

MODULE G – THE MARKET LEADER'S CHOICE

If your hot stamping business has a real global footprint regarding production facilities and product contents, it needs an even stronger organization of knowledge and skills infrastructure. Standardization of equipment and procedures as well as "task forces" for trouble shooting, launch support, inhouse training etc. has to be installed.

To accomplish this, our **Intensive Training in Press Hardening Module G** has been developed to these specific needs, and, on particular request of "the" market leader. The course has been designed with a distinctive balance between theory and practice comprising of hands-on experience on a fully equipped PHS production infrastructure, lab internships, seminars and knowledge & skills workshops.

Finally, Module G constitutes an **all-inclusive journey from fundamentals**

to industrial practice covering literally everything from:

- fundamentals of heat treatment and hot forming
- development of press hardening technology
- PHS parts in contemporary multi-material architectures
- PHS process strategies & material systems
- functional gradation, tailored property parts & strategies
- process parameter selection & adjustment
- materials testing & consistent process monitoring strategies
- quality management & failure modes.

At the end of the day, knowledge and skill have to be brought to the production shop floor!

Target Audience

The Intensive Training in Press Hardening Module G is meant to establish and improve the individual skills of engineers, technicians and foremen in the fields of production and quality assurance, as well as maintenance, production planning and control, marketing & sales, and tool design and manufacturing.

Program

The training contents are divided into 3 topical units (see figure 1), consequently following a conceptual path from fundamentals to industrial practice. In advance, an introductory part has to be prepared at home by a new textbook for professional development on press hardening which will be provided to each participant several weeks before the training. The knowledge & skills workshop repeats and deepens the information obtained by the textbook and the units in a playful way.

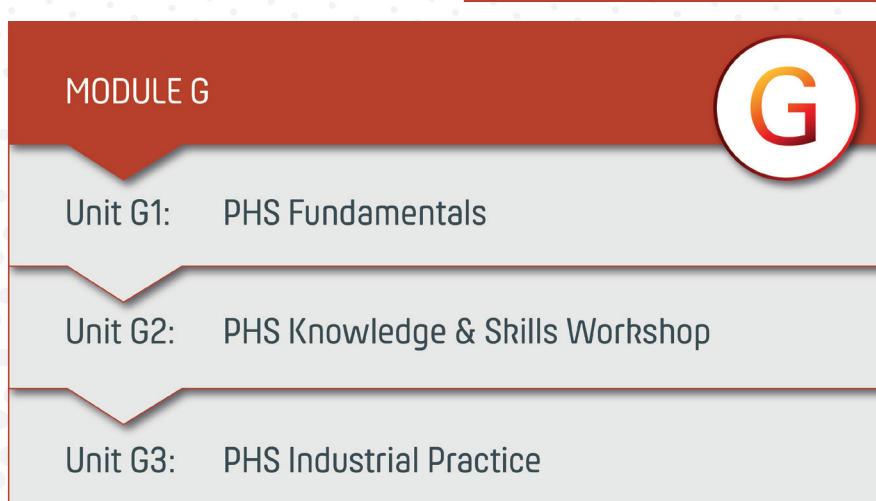


Figure 1: Line-up of learning units of Intensive Training in Press Hardening Module G

Unit G1: PHS Fundamentals

Contents. In this opening unit **fundamentals of heat treatment and hot forming** of steel are as well covered as selected aspects of thermo-mechanical coupling of both, as for example applied in press hardening. Specific knowledge and skills are provided in a combination of seminars and practical experience. This includes lab internships, which aim at **unveiling the temperature-dependent interaction between heat treatment and plastic deformation**. Particular attention is paid to the governing effects of heat on phase transformations, microstructures and mechanical properties, as well as on forming behavior, formability and flow stress.

Aims & Targets. Using their acquired knowledge and skills, participants will be able to **set defined properties for selected steels based on an appropriate choice of thermal process parameters**. Additionally, they will **understand the influence of thermal processing on forming conditions**. The fundamental principles of thermo-mechanically coupled processes, to which hot stamping can be assigned, will be properly understood.

Unit G2: PHS Knowledge & Skills Workshop

Contents. In this unit G2 the informations on the basics of industrial press hardening given in the textbook will be repeated and deepened in a playful way. It comprises an overview of the historical development, the current state-of-the-art, as well as numerous examples of **PHS applications in contemporary car bodies**. Market streams and developments are indicated. **Perspectives and expectations of different OEMs** on future PHS application are explained and discussed. Special attention is paid to the **design and application of functionally graded parts**, i.e. parts with varying properties (e.g. tailor heat-treated blanks/parts, TWBs, TRBs, patched blanks/parts etc.). All available options and principles to adjust varying properties during the production of so-called **functionally graded press hardened parts** will be comprehensively explained. Existing process variants will be evaluated as well with regard to implicit **technological risks and limits** as to the achievable local resolution of resulting part properties.

Aims & Targets. Participants will obtain by this workshop a **comprehensive overview over more than four decades of development in PHS technology**, ultimately putting the training group on the same page regarding their perception of technological contents and market expectations. **Options to adjust varying part properties (e.g. soft zones) in a press hardening process are fully understood** as well with respect to their technological potential as to existing restrictions.

Unit G3: PHS Industrial Practice

Contents. A major challenge in press hardening is processing safely and reliably, while efficiently combining heat treatment and forming. **Different process variants are systematically explained** as well from a process oriented technological viewpoint as from a material oriented technological viewpoint.

The **properties and behavior of different material processing systems** (= steel substrate + coating) are explained with particular focus on their specific requirements and particularities during hot stamping.

The tribological effect of different surface consistencies resulting from the characteristic thermal treatment of coated and/or uncoated PHS in contact with selected tool steels and/or tool coatings are also discussed in-depth.

The **production of functionally graded components** using locally variable time-temperature profiles during hot stamping are comprehensively explained including **suitable control strategies**. This knowledge is reinforced by **“hands-on” experience** during extensive press hardening trials on industrial-scale PHS equipment.

Among others, special attention is paid in **Unit G3** on the following aspects:

>> PHS process monitoring and CQI-9 requirements

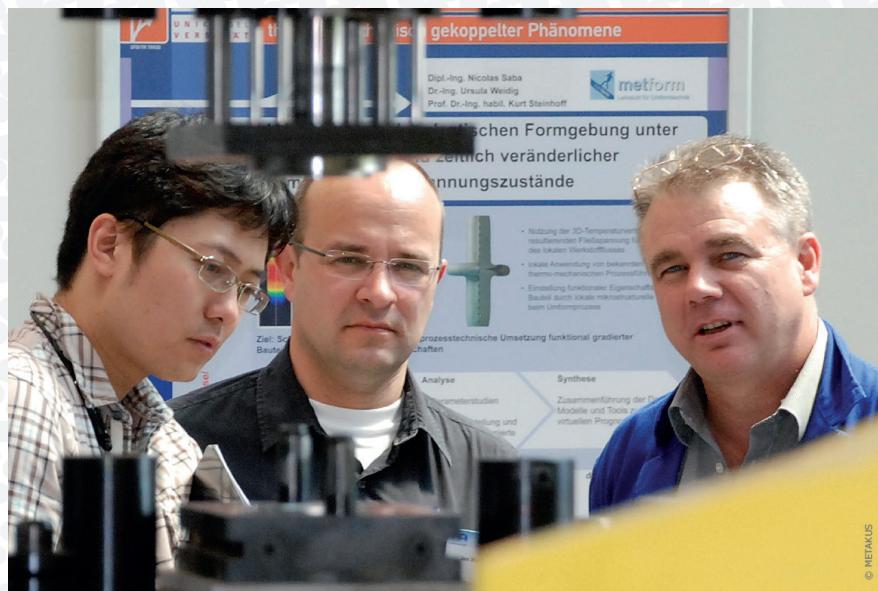
The **effect of all relevant process parameters on the resulting product quality** is explained. Coming from that, **appropriate in-line monitoring strategies** for application in industrial hot stamping processes are presented. Handling of applicable **measuring principles, devices and equipment** will be trained. At the end of the day, the following questions will be answered:

- ❖ What should be measured?
- ❖ Where should measurements be carried out?
- ❖ How should measurements be carried out?
- ❖ Why is the measurement necessary?

>> Product quality control

When producing UHSS components by industrial hot stamping, the most important product properties (e.g. surface topography, mechanical properties and electrical properties) are adjusted within the manufacturing process itself. Therefore, sufficient knowledge and practical skills concerning the choice and **application of appropriate quality testing methods** are trained. This part of the Module G training particularly focusses on a **proper indication of all relevant material properties of uncoated and coated PHS**, including among others the following procedures:

- ❖ Mechanical testing (tensile test, hardness measurement)
- ❖ Nondestructive testing
- ❖ Metallography and microscopy
- ❖ Surface analysis (coating layer + topography)
- ❖ Electric resistance.



>> Hot stamping of coated UHSS

The **specific behavior of various metallic coatings** on steel substrates under characteristic thermo-mechanical loading situations as applied in industrial hot stamping are explained. In addition to standard **AlSi-coated 22MnB5** applied in direct press hardening, attention is paid to the **particularities of different zinc coating variants (Galvanized – GI, Galvannealed – GA, ZnNi)** available for direct and indirect press hardening. Specific time-temperature profiles and resulting **characteristic layer consistency and properties** are addressed in the same way as **induced failure mechanisms**. For each individual type of steel substrate – coating combination, characteristic changes of physical and chemical properties (e.g. layer consistency, microstructure, surface topography, oxide formation, electrical resistivity, thermal conductivity) along the integrated heat treatment and hot forming process route are explained and unveiled during practical press hardening experiments on a full scale PHS prototype line and subsequent material testing.

Aims & Targets. Participants will gain the **ability to reliably handle and utilize the latest material processing systems**, which are essential for press hardening of car body components under industrial mass production conditions. Based on their acquired knowledge, they will be **capable of making appropriate process parameter choices** for different material systems as well as for functionally graded PHS parts in terms of **adjusting defined patterns for mass and/or microstructure (= mechanical property) distribution**. Methodological skills on through-process monitoring of interdependent process and part characteristics will be available.

Training participants will receive a complete overview of all relevant PHS process parameters. **Skills for a proper choice and application of appropriate measurement methods** including the **necessary capabilities to understand and interpret measurement results will be available**. They will be able to **evaluate the plausibility and accuracy of measurements**.

Participants will acquire **specific knowledge concerning the quality-determining characteristics of PHS components**. They will be trained to **make proper selections of testing equipment and procedures** in regards of the mechanical properties, surface layer consistency, surface topography and electrical properties, particularly those of PHS with various metallic coatings. They will be able to perform a precise characterization and evaluation of thermo-mechanically induced modifications of properties from as-delivered state of the blank material to final PHS component.

Each participant will individually develop a **thorough understanding of the specific behavior of different metallic coatings under typical thermo-mechanical loading situations as typically applied in press hardening**. He/she will be able to define **corresponding process parameters and related process windows**. They will develop a **sufficient understanding of the relationship between the selected process parameters and the resulting material properties**. Participants will receive sufficient knowledge regarding the analysis of physical and metallurgical coating properties and their evaluation, particularly with respect to part quality and failure.

Schedule Module G

The Module G training course consists of five full days of seminars, workshops and lab internships (see figure 2). It takes place at the METAKUS PHS Training Center in Germany.

Schedule	1 st Day	2 nd Day	3 rd Day	4 th Day	5 th Day
AM	Welcome & Introduction	G2 Knowledge & Skills Workshop	Seminar G3/A	Seminar G3/B	Seminar G3/C
	Seminar G1/A				
Noon	Lunch break	Lunch break	Lunch break	Lunch break	Lunch break
PM	Seminar G1/B	Lab G2/A	Lab G3/A	Lab G3/B	Lab G3/C
	Lab G1/A				
		Seminar G3/A	Seminar G3/B	Seminar G3/B	Feedback Round

Figure 2: 5-day schedule of Intensive Training in Press Hardening Module G – all-inclusive 1-week journey from theory to practice.