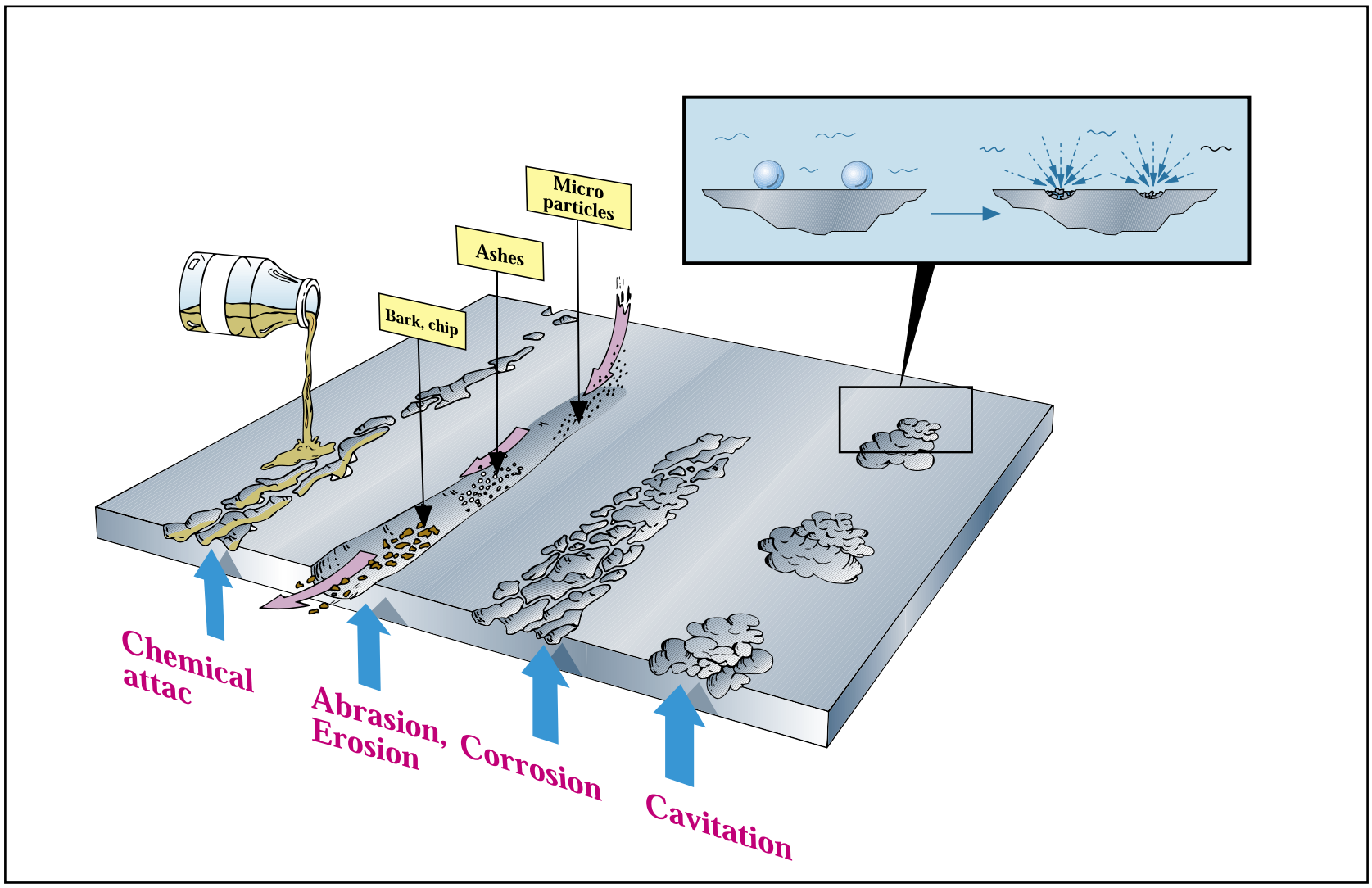


Renovating and protecting metal

Metal is used in many different industrial equipment and constructions. The metal gives the construction its structural strength but when in contact with water, particles, oxygen and/or chemicals, the metal surface starts to corrode, oxidise and wear out.

This will happen to all metals and alloys such as iron, aluminium, stainless, acid proof, duplex, smo, hardox, nihard, titanium etc.

Corrosion (such as galvanic, pitting, crevice, intercrystalline etc.), chemical attacks and in some cases the combination of erosion, abrasion, and temperature, will have a speedy damaging effect on the metal.

It costs the European industry billions every year.

A damaged surface does not necessarily mean that the inner part of the construction has lost its strength. The equipment COULD have a longer life cycle IF the renovation and protection of the metal surface are improved.

As we all know, it is difficult to teach an old dog new trick. The new technique (which has been proven to work) is not yet used to its full capacity.

After many years of experience, SKIU can confidently use methods and products such as:

- cement based wear protection
- FRP
- composites - surface protection
- composites - strenghening
- polyurethane
- polyurea
- welding
- thermal spraying

Each product is used on different types of metal damage. It is utterly important to appreciate what has caused the damage in order to know which product to use and how to use it. By looking at previous jobs we have also learned to apply the most economically friendly solution.

Only a few companies sell and possess the skills to apply composites accurately and to the right area. On the following pages we will focus on how the metal equipment can be renovated and protected with composite technology.
Economical applications have been carried out on:

- rotary vane feeder
- cyclonesand
- cones
- coal crushers
- mixers
- pumps (liquid, vacuum)
- flue gas equipment
- pipes
- chimneys
- scraper conveyors
- screws
- pitches
- suction boxes
- tanks
- rolles
- valves
- heat exchangers

When renovating damaged equipment, it is not enough just to know the product. You also need to know how the equipment works and the processes involved in order to attain the most economical upgrade and renovation.

Not one person or company knows all the processes and renovation methods for metal equipment. However, our European network have been successful in recruiting people and companies that have the necessary knowledge about the most important processes and optimising methods.

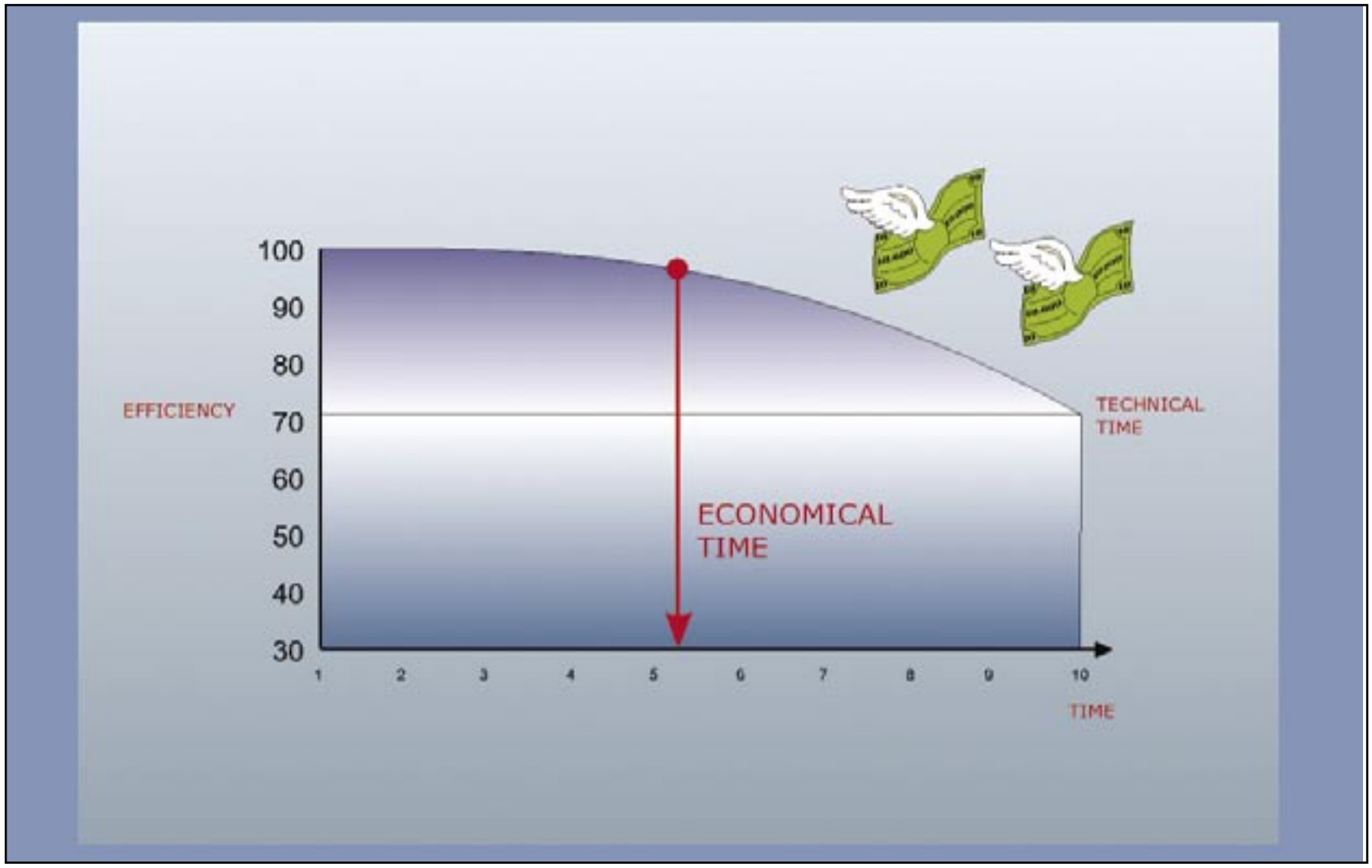
In a separate article we describe how everyday use of vacuum- and liquid pumps can reduce the overall costs.

Metal components in pumps wear, which will cause a reduction of the pumps capacity. When this happens, the pump requires more energy in order to pump the required quantity of media.

Since year 1990, the use of composites has extended the life cycle of thousands of pumps per year, all over Europe. Customers, who have used composites, have been able to save > € 100 000 in reduced energy costs.

When renovating and protecting metal, the first step is to inspect the equipment in order to see what has caused the damage and from that decide which technologies and products to use. In order to ensure that the proposed method is worth using, a cost analysis is presented.

It is extremely important to our Scandinavian network that the work we carry out save our customers both time and money, using methods that are as environmental friendly as



possible.

It is essential that the customer have a good understanding of how we work to reach the best results. Together we can assemble all the required parameters in order to calculate the costs before and after the renovation.

To obtain the best results, the following preparations must be carried out:

- cleaning
- perspiration
- SA 2½ - 3
- profile 75-125µm
- conventional blasting

- ”Dust free” blasting with the sponge jet method

Epoxies give the metal its density and strength and are in general known for their excellent adhesion. Depending on factors such as temperature and other necessary characteristics, the epoxy could be based on polyamide, isoforondiamine and cycloaliphatic, etc.

IN ORDER TO REINFORCE the epoxy a multitude of different materials can be used, i.e.:

- steel
- ceramics
- laminates
- carbon fibre
- kevlar
- nano

How to combine the right epoxy with the right reinforcing material is one of our factory secrets, however, according to the SSG Report 1908 (which we have partly written)(which we have been involved in writing) the material should in general receive the following test results in order to be titled a “composite”.

- Pressure durability
D 695 min 600kg/cm2
- Bending durability
D 790 min 500kg/cm2
- Tensile strength
G 1002 min 150gk/cm2

Temperature resistance can only be achieved by using an epoxy which is developed to tolerate the temperatures it will be exposed to.

Temperature resistance is presented by Tg (glastransition temp), or HDT (heat deflection temp).

There is no point using the composites in immersed media above this temperature, as a higher temperature will decrease the composite protections maximum life cycle.

In order to attain the best possible renovation, we first need to carry out an application analysis to choose the right product for the right media. A cost analysis shows the most economical solution.
A control report is also written to ensure that all the work is carried out correctly.

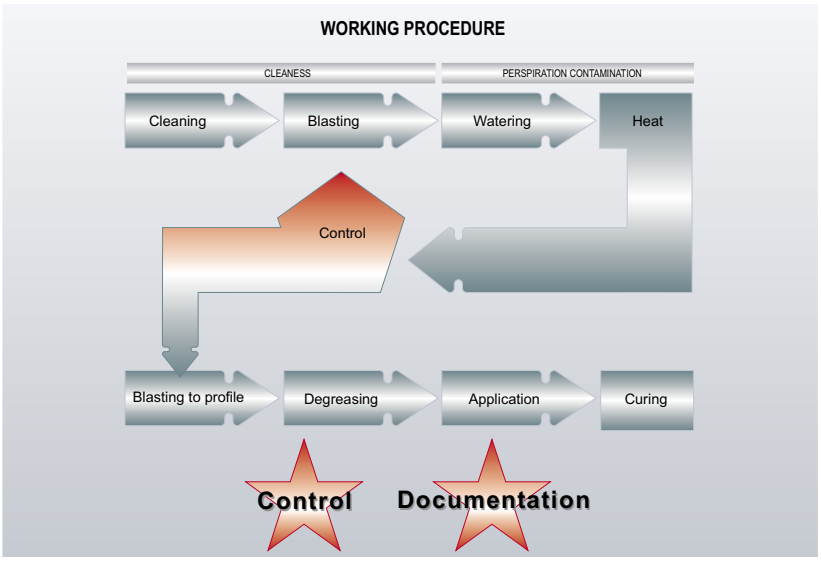
We protect your corroded equipment

A lot of equipment that has been damaged by corrosion is replaced without need.

Today we have the technology and knowledge, making it possible to renew and protect i.e. pumps, valves, pipes, heat exchanges, electro filters, tanks, rollers, suction boxes, transport screws.

Whether the equipment could be protected or renovated depends on the type of corrosion and the medias temperature, pH and content of chemicals and particles.

Nowadays, the progression of industry products has made it possible to protect the equipment from most chemical attacks up to 200° C. Just a few years ago this would have been impossible. However, the development continues; it is just to embrace it and use it in the right place and the right way.



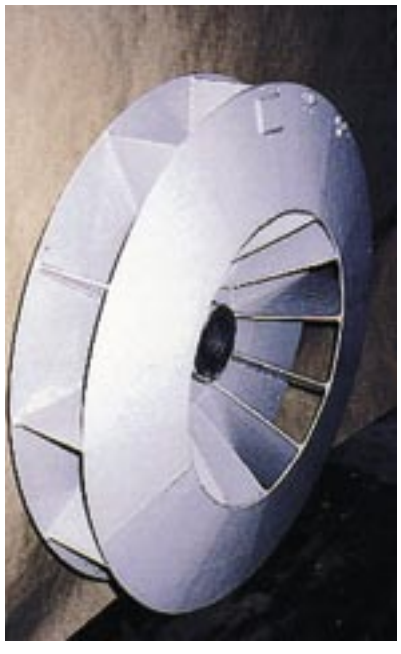
To attain the best possible repair and upgrade of the equipment, the preparatory application and hardening MUST be carried out correctly. To ensure that the work is done properly the whole process is documented.

Fans

Many industries use fans. Due to a build-up of particles the fans start to vibrate, creating an unbalance which is caused by the vibration. This can damage bearings before the correct action is taken.
By maintaining the fans using tested materials and technologies, the unbalance can be prevented. Composites normally have low friction coefficients and high surface energy, meaning that the particle cannot stick too easily.

This in turn reduces the chance of unbalance and vibrations.

Whether it is possible to surface treat the fan in this particular way, depends on the medias temperature, pH and content of chemicals and particles.



Renovation and manufacturing of tanks

We repair and upgrade tanks with typical damage such as welded joints with galvanic and/or pitting corrosion. If the minimum thickness of the wall still remains, using composites is guaranteed to be the best method to restore the metal.

To attain the required quality, composites have an adhesive property over 15 MPa.

We have even generated collection tanks for sulphuric acid which, instead of being produced with expensive alloys, have been constructed in regular steel and protected with a chemically resistant composite. We protect against media such as sulphuric acid, hydrochloric acid, carbon dioxide, hydrogen peroxide, oil and diesel.

Inspection is important

An inspection should be carried out in advance to make sure that the thickness of the metal is sufficient enough to allow repairing and upgrading of the equipment.
Today we can use a wide range of materials and methods to protect most of the equipment in the industry, munucipalitys and power stations.

We have resources and methods

There is a range of equipment worn by many different media such as bark, woodchips, pulp, recycled paper, sawdust, pvc granulate, waste, sand, ash, coal, slurry, oxide scale, to name a few.

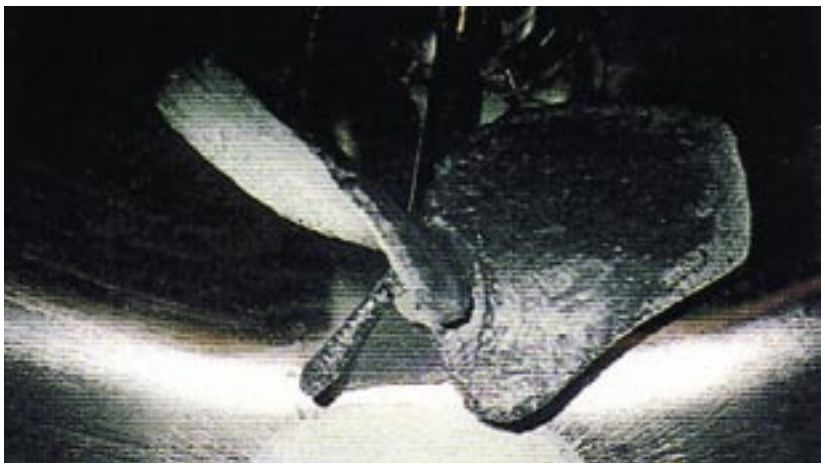
How much the equipment wears, depends on the particle size, speed, angle and temperature. It also determines whether it is possible to repair and protect the equipment with other materials such as:

- *thermal spraying*
- *cement based 400 MPa*
- *hard welding*
- *rubber*
- *ceramic reinforced composites*

Screw pumps

Waste water plants are in many cases used to allow screw pumps to pump large volumes of water. This can result in corrosion and erosion of the pump, which in turn make the critical dimension too large, reducing the pumps capacity and increasing the energy consumption. The trough can also be damaged by corrosion and erosion.

We have renovated and protected a number of screw pumps and concrete troughs, with considerable economical benefits for the customer as a result.



Mixers

We are also repairing and surface protecting other sensitive equipments such as mixers for sludge, white liquor, etc. Previously, these mixers were manufactured in acid proof steel.

Ceramic reinforced composites have extended the life cycle from three months to more two years, saving the customer thousands of Euro.

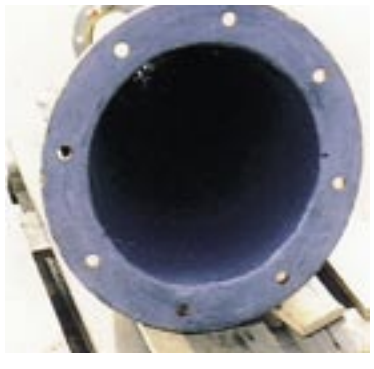
Transport screws

.We have renovated and protected hundreds of transport screws from wood chips to bark.

Studies have shown that these screws have a longer life cycle than screws manufactured in stainless steel, hardox etc.

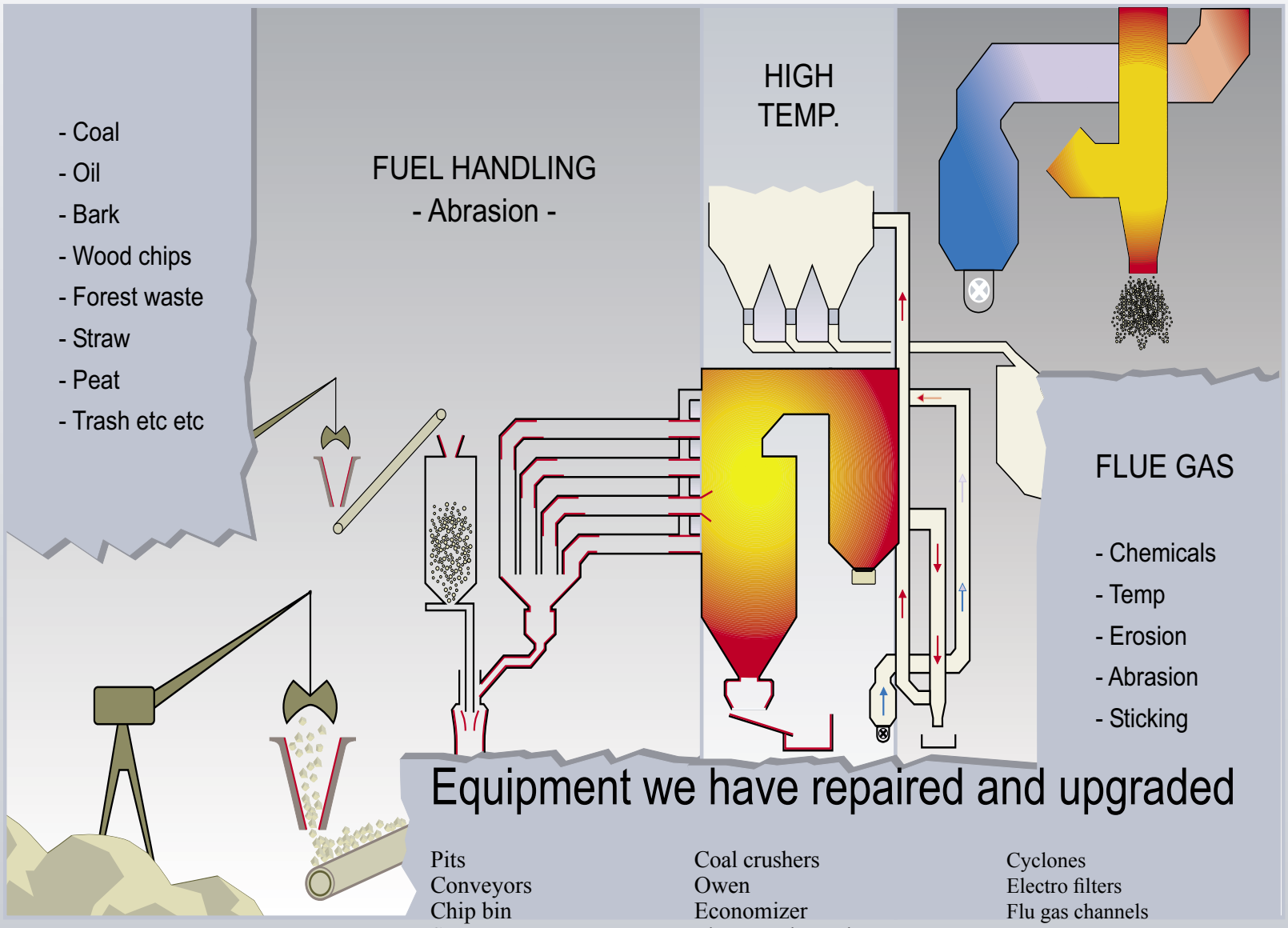
Thus, the customer has as an alternative manufactured the screws in regular steel and protected it with ceramic reinforces composites. Previous results show that the customer has saved thousands of Euro by using this method.

Cones and cyclones



Cones, cyclones, etc. are exposed to various hard wear. When protecting and repairing the cones, a form is used in order to attain the acquired surface finish. By doing this, the risk of break downs is reduced and the life cycle extended.

POWER PLANTS



Equipment we have repaired and upgraded

Pits	Coal crushers	Cyclones
Conveyors	Owen	Electro filters
Chip bin	Economizer	Flu gas channels
Screws	Flue gas channels	Scrubber
Pitches	Fans	Pipes for ash
Pipes	Screw for ash	Fans
Driving ramps	Cones	Chimneys
Tanks	Pumps	Heat exchangers
Cyclones	Valves	

We have many years of experience in repairing and protecting metal in power plants

Metal damages in European power plants are in many cases very costly.

The damage on the equipment and constructions and the high costs is caused by wear, erosion, corrosion and acid attack, sticking to a variety of different temperature ranges. This determines which material to use.

Since the beginning of the 90s we have repaired a large amount of equipment in power plants across many European countries. It is important to use the right material the right way and at the right place, in order to attain the lowest possible life cycle cost (LCC) and minimal break down time.

Over the last 20 years we have repaired and protected equipment with i.e. ultra high performance concrete (400 MPa - 1200° C), ceramic composites (150° C), chemically resistant composites (200° C), polyurathane, polyurea and thermal spraying. This means that we have been able to protect even he most extreme wear and acid attack.

John Beeget SINTEF (left) and Arne Øwre-Johnsen with the test equipment SINTEF have developed for the safecoat project relating to warm/cold wall effect.

Coordinator Klas Vikgren together with professor Anders Ulfvarson of Chalmers Technical University and Tommy Thörn, representative for the participating companies.

Composite coating or conventional painting in corrosive environments?

Everyday the corrosion costs communities millions of Euro. Some industries, municipalities and shipping companies are more affected than others by corrosiondamage and increased maintenance and production costs.

The many meetings with ship owners such as Stena Line, B&N, Broströms, Wallenius, Saudi Petro gas Co and offshore outside Norway and England during the 90s made us discover that the following areas suffer badly from corrosion:

- **Sidewalls of tanks with Crude Oil 70° C**
- **Roofs of ballast tanks 70° C**
- **Weld joints**
- **Edges**
- **Microbiological corrosion (mic)**
- **Aging**
- **Temperature variations,**
- **Chloride content,**
- **Moisture**
- **Underfilm corrosion**
- **Equipment in contact with salt water**

During the same period, we met around 80 paper mill owners within the paper industry and noticed that their corrosion problems predominantly involved:

- **Paper machines**
- **Rolls**
- **Cranes**
- **Fans**
- **Pumps**
- **Valves**
- **Tanks**
- **Flue Gas .**

The corrosion protecting paint which is used on all these problem areas is mainly conventional painting.

In order to show that there are better developed corrosion protecting pains available and to prove that composites give better corrosion protection than the best conventional paints, we applied for an EU-grant in 2000.

The following companies applied for the grant:

- **Öwre-Johnsen AS, Norway**
- **SIU Ltd, Sweden**
- **Teke OY, Finland**
- **JM Shotblast, England**

Five research institutes and universities also took part:

- **Sintef, Norway**
- **Corrosion Institute, Sweden**
- **Chalmers Technical University**
- **Gothenburg University**
- **Tammerfors University, Finland**

In 2002 the European Union donated € 600 000 to this project, which would test composites against conventional painting on dry and moist metal to achieve the maximum corrosion resistance.

However, in order to obtain the fund each company were required to contribute with a similar amount through their own work.

The EU project Safe Coat, which total cost would be € 1.2 million, could then begin.

Together we decided to test and control:

- **Corrosion resistance with dry and moist surfaces.**
- **Flexibility**
- **Adhesion**
- **Warm metal and media**
- **Acid attack**

Microbiological corrosion (MIC)

- **Underfilm corrosion**
- **Osmosis effect**
- **Temperature resistance**
- **Air bubbles in the protective layer**

Tests used were: ISO
Aging 6270/2812-2
Cycling 2812-2
Condensation chamber 6270
Osmosis
Water Intrusion
Microbiologic
Cathodic 15711
Cyclic 20340
ISO 20340

- **Adhesion 4624**
- **Porosity 4626-2**
- **Rust 4626-3**
- **Cracking 4626-4**
- **Flaking 4626-5**
- **Chalking 4626-6**
- **Underfilm corrosion**

To be able to carry out the test in higher temperatures (70°C) Sintef had to construct special equipment (see picture above).

Rust protection tested were:

1. The most conventional paints for the paper industry and the ballast tanks on ships
2. Three different types of composites.

Test results showed that many composites work better than the best conventional paint products in terms of:

- **Flexibility**
- **Adhesion**
- **Warm metal and media**
- **Acid attack**
- **MIC**
- **Air bubbles in the protective layer**

None of the products passed the 70°C test., however, we found a composite which HDT (Heat deflection temperature) was 100°C. We also tested this composite and as the HDT was higher than the test temperature, the composite passed the test as expected.

During the four years following the start of the safe coat project development has quickly moved forward; today there are composites which can tolerate a heat of 200°C as well as aggressive chemicals such as caustic, acids, hydrogen and peroxide, etc.

However, not one individual product alone possess the capacity to cover all corrosion problems.

Instead specific damage analyses must be carried out before the right product can be used in the right place.

Composites are used and will be used for many years on areas where the metal is damaged by

- **Abrasion**
- **Erosion**
- **Chemicals**
- **Sticking**
- **Corroson**

Composites are more frequently used for serious corrosion where conventional painting is insufficient or only lasts for a short period. What method to use depends on the conventional paintings weakness and strength compared to composites (see above).