and shows good formability. However, from a purely technical and economic point of view, ferritic stainless steels constitute far more radical a change, insofar as they dispense with nickel altogether, instead of reducing its presence in the alloy.

The classics revisited

The discussion around “alternative” grades should not make the user forget the potential still available in the classic austenitic grades. Austenitics unite a high level of corrosion resistance with unique formability. There is also further potential in the use of the work-hardening properties of grades like EN 1.4318 (AISI 301 L/LN). They provide an excellent balance between high mechanical properties and adequeate formability, which makes them a good choice for structural applications specifically in passenger rail transport [5] and automotive design [6, 7]. Also in building and construction, work-hardened stainless steels have successfully been used for hollow sections in load-bearing applications, where they are used for lightweight, filigree structures [8] (Figure 13).

Figure 13. Glazed facade involving square hollow sections of stainless steel grade 1.4571 in the cold-worked condition CP350 (Source: Helin & Co Architects / M. Perlmutter)

Conclusions

The European stainless steel industry has accepted the challenges of the alloying-element market and turned them into an opportunity to demonstrate its innovative power. Compared to reference commodity grades EN 1.4301 and 1.4401, the applications of ferritic grades have been extended into more demanding applications previously reserved for higher-alloyed austenitics. The duplex family has been extended into lower cost grades. An answer has been found to the demand for type-200 stainless steels that is tailored to the quality expectations of the European market. In the areas of application for classic commodity grades – which form the economic backbone of stainless steel applications – designers and fabricators now have a choice between several austenitic, ferritic and duplex grades. Whatever the future development of the alloying-element market, the industry has solutions to propose.

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