FFI

Controlled Oxidation (CONTOX)

Project within Sustainable Manufacturing Systems

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FFI

Content

1. Executive summary 3

2. Background 4

3. Objective 5

4. Project realization 6

5. Results and deliverables 7

5.1 Delivery to FFI goals 8

6. Dissemination and publications 8

6.1 Knowledge and results dissemination 8

6.2 Publications 8

7. Conclusions and future research 8

8. Participating parties and contact person 9

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

The press hardening process is based on the forming of hot blanks, in the austenitic state, to improve the formability as well as obtaining a final martensitic structure by subsequent rapid cooling in the forming tools. The technique can be summarized in the following steps.

1. Punching of blanks in uncoated boron steel, 22MnB5
2. Heating to austenitizing in a gas or electrical heated furnace
3. Handling of blanks between furnace and press
4. Forming and hardening in cooled tools
5. Internal transport to surface cleaning
6. Surface cleaning by shot blasting
7. Packing of components to customer

The project main aim is to eliminate the surface cleaning (oxide removal) by shot blasting (point 6), but to reach to that target it is necessary to address a number of points. The most important of those points is to enable the possibility to paint directly on the hot-formed components while fulfilling the demands regarding paint adhesion, corrosion performance and weldability. The consequences of such an elimination of the surface cleaning step by shot blasting would give great environmental impact by reducing the energy usage and by eliminating the blasting media usage. Improvements regarding internal logistics and shape accuracy are also to be expected.

A short summary of project results will here be given in point form.

- Experimental equipment permitting to conduct controlled oxidation try-outs have been developed and manufactured.
- Direct paintable hot stamped samples have been produced by the reduction-oxidation technique (no shot blasting necessary).
- Hot stamped samples have been produced which were exposed to air for 15 seconds prior to forming and hardening in a small hydraulic press. The samples showed good corrosion results.
- Reduced furnace temperature from 930 to 870°C gives an ec-painted component with better corrosion than for those produced at 930°C.
- Samples coated by a thin aluminum layer of 0.1 μm gives a reduction in total obtained oxide thickness which provides direct paintable specimens (for less oxidative atmospheres) with promising corrosion results.

- A custom designed dew point measurement system have been developed and implemented into serial production furnaces.

A research hardening line has been ordered and will be used to fine tune/optimize the controlled oxidation technique treated in the project and to transfer the technique in to serial production by the year 2015.

2. Background

The press hardening process (or hot stamping) was invented back in the seventies in cooperation by former Norrbottens Järnverk and Luleå Tekniska Högskola. In summary, the process is based on the forming of hot blanks, in the austenitic state, to improve the formability as well as obtaining a final martensitic structure by subsequent rapid cooling in the forming tools. The technique can be summarized in the following steps, see also Figure 1.

1. Punching of blanks in uncoated boron steel, 22MnB5
2. Heating to austenitizing in a gas or electrical heated furnace
3. Handling of blanks between furnace and press
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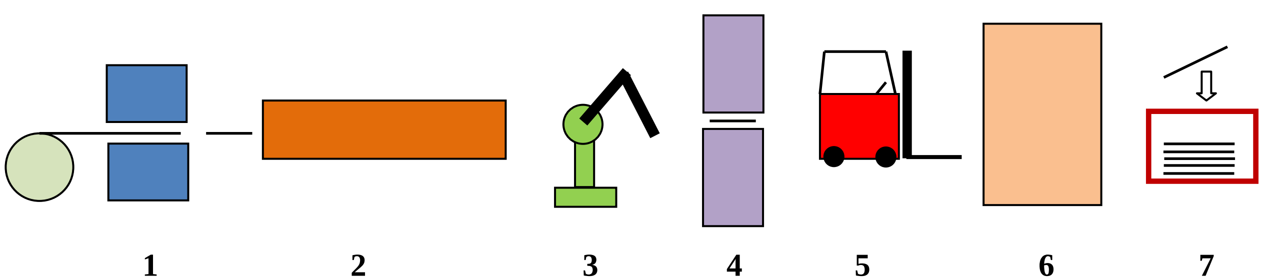

Figure 1. Illustration of a typical press hardening process.

Both a costly and energy consuming process step that also influences the component shape in a negative manner is the shot blasting. Large amounts of shot blasting media (small steel particles) are transported to each factory every year. Eventually the blasting media is consumed and a fine dust remains which is regarded as hazardous to the environment, which mean that a costly special treatment and deposit is needed.
In the press hardening process, a low alloyed steel material called 22MnB5 is commonly used due to its desirable properties and low price. The thickness range commonly used is in the interval 1 to 2 mm. Carbon content in the interval 0.2 to 0.25 wt% in combination with a low amount alloying elements provide good weldability. The steel in question has good hot forming characteristics and hardenability in combination with fine final

mechanical properties. The fine hardenability is achieved by the addition of the alloying elements; manganese, chromium, silicon and boron. The majority of the components produced are for the automotive industry around the world. The usage of Ultra High Strength Steel (UHSS) components, to which the hardened boron steel belongs, is with advantage used as passive safety components due to its excellent mechanical properties. This in turn provides great weight reductions with maintained or increased passive safety. More specific examples of press hardened components are; a, b, c-pillars, side impact beams, roof bows and bumper beams, some of these are illustrated in Figure 2. Reductions of the car body weight immediately reduce the energy usage which in turn gives a decrease in CO_2 emissions. The usage of UHSS components is expected to increase dramatically the coming years, not only in passenger cars but also in heavier vehicles such as trucks and buses. In the case of trucks, great savings both for the economy as well as environment are expected due to decreased curb weight and increased loading capacity.

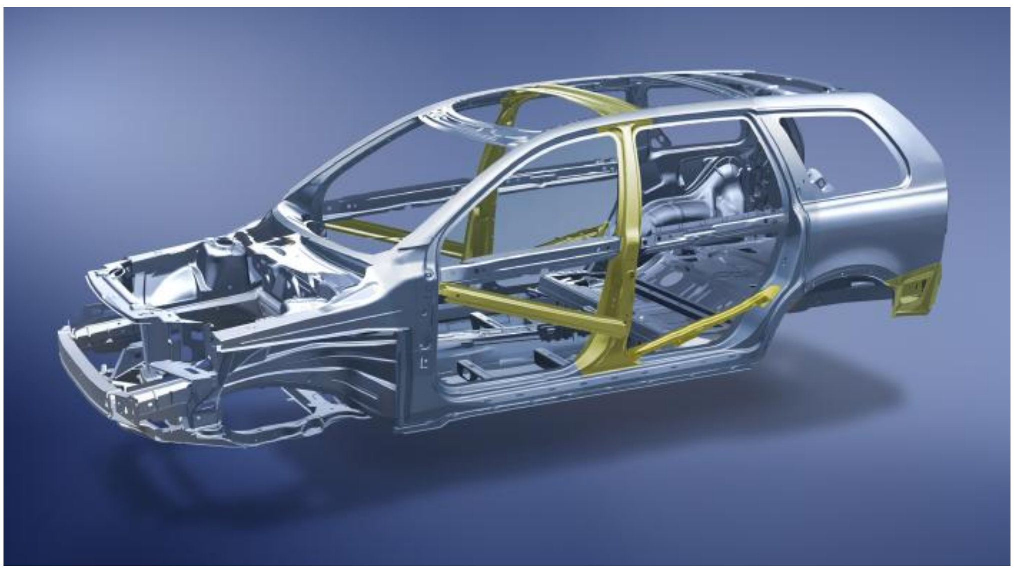

Figure 2. Illustration of some press hardened UHSS components, marked in yellow.

3. Objective

The project objective has been to develop a new innovative process technology for the press hardening process. The process developed is principally based on formation of a specific oxide layer on the non coated steel surface prior the actual forming and hardening. The major characteristics with the created oxide layer are to eliminate the shot blasting (see step 6 in Figure 1) and improve the corrosion protection performance with improved or maintained weldability/paintability.

4. Project realization

The project has been realized by the cooperative work between the three partners Gestamp HardTech AB, Swerea MEFOS and Swerea KIMAB. The project has been spit into several work packages as given and briefly explained in the following. Here given as the initial plan, which only has had minor changes throughout the project.

WP1 Design, manufacturing and assembly of the experimental equipment

Due to the need of a unique furnace design currently not commercially available that provides the desired possibilities in obtaining both controlled reduction followed by controlled oxidation, motivates the need for a custom made experimental furnace solution. Therefore, the project will start by design of the experimental equipment, manufacturing of non-standard parts, purchase of standard parts followed by assembly and function control with possible modifications/improvements.

WP2 Process optimization

In this stage of the project, basic experimental studies will be conducted. The experiments will be conducted using the equipment developed within WP1. The aim is to find and define the process window for the process technique that will be developed in order to achieve an efficient and robust process for controlled oxidation that is suitable for industrial implementation.

WP3 Manufacturing of test material for post evaluations

Within the project, test material for post evaluations will be produced based on the results in WP2. The test material produced here will be used in WP4-WP6.

WP4 Material properties – paint adhesion and corrosion resistance

Here, paint adhesion and corrosion testing of both oxidized as well as reference material will be conducted.

WP5 Material properties – welding

In this part of the project, process window identification for welding of oxidized material by different welding techniques.

WP6 Mechanical testing – spot welded joints

Mechanical testing of spot welded samples from oxidized material will be compared to corresponding welded reference material.

WP7 Industrial implementation

Here the work is focused on the transfer of knowledge gained throughout the project into a future industrial implementation. Technical and economical effects for the implementation into existing as well as new production equipments will be treated.

WP8 Project management

The project management will coordinate and follow up all project activities as well as to report and continuously spread the knowledge gained throughout the project to all parties involved.

5. Results and deliverables

- Experimental equipment permitting to conduct controlled oxidation try-outs have been developed and manufactured.
- Direct paintable hot stamped samples have been produced by the reduction-oxidation technique (no shot blasting necessary).
- Hot stamped samples have been produced which were exposed to air for 15 seconds prior to forming and hardening in a small hydraulic press. The samples showed good corrosion results.
- Reduced furnace temperature from 930 to 870°C gives an ec-painted component with better corrosion than for those produced at 930°C, see Figure 3.
- Samples coated by a thin aluminum layer of 0.1 μm gives a reduction in total obtained oxide thickness which provides direct paintable specimens (for less oxidative atmospheres) with promising corrosion results.
- A custom designed dew point measurement system have been developed and implemented into serial production furnaces.
- A research hardening line has been ordered and will be used to fine tune/optimize the controlled oxidation technique treated in the project and to transfer the technique in to serial production by the year 2015.

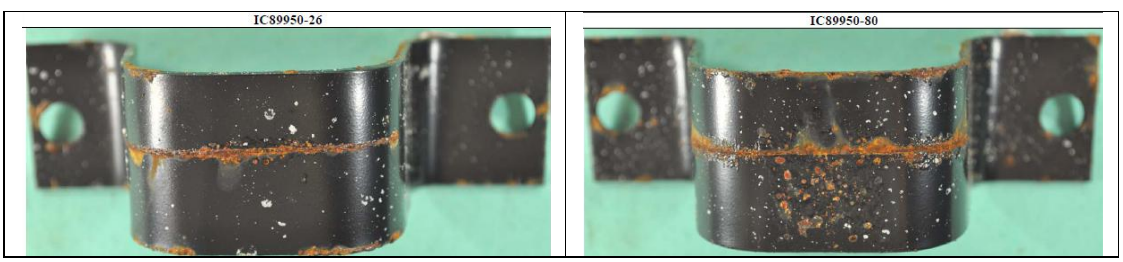

Figure 3. Visual appearance after an accelerated corrosion test for painted hot formed samples (not shot blasted). The left sample shows better results than the right.

5.1 Delivery to FFI-goals

By the good results obtained within the project, the goal is to completely eliminate the shot blasting step in production by the year 2015. This will in turn mean major direct energy savings and reduced CO_2 emissions. Furthermore, the environmental impact of using blasting media will be eliminated. The results of the project can contribute as a basis with great potential in reducing the fossil emission of CO_2 during the production of Ultra High Strength Steel components by press hardening. This will have an increasing impact on the environment due to the increased usage of UHSS components in vehicle bodies. So the socially beneficial effect will be large, both through streamlined production and through lighter vehicle structures, giving large energy savings, reduced emissions and increased safety for the occupants.

6. Dissemination and publications

6.1 Knowledge and results dissemination

The investment of a research hardening line at Gestamp HardTech's Luleå factory will speed-up the industrial implementation of the controlled oxidation technique. Having the key-ingredients for a proper process from the current project would give a great opportunity for "industrial scale up" success.

6.2 Publications

No external publications have been released at the writing moment, but participation with project posters at FFI-conferences.

7. Conclusions and future research

The project has shown very promising results regarding the possibility to avoid shot blasting. Future research in the area will primarily treat fine tuning of the controlled oxidation process and extension to fit serial production. Furthermore, extended welding studies/evaluations need to be performed.

8. Participating parties and contact person

Contact person

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