WHERE AND HOW ARE THE WELDING PROCESSES DEVELOPING

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Abstracts

There are many different drivers of the welding processes besides the ones, which we are continuously wrestling with

- Productivity
- Quality
- Working environment

Other important factors are material development. use and consumption, environmental requirements and of course cost level.

The shipyard and automotive industries are most progressive in introducing new joining processes and applying the most appropriate one in each case.

Sustainable environment is becoming another important driver of welding.

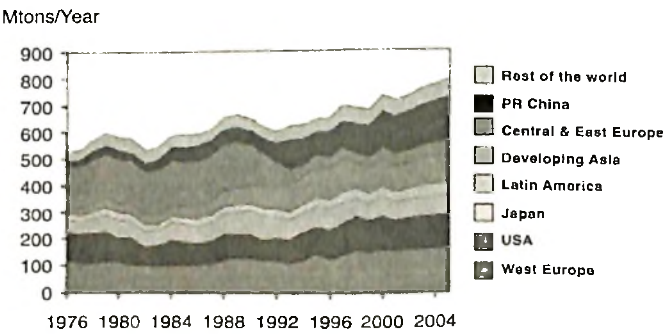
Some examples will be covered in this presentation.

1. Consumption pattern for metals

Welding is closely correlated to the consumption of metals. Steel is dominating and it will remain so for the foreseeable future. The consumption is growing with 1,4 % per annum (Figure 1) (1)

China is by far the largest consumer of steel (Figure 2) with its 23 % of the world production. The more than one billion citizens and the growing consumption e.g. in cars will result in high growth of the consumption, which figure 3 confirms.

Word Steel Consumption - 1976-2005



Steel consumpting growth 1,4 % year

Figure: 1

Apparent Consumption of Crude Steel 2001 in Mtons

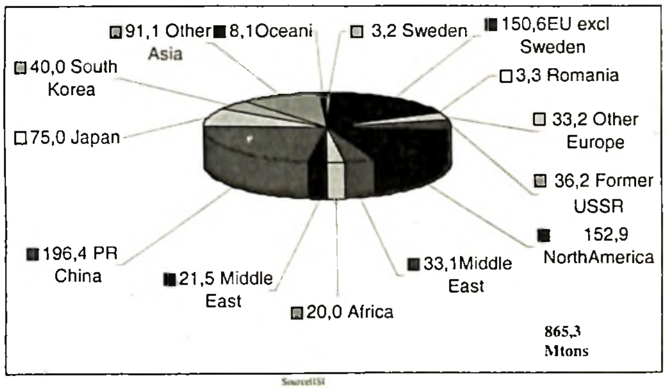


Figure 2: The high growth in China is also influenced by a growing shipyard industry.

Change in Steel Consumption in % 2001 compared to 2000

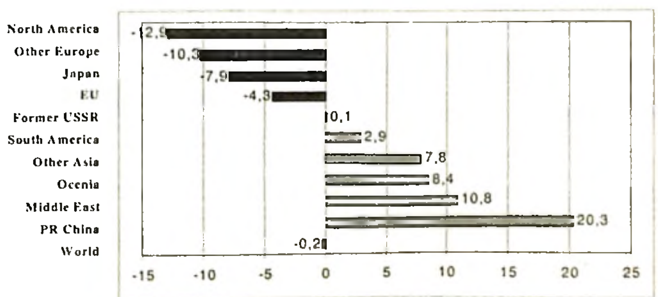


Figure : 3 demonstrates evidently the poor market conditions during 2001 in many countries.

The stainless steel consumption has however a steady growth 5,5 %/year even though it dropped below 20 Mtons two years ago but it is forecasted to exceed that level this year. This will be pushing the use of the high quality processes e.g. TIG- and Plasma-welding. Laser welding is forecasted also to be introduced.

Stainless Steel - fastest growing metal industry

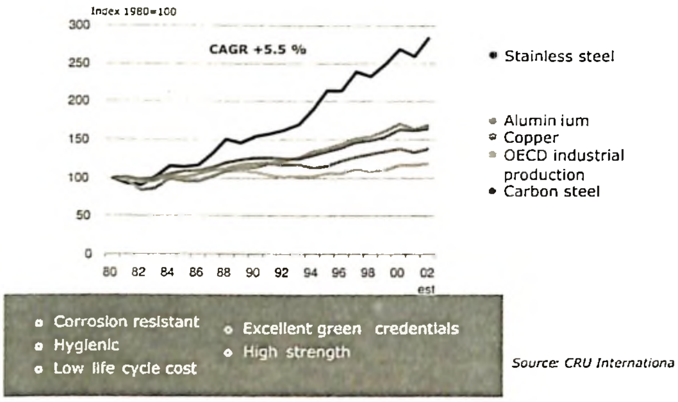


Figure : 4

The change in Al-consumption is much lower than expected 2,7 %/year (Figure 5). This figure can be drastically changed when Al is more commonly used in cars and in other parts of the transport industry.

A1 consumption

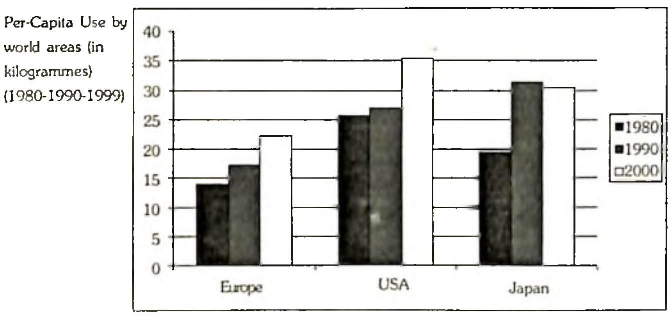


Figure : 5

2. Welding in the automotive industry

More light metals and less steel is the fastest reducing cure for reducing weight in modern cars. Some manufacturers are launching e.g. Audi and Jaguar; car bodies in Al with the objective to reduce the emission of CO_2. Even though the average weight for cars are annually increasing with 20 kg.

There is however a continuous increase of use of Al in cars (Figure 5) and the design concepts in Al are changing fast in order reduce the manufacturing cost of the Al-bodies. The former MD for Audi claimed some time ago that the car body was about 500 EUR more expensive than a steel one.

The manufacturing technology for Al-bodies needs to be further being improved. Mechanical joining with clinching and self-piercing riveting processes are examples on such measures. The laser/MIG hybrid welding is another joining process introduced resulting in lower heat distortions and stiffer car body.

Al-consumption in the car industry

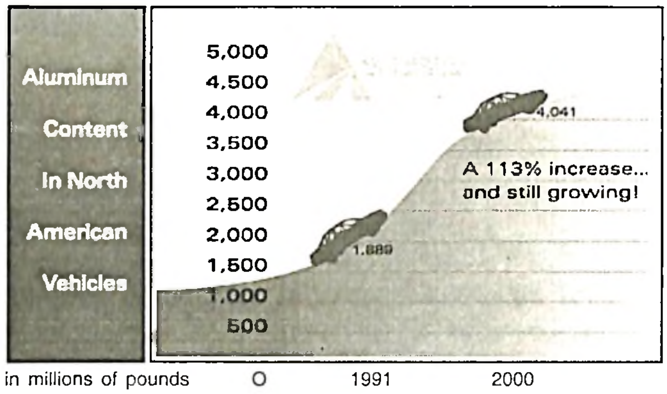


Figure : 6

The countermeasure against the higher use of Al by the steel industry is the introduction of Advanced High Strength Steels (AHSS), which is developed in project Ulsab financed by 33 steel companies. The conceptual design (Figure 7) was made by Porsche Engineering ending up with

- Meeting anticipated crash safety requirements for 2004
- Significantly improved fuel efficiency: 3,2 – 4,5 litre/100 km
- Lower CO_2 emission: 86 – 108 g/km
- Low environmental impact – recyclable
- High volume manufacturability at affordable cost
- Demonstrating effective design concepts in AHSS: - 200 kg lighter

Tube structures and tailored blanks (40 % of structures) are used. 85 % of the body is made in AHSS. The traditional manufacturing processes can be applied

- Stamping
- Spot welding
- Laser welding
- Hydro forming

It will be interesting to follow how these new options into the automaker's arsenal will be applied to improve safety, performance of lower fuel consumption without hitting the car buyer in the pocketbook.

ULSAB light weight body

25% weight reduction

improved crash safely

Tailored blanks and tube structures used

Figure : 7

3. Welding in the shipyard industry

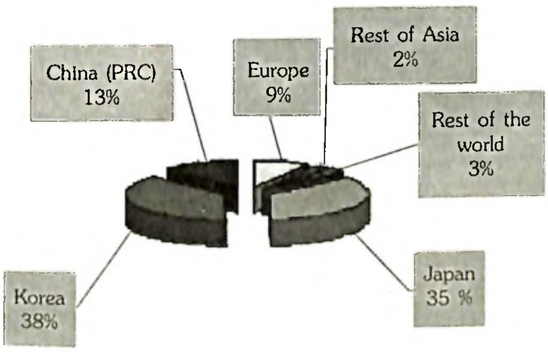
South Korea is by far the largest producer of ships (Figure 8) The market has during the last 15 years annually grown on average with 4,6 %. PRC is expected to increase its market share while in Europe Poland and Croatia is doing the same.

Arc welding will remain to be the dominating joining process but with a higher degree of mechanisation to deposit the entire weld metal corresponding (2,2-2,3) % of the steel weight in the ship.

One side SAW is the dominating process for the butt joints in the panel lines. Cored wires are often used and as well iron powder addition to increase the welding speed.

For welding the stiffeners we note more use of MIG/ MAG welding robots (Figure 9), which is since years very common in the Japanese shipyards.

Order book for ships in January 2003



Annual output 28.7 million GT

Figure : 7

Robot welding gantry

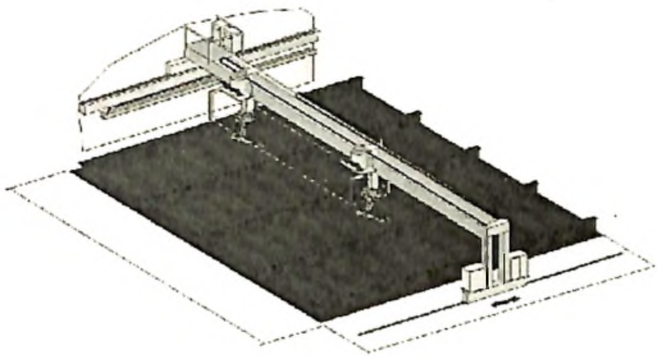


Figure : 9

A similar set-up with a gantry and suspended robots is used for curved panel welding stations.

Tandem MAG-welding (3 & 4) is becoming a common process in shipyards and construction industry. There are already about 100 installations running in production mostly in Germany (Figure 10)

Tandem MAG welding of Panel Stiffeners

Welding Data
Electrodes =1.2 mm
Throat thickness =4.5 mm
Strickout =20 mm

Parameters	Electrode1	Electrode2
Welding voltage V	29.5	30.5
Welding current A	385	301
Wire feed speed m/min	18.2	13
Travel Speed m/min	2.45	

Figure : 10

The Tandem solution has inherently greater freedom in varying the welding parameters like using different electrode diameters or mix with cored and solid wires besides the ordinary parameters for voltage, currents and travel speed. The electrodes can be aline with the joint or perpendicualer to it. depending on the application. Alined results in higher welding speed while perpendicular setup is aimed for high deposition rate.

In order to reduce the spatter and the interference between the arcs, pulsing with phase shifting is introduced.

There are additional efforts in Europe increasing the degree of mechanisation of welding. The EU-project DockWelder has the objective to demonstrate a flexible modular automation applied in welding ship sections in the dock (Figure 11).

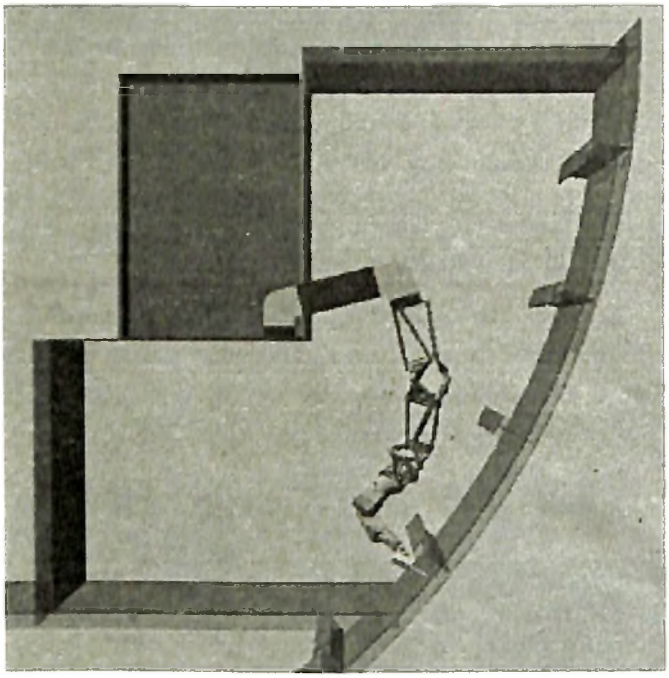


Figure : 11 - Artistic illustration of the Dock Welder

The Project the following participants

- Amrose Denmark
- APS Germany
- Cybenetix France
- Lindö Shipyard Denmark
- Ficantieri Shipyard Italy
- Inst. For Production Technology

An optical sensor for joint tracking is used in this instalation.

Many European shipyards have jointly investigated the feasibility introducing laser welding of ship panels and classification bodies have been involved for approvals of the welding procedures. Few installations with CO_2-lasers combined with cold wires were made some years ago. The accurate joint preparations with a gap < 0,5 mm required was a major obstacle. The level of impurities of sulphur and phosphor was another hindrance.

The latest process development with a combination of arc and laser welding; a hybrid process; is offering a more tolerant process with larger groove gap allowed 1,0 mm. The heat input is partly also reduced (10 %)

Besides a more tolerant hybrid process the travel speed can be drastically increased; up to 4 times for butt-welding of plate with t = 5 mm.

Such a hybrid set-up is in addition requiring a lower investment than a pure laser installation.

We are now seeing a technical breakthrough for the laser hybrid process at Meyer Shipyard in Germany. Figure 12 is an artistic sketch covering both butt-welding of the panels and fillet welding of stiffeners

The panels are manufactured with closer tolerances and much less distortion.

Ship panels 20x16 m welded with the hybrid laser MIG process

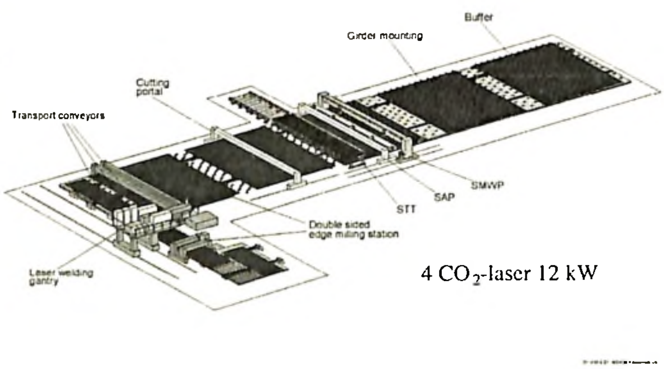


Figure : 12

There are other European shipyards also working with this process and close to invest in a laser panel line.

The next development phase has already started by developing a YAG-laser station for welding the webs and other structures on the ship (Figure 13 below).

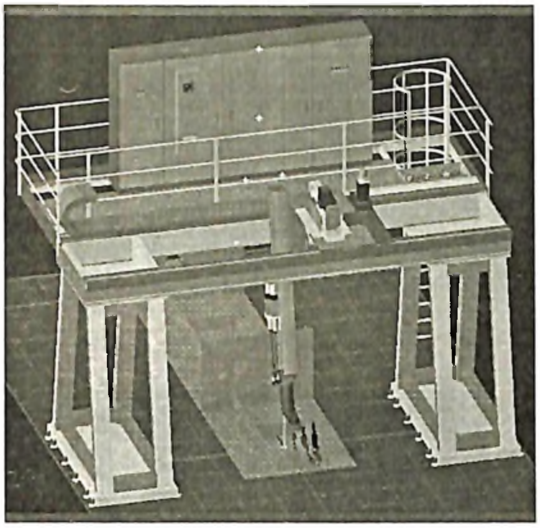


Figure : 13 - In this case a YAG-laser with the welding head mounted on an articulated robot is used thanks to the higher flexibility allowed by using an optical fibre delivering the light beam to the welding position. The wavelength is 1,06 um compared with the wavelength for CO_2 light beam 10,6 um, for which an which an optical fibre cannot be used.

4. Welding in power generation industry

The environmental sustainability objectives are among all resulting in an increased number of installed wind power stations, which contains currently a lot of weld metal on average 1500 kg. The SAW process is hence used when possible to get a high deposition rate. Then the welds must be made in down hand position with a root pass from inside and the capping passes from outside, for which two electrodes DC and AC are mostly used. Figure 14 shows typical joint preparations for the material thickness between 8-50mm.

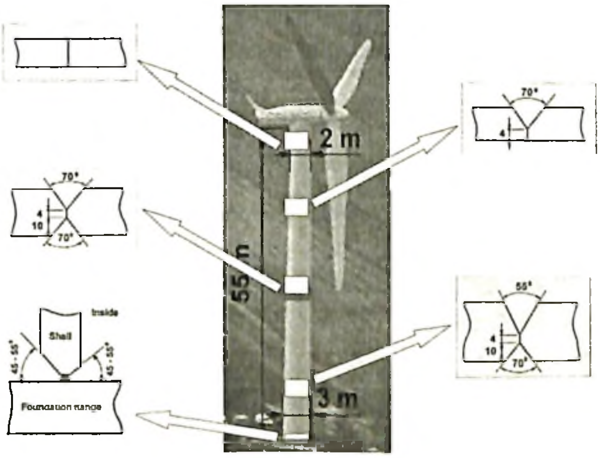
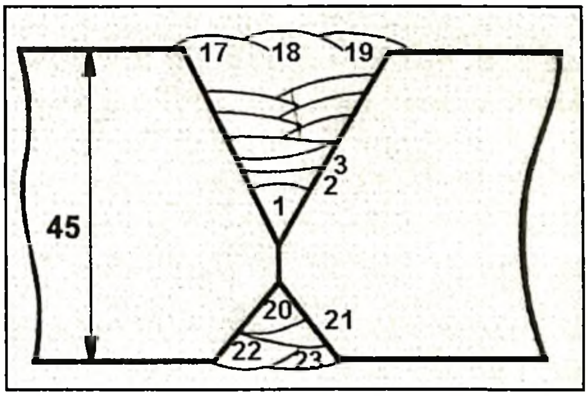


Figure : 14 - Typical joint preparations

Some welding data are listed in table 1.

t=45 mm, X-joint



Run No.	Wire diam. mm	Weld Current A	V	Spped cm/min
1	4	600	24	50
2	4	-600	25	50
3	4	600	26	50
5-12	4	600	27	50
13-19	4	600	30	50
20	4	750	26	50
21-23	4	600	30	50

table 1.

Tapering between shells of different thickness is recommended in order to reduce the stress concentration at the weld joint.

ESAB Production Line of positioners for wind towers

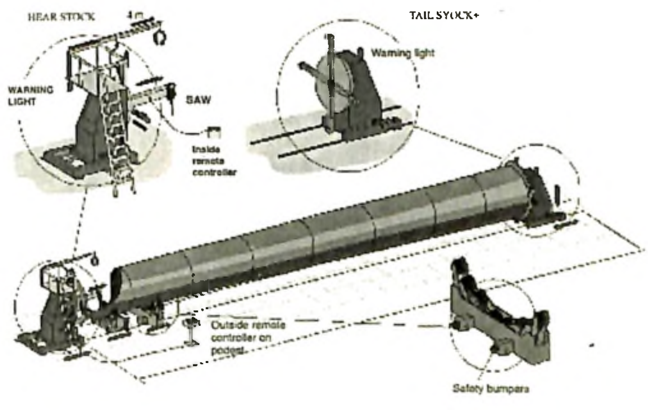


Figure 15

Systems similar to the one shown in figure 15 are often installed. As in other SAW applications metal-cored wires are introduced

In contrast to the "clean" wind power the nuclear power produces dangerous waste, which must be safely disposed. In Sweden the Swedish Nuclear Power and Waste Management Company (SKB) is carefully evaluating the Electron Beam Welding and Friction Stir Welding processes for encapsulation of the waste in durable canisters in Cu (4). These will be stored in a deep repository in the Swedish bedrock. The Cu canister consists of a five centimetre thick Cu casing. Inside, there is a cast iron insert to provide mechanical strength. The canister (Figure 16) is close to five metres long and has a diameter of about one metre. A canister filled with spent fuel weighs about 27 tonnes.

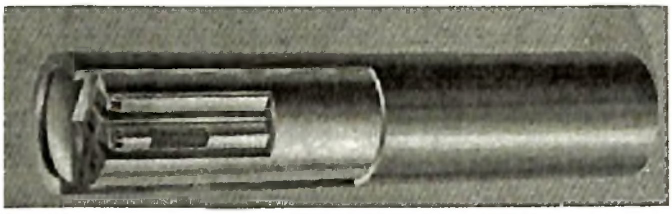


Figure 16: Cu-canister for nuclear waste

A full-scale Electron Beam Welding tests have been performed. In 1998-1999, a test rig was built at TWI for the Friction Stir Welding of mock-up canisters (5). A fixture holds the canister and rotates it during welding. The lid is pressed down with four hydraulic cylinders. The welding speed reaches 150 mm per minute. The FSW process has functioned well and SKB has ordered an installation, which is sketched in figure 17.

FSW plant for welding Cu-canister for unclear waste

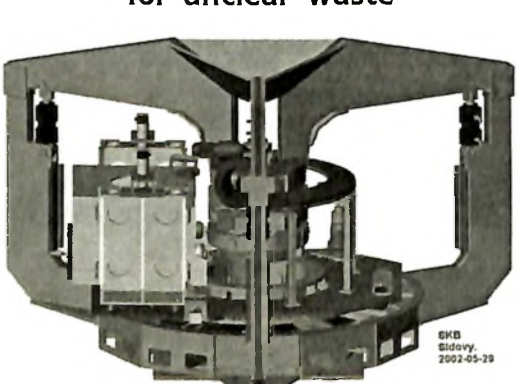
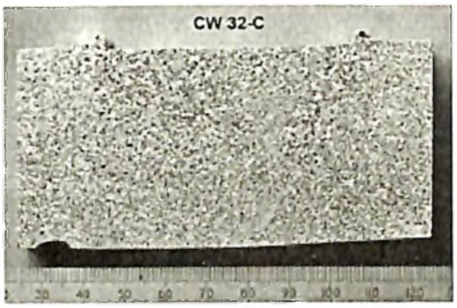


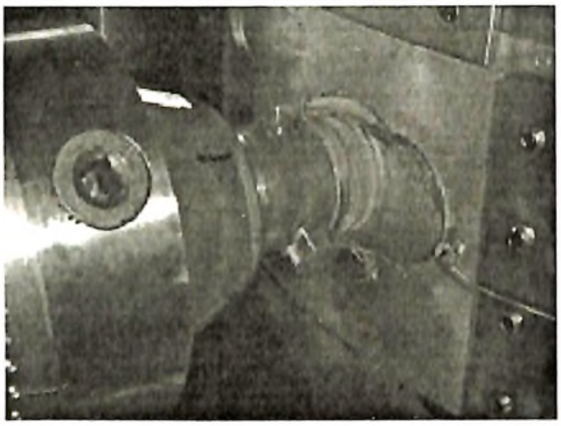
Figure : 17 - The welding head rotates during the process around the fixed canister Figure 18 shows the weld result.

Welding of a lid to Cu-canister for nuclear waste with = 50mm in Sweden



A transverse metallurgical section through 50 mm thick Cu stir weld

A 120 degree weld segment



The early stages of a Cu canister weld. Note that the tool is operating at read heat

Figure : 18

The FWS-process is continuously improve The reversal stir welding process (6) is judged to appropriate for certain butt, lap, compound lap and spot welding and material processing applications.

5. Summary

In summary it has been said in this paper

- Steel will remain the dominating material with a growth of 1,4 %/year

- China is the largest consumer of steel
- Stainless steel has the highest growth 5,5 %/year
- Al consumption growth lower than expected 2,7%/ year
- The Al-consumption may grow very fast when Al is used more in cars
- Sustainable environment is demanding development of the joining processes
- Safety issues will require major developments
- New joining processes are introduced
  - Hybrid Laser MIG
  - FSW
- The main drivers of the joining processes are
  - Shipbuilding
  - Car manufacturing
  - Sustainability
- Joining activities will be moved geographically with changes in consumption pattern

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