ATZK ASSOCIATION FOR THE HEAT TREATMENT OF METALS

Proceedings of Abstracts

European Conference
ON HEAT TREATMENT 2016
and
3rd International Conference on Heat Treatment and Surface Engineering in Automotive Applications

11 – 13 May 2016
Prague, Czech Republic, Břevnov Monastery

A3TS · ASMET · IFHTSE · ASSOCIAZIONE ITALIANA DI METALLURGIA · ATZK · VWT · ASTT · SVW

Foreword

Dear participants of the European Conference on Heat Treatment 2016, attached please find a brochure which contains all necessary information about our conference, abstracts of papers and some organisational guidelines.

Our meeting is one in a series of European conferences organised by heat treatment associations in Austria , Belgium, the Czech and Slovak Republics, France, Germany, Italy, the Netherlands and Switzerland and are dedicated to knowledge transfer between research and practice and the exchange of experience among engineers and scientists. At the same time, our conference is included in the series of conferences of the worldwide organisation IFHTSE.

The Association for the Heat Treatment of Metals in the Czech and Slovak Republics (ATZK), which unites heat treatment experts from both countries has chosen ‚Heat Treatment in the Automotive Industry' as the central theme of the conference. The reason for this is that the automotive industry in our countries has a long-lasting tradition. The first serial-produced automobile within the borders of the current Czech Republic, Präsident, manufactured by Kopřivnice wagon works NW (later renamed to TATRA), dates back to 1898. The tradition continued with the automobile factories such as Praga, Walter, LIAZ or Zetor and, last but not least, the automobile manufacturer Laurin & Klement, later Škoda-Auto, which may be regarded as the country´s largest motor vehicle producer, with an annual production of more than 1 million cars. The tradition is currently being sucessfully advanced by other end product manufacturers such as Hyundai and PSA in the Czech Republic and VW, Kia and PSA in the Slovak Republic. In addition to the aforementioned it should be noted that there is also an array of sub-suppliers in all spheres of the automotive industry ranging from forging workshops and the production of binding material and bearings to the production of gearboxes, clutches, wheels and tires. In addition, the production of tools for making various types of components from non-ferrous metals and plastics is significantly developed.

It is obvious that the automotive industry represents an essential branch of industry in the Czech and Slovak Republics and it constitutes approximately 8 % of the GDP in the Czech Republic. Both countries produce the highest number of vehicles in the world per capita and are noted for their deep engagement in international cooperation. The Czech automotive centre plays a key role not only in the European but also in the global perspective. Based on the long engineering tradition, good infrastructure and skilled workforce, it significantly contributes to the worldwide automotive manufacturing and R&D.

The choice of the theme for the heat treatment conference was therefore quite simple for the ATZK representatives. The conference enters the series of the IFHTSE as the 3rd International Conference on Heat Treatment and Surface Engineering in Automotive Applications. The extensive program of the conference offers the current trends in automotive applications ranging from mass production to manufacturing of tools, from scientific work to practical application and with its plentiful array of exhibitors it creates the atmosphere for the deepening of contacts between scientists, development engineers and manufacturers.

On behalf of the organisational staff, I wish to all participants of the conference many intensive professional contacts and plentiful new findings. Last but not least, I wish you a wonderful experience of the historical city of Prague.

Pavel Stolař
President of ATZK

Content

Improved modelling capabilities and simulation of heat treatment and surface engineering Reliability and process control, series production control, measurement

Poster session

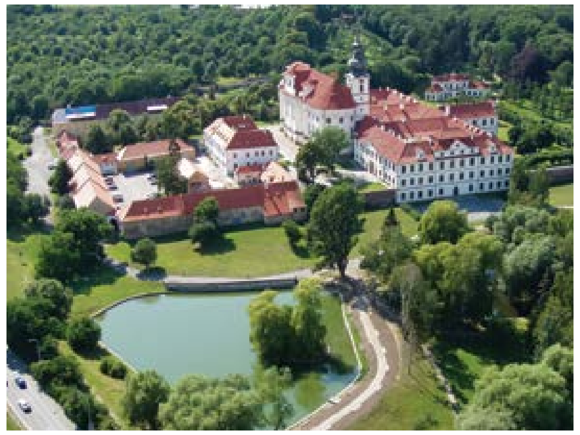
Conference sponsored by

Aichelin Young Speakers Award

The award, sponsored by the Aichelin of Mödling, will be given at this conference for the best talk of a speaker under age of 35. The award is endowed with the sum of 1500 €.
Detail conditions see on www.htconference-prague2016.cz.

Poster Awards

Awards, sponsored by the Burgdorf GmbH & Co.KG, will be made for the three best posters (the first EUR 800, the second EUR 500, the third EUR 300), as judged by an independent panel of experts. Posters will be displayed for the entire period of the conference.



Program for Accompanying Persons - Explore Prague in two half-day tours

The Vltava River as a silver ribbon divides Prague into two parts, which makes it easy to explore Prague in this way as well. By dividing the sightseeing of Prague into two parts, you will be able to see more details - and be sure you will be shown many of them! Each sightseeing tour takes 4 hours and includes lunch.

Excursion in Škoda Auto a.s., Vrchlabí

The excursion in the modern heat treatment plant of gear parts in the company Škoda Auto a.s., Vrchlabí will be held **on Friday 13 May 2016 from 1 p.m. to 7 p.m.**

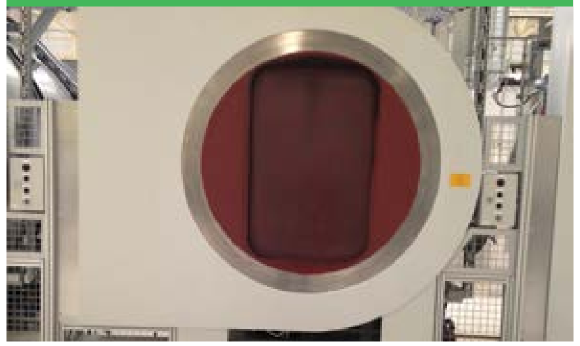
The short presentation will contain history and products of company Škoda Auto a.s., it will be followed by a guided tour of hardening shop, heat treatment lines 1 and 2, quenching press station, control methods, installation and assembly of gearboxes. The quality of selected types of tests will be demonstrated in the laboratory.

1. Škoda Auto a.s., Vrchlabí – history

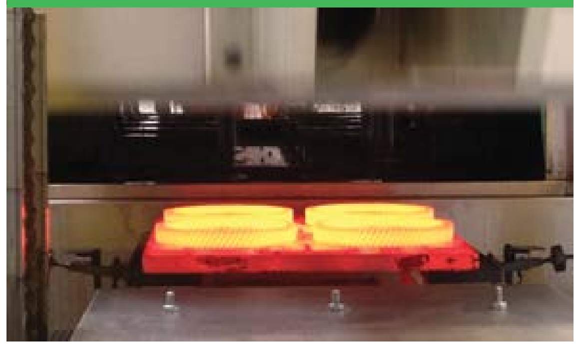
2. Hardening shop 1 - Modultherm

3. Control methods

4. Hardening shop 2 - Modultherm



5. Hardening shop 3 – Quenching press



6. Laboratory

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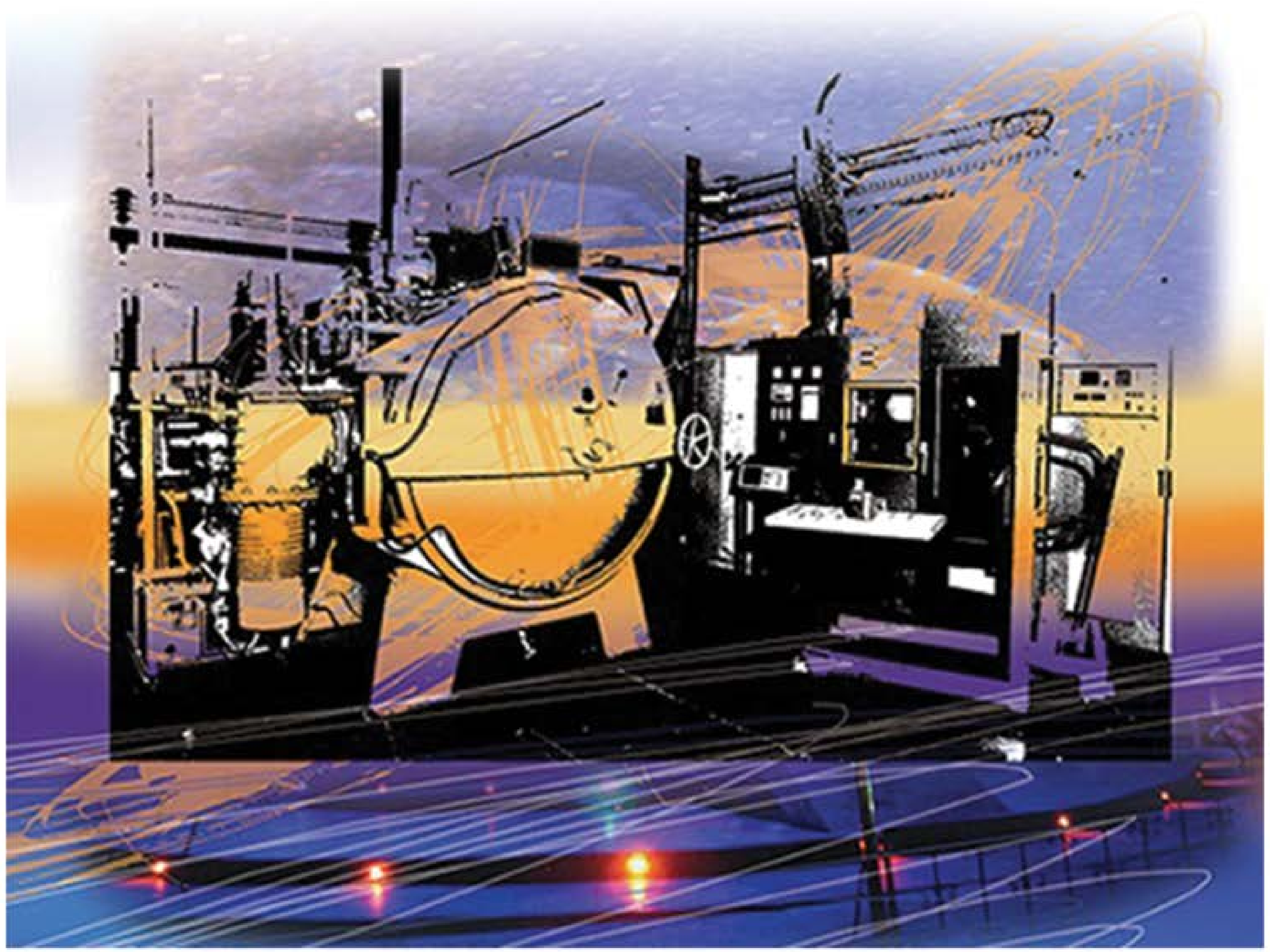
Forthcoming Conferences

2016	JUN	22–24	**4th Symposium on Surface Hardening of Corrosion Resistant Materials**	La Valletta	**Malta**	
2016	SEP	13–15	**10th International Conference «Inovation Technologies of Heat Treatment»**	Moscow	**Russia**	http://www.htexporus.com/conference.html
2016	SEP	20–23	**Heat Treat Mexico**	Queretaro	**Mexico**	http://www.asminternational.org/web/htmexico
2016	SEP	26–28	**3rd Mediterranean Conference on Heat Treatment and Surface Engineering**	Portorož	**Slovenia**	vojteh.leskovsek@imt.si
2016	OCT	04–07	**International Tooling Conference**	Bratislava	**Slovakia**	http://www.tool2016. org
2016	OCT	26–28	**HKS 2016 [languages: German/English]**	Cologne	**Germany**	http://www.awt-online.org/haertereikongress.html
2016	NOV	12–14	**5th Asian Conference on Heat Treatment and Surface Engineering**	Hangzhou	**China**	http://ww.5achtse.org
2017	JUN	26–29	**24th IFHTSE Congress / European Conference on Heat Treatment**	Nice	**France**	http://www.a3ts.org
2018	APR	12–13	**European Conference on Heat Treatment**	Friedrichshafen	**Germany**	
2018	AUTUMN		**International Conference on Quenching and Distortion Engineering**		**Japan**	



Automotive Engineering - Driving force for the heat treatment technology

Hans-Werner Zoch
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Powertrains in passenger cars are among the highest loaded units in mechanical engineering. Besides wheel bearings especially the components of gear boxes - rolling bearings and gears - face very high loads because of lightweight design trends and very often non-ideal operating conditions due to poor or contaminated lubrication.

The steel grades in use still are the well known through-hardening bearing steels and case hardening grades, yet heat treatment of both has seen a significant development in the last years. Most of those developments took place in thermo-chemical heat treatment processes, where carbonitriding could increase fatigue resistance. Rolling contact fatigue in bearings and tooth flank fatigue in gears can improve significantly by a certain controlled amount of properly stabilized retained austenite, which is able to reduce stress peaks in the contact loaded areas without deteriorating the fatigue strength of the tooth root. This stabilization of retained austenite can be achieved by alloying as well as by heat treatment. New investigations on so-called carbo-austempering show promising results in generating a phase mixture of martensite, bainite and retained austenite in case carburized components.

Controlling multiphase heat treatment microstructures is a challenge, especially in high production rate processes. Available in-situ measuring technology like the still known "bainite sensor"are useful tools to adjust heat treatment parameters to the desired targets.

The challenges on heat treatment will continue as recent activities in the joint project "Lightweight Forging" of the massive forming and steelmaking industry in Germany point out. New designs of gears and other gear box components following strictly lightweight design principles and the use of high performance steels will increase the sensitivity to distortion, which require a full "Distortion Engineering" of the process chain to meet economical goals as well.

Controlled atmosphere furnaces and process technology in Automotive Industry - state of the art and outlook

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This invited lecture gives an overview of the process and furnace technology of controlled atmosphere furnaces and the requirements in regard with the automotive industry.

Based on typical parts which are heat treated in atmospheric furnaces, the commonly used furnace types and their mechanical design (burners, quenching devices, etc.) are explained. Furthermore the required gasifying and process control are mentioned in direct correlation with the preferably used thermal and thermochemical processes.

Increased demands concerning the reduction of process time, reduced heat treatment costs and improved energy efficiency can be met by technical and technological innovations. High temperature carburizing will significantly reduce process time and save heat treatment costs. Furthermore, continuous gas carburizing furnaces can easily be linked with a gas quenching cell.

An outlook to future developments of atmosphere furnaces will finish the presentation. In this outlook the energy efficiency, primary measures for energy savings, but also energy recovery have a high priority and will very important in the future.

Vacuum heat treatment processes and systems - state of the art and trends

Klaus Löser
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Vacuum processes and systems are widely used in the heat treatment of metals to avoid surface reactions, such as oxidation or decarburization of parts, which cannot be prevented in the heat treatment of metals under atmosphere.

These days the hardening of high alloyed tool steels is preferably performed in single vacuum chamber furnaces with integrated gas quenching devices. Compared to the formerly used salt bath or protective gas heat treatment, this technology offers ecological and economic advantages. For hardening of tool steels a vacuum level in the range of 10-2 to 10-3 mbar is sufficient. However annealing of materials with high affinity to oxygen like Ni-based alloys and Titanium, as used in the aircraft industry, a lower vacuum level in the range 10-4 to 10-5 mbar is required.

To achieve the desired microstructure by vacuum hardening, the parts are heated up by radiation or convective heating to hardening temperature, held at that temperature for a sufficient amount of time and then need to be quenched to room temperature. The introduction of the gas quenching technology allowed to significantly reduce the distortion of the quenched parts. Compared to liquid quenching, gases like argon, nitrogen or helium do not show any phase transformations during quenching and do not leave any residue on the parts, avoiding additional investment in washing machines or fire monitoring devices. Through the steady increase of the quenching pressure and the gas velocity, as well as the development of suitable quenching systems, so-called "cold chambers", even low-alloyed case hardening steels and tempering steels can be hardened.

Casehardening using vacuum carburizing with subsequent high pressure gas quenching was introduced in the 90´s as a new heat treatment technology for surface hardening processes of metallic parts and is widely used in the machine building industry, especially in the automotive industry. To allow for high volume production, modular multi-chamber furnace systems are developed. These systems are preferably used to case-harden the new generation of highly stressed shafts and gears of transmissions and components of diesel injection systems.

The paper presents a survey of the state of the art of vacuum processes used for thermal and thermo-chemical heat treatments as well as the corresponding system technology. Typical production applications are introduced and future trends in this technology are presented.

Electron beam surface treatment in automotive industry - History, state of the art and prospects

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Thermal electron beam (EB) technologies are used for surface treatment in different fields of metal working industry, and have, to some extent, become a successful industrial application for automotive components also. Main objects of EB surface technologies are the improvement of hardness and the local wear (and partly corrosion) protection. In manifold manner the different technological variants are used for a broad range of materials in particular steels, cast irons, and light-weight materials. Both, EB single surface treatments (hardening, remelting, alloying, cladding, texturing) and combined (duplex) EB technologies in connection with thermochemical treatment and hard coating will be illustrated.

The characteristics of these different surface technologies are disclosed and the attainable changes of microstructure and properties will be demonstrated. The rapid technical and technological development in this field offers steady new possibilities of application. Currently, the potentials of these modern technologies are not exhausted by far. The lecture presents as well as a survey about the history of the development, the actual status of material scientific investigations, and the technical state of the art in this field. In connection with different examples, both, the technological options and limiting factors of EB surface technologies are discussed. Selected industrial applications are represented, and a forecast for advanced fields of application for these innovative surface technologies is provided.

Properties and range of application of liquid quenchants with particular emphasis on the car manufacturing industries

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According to DIN EN 10052 quenching is defined as „Cooling a part faster than with still air“. The quenching media commonly used for heat treatment of steel and aluminium parts are water, brine, aqueous polymer solutions, quenching oils, molten salts and pressurized gases such as air, nitrogen, hydrogen and helium.

Quenching is a very important part of the total heat treatment process and its success. The heat transfer characteristics of the quenchant strongly influence the parts’ microstructure after heat treatment, the resulting mechanical properties of the quenched component but also the amount of internal stresses and distortion.

The choice of the quenchant, its proper use and adaptation to the specific component, heat treatment installation and heat treating process is mandatory to make sure that the heat treated part meets the well defined requirements for safe, consistent and longtime functioning. Last not least an optimized quenching process helps to minimize the costs for heat treatment and rework.

In this paper the main liquid quenching media like quenching oils and polymer quenchants are presented with their physical and chemical properties. Moreover their main applications in the car manufacturing industries are shown based on practical examples.

Finally an outlook on the future development of liquid quenchants and quenching technologies is given.

Vacuum heat treatment with over pressure gas quenching and cryogenic process of large scale series production parts made of lower alloyed steel 1.2067 = 100Cr6

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The automotive industry has high demands to the heat treatment process regarding final hardness, retained austenite and dimensional stability. Also a high level of reproducibility is requested for example on large scale series production parts made of lower alloyed steel quality 1.2067 = 100Cr6.

The required quenching speed which is necessary for the successful hardening of such low alloyed steels is conventionally achieved by water- or oil-quenching technology. For components with small dimensions also over pressure gas quenching in a vacuum hardening furnace with separate quenching zone can be the solution with the advantage of an dry, metallic bright surface.

The requested final values for hardness and retained austenite content are adjusted by a subsequent cryogenic treatment as well as an following tempering process in an appropriate vacuum tempering furnace with integrated cryogenic module. A controlled deep freezing gradient for a slow and smooth cooling to subzero temperature reduces here the risk of stress cracking. A metallic bright surface as well as completely reproducible heat treatment results with load thermocouple documentation are further advantages.

Care and maintenance of oil quenchants used for quenching automotive components

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Quenching, and quench oil, is a critical part of the manufacturing process for a heat-treated part. In this paper, the effects of many common issues with quench oils are illustrated. These include contamination, soot, and filtration. A brief review of the mechanism of oxidation of quench oils, and the base oils used in modern industrial quench oils will be included.

New trends in heat treating and quenching

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There are 10 new trends shaping the future heat treatment. These new treads will improve reliability and lower the cost general heat treatment. Among these trends are increasing usage of vacuum heat treatment, changes in control system use to monitor and record furnace performance, interconectivity (Internet of Things), globalization of heat treatment standards and cost, replacement of furnaces and technologies that generate high CO2 pollution, increasing importance of brazing, PM and Nano surface modification and new quenching mediums such as NAnoquenching, IQ, and vegtables quenching. New Thermal,chemical surface modification will improve distortions control. New design quenching tanks with new quenching mediums will provide better quenching process.

Note: The presentation overview what happen in the next 5 to 10 years in heat treatment and quenching technologies.

Intermetallics for automotive industry

Pavel Novák, Pavel Salvetr, Andrea Školáková, Kateřina Nová
University of Chemistry and Technology, Prague, Department of Metals and Corrosion Engineering, Technická 5, 166 28 Prague 6, Czech Republic, panovak@vscht.cz

Intermetallic compounds are very interesting materials, having the properties between metals and ceramics. Due to this fact they enable e.g. utilization at high temperatures or in severe corrosion environments. Many intermetallic compounds also have other interesting properties, such as shape memory or ability to store hydrogen reversibly. Due to these properties, intermetallics are interesting materials for application in automotive industry. This paper summarizes current applications of intermetallics and also possible future trends in this industrial branch. There are described the changes of phase composition and properties with temperature and corrosion behaviour at high temperatures (e.g. for application as exhaust valves).

Distortion of heat treated components – basics and examples for reduction

Thomas Lübben, Hans-Werner Zoch
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Dimensional and shape changes, which occur during the manufacturing of metallic components, cause high additional costs, because they give rise to reworking or even scrap. According to a 1995 survey of the Verband Deutscher Maschinen- und Anlagenbau (VDMA) (association of German engineering industries), in the area of power-transmission technology alone, the costs for the removal of distortion totaled 850 million Euros/year in Germany. To minimize these costs, the control of distortion is one of the greatest challenges in modern economic production and is gaining in importance because of the current trends of downsizing or lightweight construction.

In this lecture the basics of distortion generation will be presented. Unavoidable and avoidable size and shape changes will be addressed. Finally selected of distortion minimization and compensation will be discussed.

Distortion of grooved steel cylinders due to high speed quenching

Friedhelm Frerichs, Thomas Lübben
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Kobasko et. al. have primarily shown that rapid water quenching can create compressive residual stresses near the surface and hereby a significant increase of the fatigue-limit results (Intensive Quenching). Depending on steel grade, dimensions of the component and quenching intensity through hardening or only shell hardening will occur. Kobasko supposed furthermore that in case of very fast cooling processes distortion effects can be reduced in comparison to common quenching methods. This hypothesis seems reasonable because the martensitic shell maybe stabilizes the work piece and restricts the development of undesired distortion effects.

To prove Kobaskos hypothesis of distortion reduction by high speed quenching workpieces made out of the unalloyed steel grade C35 were taken. To provoke significant distortion effects grooved cylinders were investigated. The very fast quenching was carried out in a special device developed for high speed quenching purposes. The facility produces very high heat transfer coefficients up to 50000 W/(m²K) by use of tap water with flow velocities in the order of 10 m/s. For comparison the same workpieces were quenched in oil with heat transfer coefficients one order in magnitude lower. The quenching results are characterized by measuring the distortion effects, the microstructure, the hardness, and for some cases the residual stresses at the surface.

Keywords: High speed quenching, shell hardening, distortion, compressive stresses, unalloyed steel

Experimental study and modeling of quenching processes of ultra high strength low alloy steel

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By using thermal dilatometric experiments, martensite and bainite transformation kinetics of a kind of ultra high strength low alloy steel were established. Martensitic transformation plasticity was investigated when martensitic transformation was carried out under uniaxial compression and tensile stresses. Temperature evolutions in a half tube sample were measured to obtain heat transfer coefficients during quenching. Based on the quenching model and HTC established, evolutions of temperature, microstructures and stresses in the half tube sample during quenching were calculated. The influence of martensitic transformation plasticity on internal stresses was numerically studied.

Keywords: Quenching, Transformation plasticity, Ultra high strength steel, Mathematic model

CFC and carbon in heat-treatment of steel

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The presentation describes the particular characteristics and the structure of CFC which predestines this material particularly suitable for use as a substitute for steel structures in high temperature applications. Production of CFC is described and illustrated the specific properties, compared to steel. Advantages and disadvantages in heat treatment are specified. Describes are the possibilities to combine CFC with other materials such as fiber ceramic and steel. This is particularly necessary because of carbon reaction with steel at elevated temperatures, and a protection is necessary here. Also the increase of abrasion during handling is important and it will be presented proven and new solutions. It is reported also about possibilities of the use of CFC in the oil quenching in multi-purpose chamber furnace and pusher type furnaces. Examples of systems in the automotive industry practical applications during quenching and tempering steels and soldering components are shown.

Carbon/Carbon materials for heat treatment applications

Bernd Groos, Marcel Páter
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Carbon (graphite) materials are widely used in vacuum heat treatment applications. For long time have been used mainly as hot zone insulation and for heating elements manufacturing. Within last decade became carbon fiber composite a construction material for fixtures, replacing high-temperature steels. Presentation describes properties of different carbon fiber materials, both soft and rigid felts and composites (CFC). Principles of heat transfer considering material micro structure, exceptional mechanical and chemical properties of graphite are shown. Besides, limitations for using graphite materials in heat treatment processes, are mentioned.

Presentation shows as well best practice experience from industrial use of CFC fixtures, esp. in automotive. Replacing metal fixtures with graphite ones under proper conditions brings energy and cost savings, increasing of furnace capacity and significant part's quality improvement - from better hardening results to no deformation.

Heat treatment of a stainless bearing steel for special purposes

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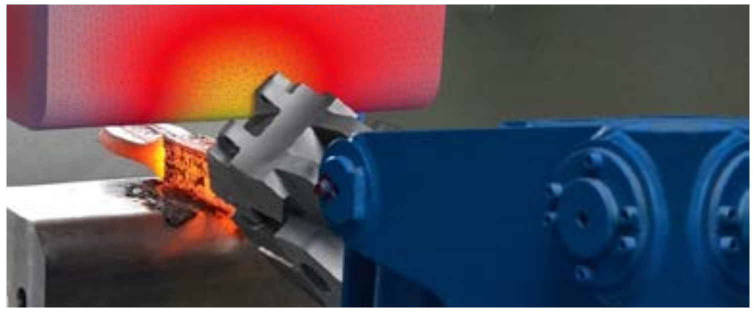
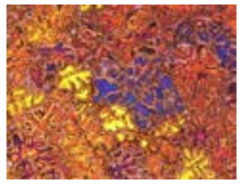
In order to meet requirement of high technology and harsh working environment, many researchers focused on developing new-type bearing steel, namely automotive industry. Recently, more

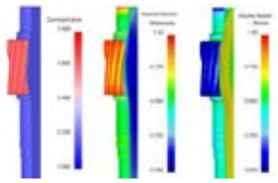


COMTES FHT is a private research organization involved in applied research and development of metallic materials and their processing technologies (melting, casting, forming, heat treatment etc.).

The company runs a unique metallurgical laboratory equipped with VIM furnace for melting and casting of a wide range of steels and non-ferrous alloys up to 500 kg per heat. The cast blocks can be forged on a hydraulic forging press and/or rolled into sheets on a reversible hot/cold rolling mill.

The heat treatment laboratory is equipped with several induction heat treatment units and furnaces for vacuum hardening, nitriding, carburizing, boronizing etc.





Several tools for technological optimizations are available at laboratories of COMTES FHT such as various FEM software tools (DEFORM, ABAQUS etc.), a “Gleeble-like” thermo-physical simulator or small hydraulic presses. COMTES FHT is also involved in special technologies such as manufacturing of ultrafine grained titanium for medical purposes or additive manufacturing using metal powders.

The materials testing laboratory of COMTES FHT offers both standard and non-standard mechanical testing (incl. fatique and high-dynamic tests), measurement of thermo-physical properties (dilatometry, calorimetry etc.), microstructure analyzes using light and electron microscopy, chemical analyzes etc.

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researchers found that high nitrogen steel had high strength, high hardness, high wear resistance, excellent corrosion resistance and toughness, these excellent properties make high nitrogen steel become a quality bearing steel. Investigated steel contains 1% carbon, 16% chromium and 0,2% nitrogen.

In order to achieve the optimum lifetime of bearings, extremely fine microstructure and high hardness are required after final heat treatment. Due to high content of retained austenite after standard quenching, final properties can be improved using deep cryogenic treatment. Quenching to the cryogenic temperatures significantly reduces amount of the retained austenite in the structure. Consequent tempering lead to the more homogeneous microstructure compared to the conventional quenching.

The article describes impact of the cryogenic quenching on microstructure and hardness of the high alloyed bearing steel. The quenching was performed from different quenching temperatures. The cooling was performed in oil bath to the ambient temperature. Samples were then cooled to the -160°C for 8hours. They were annealed subsequently and compared with samples quenched and tempered without cryogenic treatment. Metallography analysis was performed using optical and scanning electron microscopy.

Close relations between metallic materials, heat treatment and thermochemical treatment on the microstructure: contribution of metallographic examinations performed on automotive parts in through several case studies

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Metallurgical analysis is widely used in the field of heat treatment of metals to ensure the quality of the treatments carried out on a wide variety of industrial parts and treatments carried out. It is therefore a valuable tool for subcontractors of the heat treatment industry to monitor their production and treatment response on various parts. Through different examples, we will present actual cases that involve automotive parts.

We show that there is a strong interdependence between material and heat treatment, one being related to each other, a successful treatment depends both on the metallurgical quality of the material and the production quality of the heat treatment process. We will discuss the type of treatments like: vacuum hardening or under protective atmosphere, surface induction hardening, carburizing, nitriding and brazing.

Improved materials and enhanced fatigue resistance for gear components

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To answer the demand for fuel-efficient vehicles, modern gear boxes are built much lighter. Improving fatigue resistance is a key factor to allow for the design of thin components to be used in advanced transmissions. The choice of material and the applied heat treat process are of key importance to enhance the fatigue resistance of gear components.
By applying the technology of Low Pressure Carburizing (LPC) and High Pressure Gas Quenching (HPGQ), the tooth root endurance strength can be significantly enhanced compared to traditional heat treatment with atmospheric carburizing and oil quenching.
Besides heat treatment, significant progress has been made over the past years on the steels being used for gear components. The hardenability of case hardening steels such as 5130, 5120, 20MnCr5, 27MnCr5, 18CrNiMO7-6 etc. has been stepwise increased in recent years. An important factor for fatigue resistance is the grain size after heat treatment. Therefore grain size control is a key goal when developing new modifications of steel grades.
Besides the technological benefits of grain size control, there is as well an economic motivation for it. After enhancing grain size control, it was possible to increase the carburizing temperatures over the past years from 930°C to 980°C which resulted in shorter heat treatment cycles and thus in significant cost savings.
With the introduction of new microalloyed steels for grain size stability, carburizing temperatures can now be even further increased to temperatures up to 1050°C, leading to even more economic process cycles. By adding microelements such as Niobium or Titanium in the ppm-range, nitride and carbonitride-precipitates are formed. These precipitates limit effectively the grain-growth during the heat treatment process.
The paper shows the latest progress in steel grades and in case hardening technology for gear components.

Keywords: case hardening, fatigue resistance, Low pressure carburizing, High pressure gas quenching, case hardening steels; hardenability; grain size control, transmission components

In-line heat treatment of flat products

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An in-line heat treatment of rolled materials is becoming frequently used by hot rolling plants. This method achieves the required material structure without the necessity of reheating. This paper describes a design procedure of spray cooling sections for obtaining demanded structure and mechanical properties of steel flat products. The design involves several important parts. First, it is necessary to obtain boundary conditions for the numerical model. Several types of nozzles are tested and dependence of the heat transfer coefficient on the surface temperature is obtained for all tested nozzles. After that, the cooling process is simulated using obtained boundary conditions. The required cooling regime and appropriate type and size of nozzles are selected with the knowledge of the CCT diagram and results of simulations. The selected heat treatment regime is then validated on the small sample quenching test and the regime is modified if it is necessary. Finally, the full scale sample is heat treated on the new experimental stand which was developed at the Brno University of Technology. This experimental stand allows cooling of the moveable sample by two types of nozzles. First, it is cooled by intensive spray for short time period and then it is cooled by soft spray. The stand is able to stop the cooling and temper the sample. This paper presents laboratory results of the heat treatment of S355 steel which was spray quenched from the initial temperature 910 °C and self-tempered (the hot core tempers the quenched outer part) at the temperature 600 °C.

Keywords: heat treatment, quenching, spray cooling, heat transfer

Effect of conditions of cryogenic treatment on the properties of the selected tool steels for cold work

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The paper evaluates the properties of the two tool steels for cold work which differ in the way of production, content of carbon and vanadium. The large hardenability, toughness, dimensional stability and wear resistance are characterized for both. These are a subledeburitic steel X63CrMoV5-1 made by classic metallurgy and ledeburic steel Vanadis 6 steel produced by powder metallurgy. Different austenitizing temperatures in the range of recommended values for the material are used during the heat treatment. Both materials were tempered at a temperature of 530 °C. It was also situated cryogenic treatment at temperatures of -180 ° C, and most likely per 4 hours to conventional heat treatment cycle. The effect of timing of cryogenic treatment in the cycle of heat treatment was observed. Hardness measurement, three-point bending test and a test of resistance to wear by pin-on-disk are used to assess the effect of heat treatment conditions on the properties of investigated materials.

Subzero treatment of cold work tool steels – metallurgical background and effect on microstructure and properties

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Powder metallurgy made Vanadis 6 ledeburitic tool steel, as an example material, has been conventionally heat treated and subzero-treated by using various combinations of the austenitizing temperature, sub-zero treatments (temperature and time) and tempering regimes. The microstructure and phase constitution have been analysed by scanning electron and transmission electron microscopy and microanalysis, X-ray diffraction and internal friction methods. Besides the microstructure, the hardness, flexural strength, fracture toughness, tempering response and wear resistance have been investigated. The obtained results infer that: i) The microstructure of as quenched/as-subzero-treated material consists of martensite, retained austenite, eutectic, secondary and small globular carbides. ii) Retained austenite is almost completely eliminated by application of subzero treatment. iii) As-subzero-treated material contains a great number of ultra-fine cementite precipitates as a result of accelerated martensite decomposition. iv) The amount of small globular carbides is significantly increased by subzero treatments; the lower the temperature (or longer duration) of sub-zero treatment the higher is the amount of these particles. v) The hardness is higher for as-subzero-treated and/or low-temperature tempered steel but it is influenced rather slightly negatively by subzero treatments followed by tempering in the normal secondary hardening temperature range. vi) There is no negative but rather marginally beneficial impact of subzero treatments followed by tempering in the normal secondary hardening temperature range on either toughness or fracture toughness of the steel. vii) Wear resistance is improved by sub-zero treatments when followed by high temperature tempering despite the slightly lower hardness of the examined steel. Finally, the most probable source of the impacts of subzero treatments on either microstructural characteristics or mechanical properties and wear performance of the material is hypothesised and discussed.

Study of the properties and structure of the selected tool steels for cold work depending on the parameters of heat treatment

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Tool steels produced by powder metallurgy (P/M) are perspective materials, although there are more expensive in comparison with the conventional method produced tool steels. The work focuses on the study of mechanical properties and structure depending on the heat treatment conditions for the two tool steels. These are the steel for cold work 1.2379 produced by classical metallurgy and high-speed P/M steel Vanadis 23. Both materials were heat treated in a conventional manner for them, so as to achieve a hardness of61 HRC. There were also put cryogenic treatment at temperatures of-90 °Cand-196 °C per 4hours between hardening and tempering in two cases. It was evaluated hardness, strength by three-point bending test and wear resistance by method Pin-on-disk.

The mechanism causing the surface hardness instable after quenching used by 60SICRV steel

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60SICRV steel is widely used in the application of suspension spring and hand tool manufacturing due to it's high strength and good toughness properties undergone by suitable heat treatment. Parts of hand tool manufacturers found that the hardness of some bit surfaces is instable. No obvious decarburized microstructures are observed on the surface of spheriodized wire inspected in optical

microscopy. As a result, it is difficult to judge who must be responsible for the indemnification among steel company, wire rope manufacturing company and heat treated company. This research has found that the transformation point Ac3 of 60SiCrV is located near the austenitizing temperature. Therefore, some spots of bit surface will be unable to austenize entirely in where the carbon equivalent is insufficient and the hardness will be insufficient after quenching. For improving this phenomenon, it is suggested that increasing austenizing temperature in former section of the furnace or adding higher carbon content in the steel will prevent the microstructure from occurring incomplete austenization.

Lifetime increase of tools for fine blanking of steel sheet

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In order to improve the lifetime of blanking tools, the application of high quality steel, heat treatment and coatings has become an interesting issue for many European companies dealing with stamping, punching and blanking operations. Important trends such as longer life time, higher accuracy and higher complexity of the products are a challenge and require more special materials and techniques.

The technological solutions to improve the existing processes are not obvious because of the enormous choice in available materials, heat and surface treatments such as PVD coatings for the envisaged industrial processes and applications. An in-depth research to understand the manufacturing processes to increase the performance and lifetime of the tools as well as the opportunity of further optimization were the main goals of this project INFIBLANK.

In many blanking processes where heavy duty conditions are applied, the use of hard metals, durable coatings and wear resistant tool steel is already established to extend the lifetime. The coatings studied in this project were applied by using mainly PVD depositions but in some cases, also tools without coatings were considered. However, the ever increasing production rate and the use of high strength steel sheet can induce problems in the wear and fracture behavior of blanking tools with low lifetimes as a consequence. This project studied the tribological synergy of the substrate-heat treatment-coating relationship and their influence on life-time in heavy load conditions. A preliminary study was performed on the cutting edges of special designed triangular punches made of several high alloyed steels which were heat treated in a conventional way and by deep cryogenic treatment after quenching.

After research some demonstration tools were tested in industrial conditions to show the feasibility of some selected combinations.

Investigation of the mesoscale behavior of heterogenous steels concerning fracture initiation

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During heat treatment processes, particularly quenching, cracks may form due to the presence of high thermal and mechanical stresses and strains. Many studies on the quench cracking have been performed searching to explain the origin of the phenomena or evaluating its susceptibility in metals under different process conditions [1]. However at this moment, the mechanism of crack generation and propagation, and consequently a strict criterion for cracking prevention, is yet not fully understood. Furthermore, material anisotropies at mesoscale level, like inclusions and segregations, are meant to play an important role in it. In spite of the increasing detail in the heat treatment simulation, taking into account, e.g., creep and transformation plasticity; perfect microstructures are still normally assumed. However, in real parts, chemical and hence structural inhomogeneity may lead to high local stresses and strains, causing local plastic flow or microcracks formation. A numerical evaluation, through a representative volume elements scheme, concerning stresses and strains as fracture initiation criterion of the cracking sensibility in a 100Cr6 steel at the inclusions level is here proposed; and intensive quenching [2] on cylindrical specimen results are discussed.

Keywords: quenching, microcrack, inclusion, segregation, 100Cr6.

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Effects of deep cryogenic treatment on properties of aluminium bronze

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This paper attempts to summarise the changes of properties which take place in aluminium bronzes using deep cryogenic treatment. In general automotive applications are driving forces of this treatment. The methods, which were chosen for assessing the results of heat treatment with regard to their availability, included measurement of hardness and observation of microstructure using light and scanning electron microscopy. Additional tools for evaluation of microstructure comprised measurement of microhardness and chemical analysis by EDS. An important part of the experiment is observation of tribological properties. Upon completing experiments of this kind, one can define the heat treatment conditions necessary for obtaining optimum properties. In addition, the paper presents important findings on how to improve the corrosion resistance of aluminium bronzes using deep cryogenic treatment.

An investigation of the tribological behavior of high-speed tool steels at elevated temperatures

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The tribological behavior of work roll materials is a key issue during the hot rolling process of metals. The high surface pressures and temperatures, which are present in this process, lead to pronounced high temperature mechanical and sliding wear impact of the roll materials. Therefore, materials behavior (hardness and wear resistance) at elevated temperatures is a topic of interest for industrial applications. In this context, the presented study investigates the mechanical properties and sliding wear behavior of high-speed tool steels (HSS), which are a common work roll material of the intermediate and finishing stands of hot rolling manufacturing lines at elevated temperatures. Experimental analysis focuses on the mechanical properties of HSS at elevated temperatures, represented by high temperature macro-hardness measurements, and on the microstructural surface changes of the aforementioned materials during metallic sliding wear at 25°C, 400°C and 600°C. The results of this study give an overview about the absolute value of the hardness of HSS at elevated temperatures and its evolution at constant temperatures of 400°C and 600°C.To conclude interdependencies between mechanical properties, microstructure and wear behavior at elevated temperatures, the results are discussed and connected with wear experiments. For this reason, detailed wear experiments and microscopic analyses of the worn surfaces are presented.

Investigations point out the main differences between room temperature sliding wear and high temperature sliding wear. Investigations reveal that the wear behavior is mainly dependent on the formation of a tribochemical wear layer at the surface of the wear bodies. This layer suppresses direct metallic contact and changes the characteristics of the tribological system. Discussed issues of high temperature sliding wear are the formation and stability of tribochemical wear layers, their connection to and support by the bulk material as well as the fracturing and damage of the layer-bulk-material compound.

Answers to seven frequently asked questions regarding cleaning and heat treatment

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With the recent progress in heat treatment technology, enhanced processes promise to obtain any desired surface specification using increasingly precise process control with respect to material condition, temperature profile, and atmosphere. However, if in heat treatment practice expectations are not met, part of the solution can be to review the parts' treatment prior to heat treatment, including the benefit of cleaning processes. With this respect, seven FAQ's have been collected and will be discussed:

1. Why cleaning? Types of soil and contamination. Detection.
2. Sources of flaws and defects in heat treatment? Barrier layers. Passivity. Information policy.
3. Cleaning or activation? Different processes, different tasks.
4. Does pre-oxidation work? Unwanted effects of oxide layers.
5. Aqueous or solvent cleaning agents? Help for selection.
6. Cost of cleaning plants? Demands. Process technology. Size.
7. Cleaning process control? Monitoring cleaning agent condition and maintenance.

Opportunities and challenges with the next eneration high efficiency burners and radiant tubes

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Gaseous fuels are the preferred source of energy for many heat treating furnaces from an economical as well as ecological point of view.

Using the hot exhaust to preheat the combustion air is a well known method to increase the efficiency of such heating systems. The main focus of research and development in this area was and is focused on increasing the fuel efficiency while lowering the emissions and especially the NOx-emissions. Modern tools like numerical simulation and also more sophisticated experimental methods are in use to support the progress in burner design. The research cannot only include the burner itself but must also incorporate the environment which it is installed, e.g. the radiant tube, the furnace, the process and so on.

New recuperative and regenerative burners enable a considerable reduction in waste gas losses while maintaining or even lowering hazardous emissions. But there are also some challenges which need to be considered. These challenges, regarding furnace and burner control, media cleanliness and maintenance expertise will be addressed. Detailed knowledge and cooperation with the customer is necessary to successfully introduce new technology into the market.

Keywords: gas burner, combustion, emissions, flameless oxidation

Integration of heat treatment into the production line

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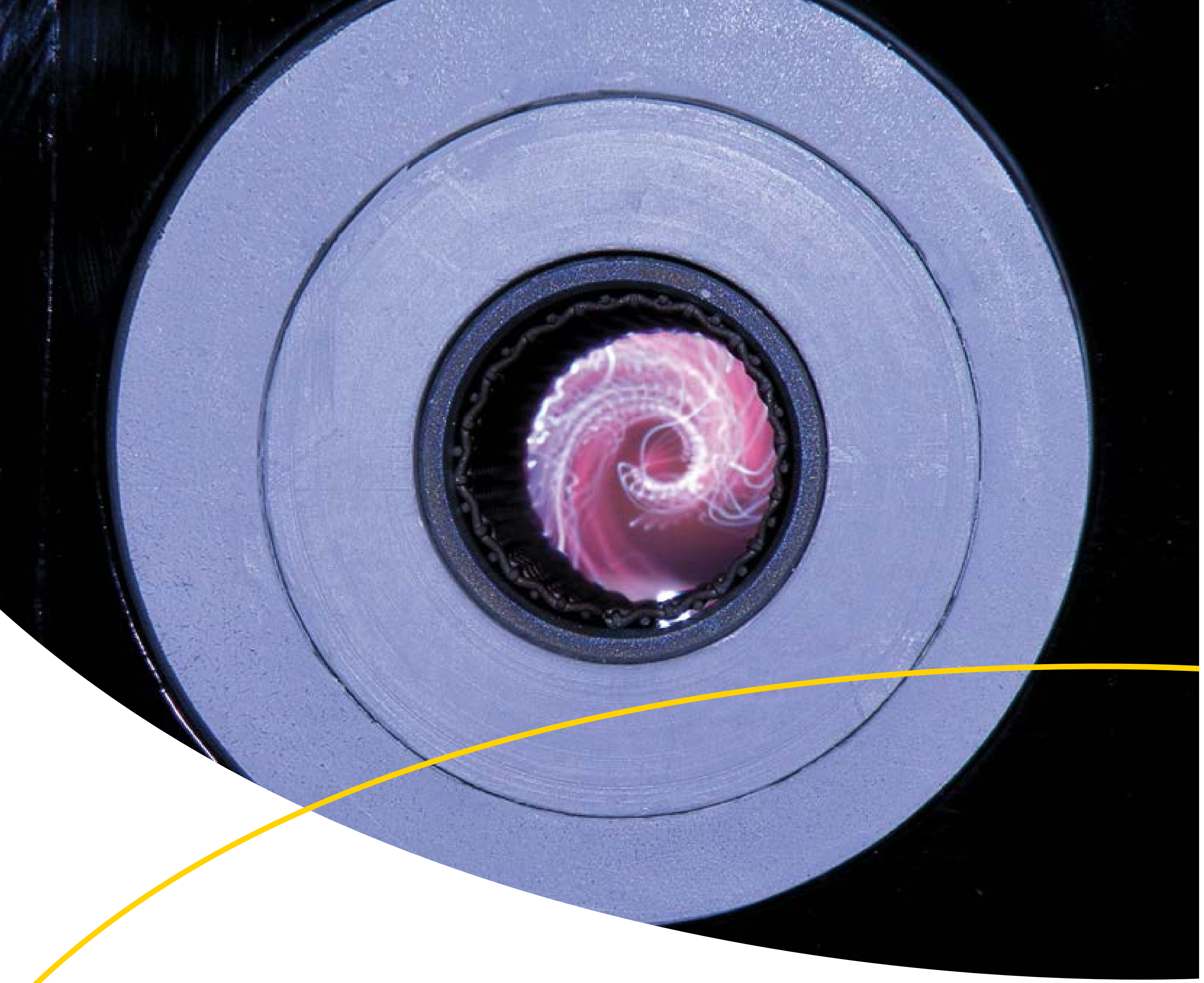
Within the classical gearbox manufacturing of an automotive company, heat treatment as a production step between soft and hard machining will mostly be located in a separate hardening area with transport of work pieces between the processing stations.



In our fast-moving world, increasing flexibility and shorter lead times are called for, entailing a reduction of intermediate buffers in the production process and the fully integration of heat treatment into the production line.

This paper outlines different solutions of a stepwise transition from a centralized hardening shop to integration of heat treatment in a line process. Ideally, this would be a conversion of the complete work process to a so-called "one-piece-flow".

Heat treatment by induction is the ideal way for the manufacture of individual parts and thus perfectly suited for one-piece-flow production. Both individual inductive process steps, hardening and tempering, are described in detail and compared with conventional heat treatment. Terms and conditions for a switch-over to inductive short-time processes are presented and explained.
Finally, this paper provides an outlook for future developments with regard to heat treatment as an integral element of the production line.

Accellerated carburizing in atmosphere furnaces avoiding intergranular oxidation

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As manufacturing industries demand lighter, high strength, near-net shape components going along with competitive production costs, heat treating requirements and practices evolve. In carburizing, steel parts are expected to be internal oxidation free and contain possibly little dissolved hydrogen. Furthermore, operators are interested in reduced cycle times to improve productivity. Such requirements can be met by using low-pressure, vacuum furnace carburizing (LPC), but many heat treating plants operate only atmospheric pressure furnaces and rely on endothermic-type, H2-N2-CO atmospheres. This paper presents a newly developed retrofit system, enabling atmospheric furnaces to produce LPC-quality parts with electrically-activated, N2-CH4-C3H8 gas blends. The activation of such oxygen-free, low residual-H2 and marginally flammable blends takes place inside a tubular gas injector at furnace inlet. Industrial demonstrations presented here include intergranular oxide-free carburizing in sealed-quench and pit furnaces as well as flash recarburizing of hot-rolled strip blades for agricultural applications. Atmosphere compositions, process control methods and design of gas flow field inside furnace are discussed.

Low temperature carburizing of stainless steel – an alternative to hard chrome plating

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Due to the European REACH act, the use of hexavalent chromium for chrome plating will be highly regulated from 2017 on. Therefore many users of hard chrome plating seek for possible

substitutions. Examples in the automotive industry cover fuel and exhaust treatment components like slide bearings as well as kinematic components exposed to salt fog environment in the engine compartment.

Concerning corrosion resistance, stainless steels could substitute hard chrome plating without any doubt. But due to the poor tribological behaviour, especially low abrasive/ adhesive wear resistance and a tendency to fretting, a broad application is limited. With the proprietary S^3P (Specialty Stainless Steel Processes) treatments it is possible to highly improve wear properties while maintaining corrosion resistance. The different processes are suitable for austenitic, duplex and martensitic stainless steels as well as nickel and cobalt base alloys. The thermo-chemical diffusion processes enrich the surface with carbon or nitrogen. Despite the formation of a supersaturated and very hard layer, carbide or nitride precipitation and thus a loss of corrosions resistance is avoided. Therefore those processes are a feasible solution to replace hard chrome plating.

In this paper technological properties of carbon supersaturated austenitic stainless steel are introduced. Comparing studies of corrosion, ductility and wear properties are presented for S^3P treated, hard chrome plated and untreated austenitic stainless steels, showing the superior properties of low temperature carburized stainless steel. Furthermore fatigue, galling and cavitation erosion properties are discussed. Possible fields of application are presented.

Keywords: Stainless steel; Carbon Supersaturation; Expanded Austenite; Automotive; Wear; Hard Chrome Replacement

Low pressure carbonitriding with methylamine

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State of the art processes for low pressure carbonitriding use ammonia as the nitrogen donor, and acetylene as the carbon source. Own experiments showed that the nitrogen utilization is low during the nitriding step with ammonia, the nitrogen uptake is slow and the maximum temperature during nitriding is limited to about 850 °C due to decomposition reactions of ammonia in the gas phase. This leads to long process times and high process gas flows to achieve the desired nitrogen uptake of the steel. A theoretical study was conducted to find other possible carbonitriding gases and with methylamine (CH3NH2), as a simultaneous carbon and nitrogen source, an alternative was found with which promising carbonitriding results were achieved.

In this presentation carbonitriding results (e.g. carburizing and nitriding fluxes, and process gas utilizations) obtained for the 18CrNi8 steel in a thermobalance are shown. The gas phase compositions were analyzed during the methylamine pyrolysis as well as during carbonitriding by gas chromatography and mass spectrometry. The mass uptake during carbonitriding is illustrated, and the nitrogen uptake is compared to processes with ammonia as the nitrogen donor gas. The challenges of methylamine as a carbonitriding gas are discussed.

Keywords: low pressure carbonitriding, 18CrNi8, case hardening, ammonia, acetylene, amine, methylamine, pyrolysis

Heat treatment integrated in the machining process

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ECM Technologies is the leading company in vacuum carburizing furnaces worldwide;
The INFRACARB ® process for low pressure carburizing & low pressure carbo nitriding is implemented for mass production heat treatment plants ICBP FLEX ® since the beginning of the 90's.

Last requirements in terms of quality (distortion) and machining philosophies of the automotive industry lead to new generation of heat treatment furnaces. ECM Technologies enlarges its portfolio of technical solutions for:
Carburizing of sintered parts
Heat treatment furnace fitted in the machining flow.

UniCase Master ® - in-line, low-distortion, precision case hardening for automotive, transmission & bearing Industries

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Gears are part of mechanical power transmission devices and gear boxes used in machinery and vehicles. They are produced on a massive scale, and for the automotive industry global annual output reaches about 1 billion pieces.
Gears are commonly made of steel and have teeth with a hard surface and a flexible core which provides suitable strength and service life. These properties are usually obtained by heat treatment on the basis of atmospheric carburizing and quenching in oil, realized in continuous furnaces.
Traditional technology is characterized by low precision and repeatability in process results, large hardening distortion and high material handling costs mostly because of the batch type of heat treatment and inability of integration into in-line manufacturing.
There is a very strong industrial need of overcome traditional technology disadvantages and allow heat treatment meets of modern industries requirements. This article introduces a single-piece flow case hardening system by low pressure carburizing and high pressure gas quenching which allows individual adjustment to the size and shape of the particular gear in order to minimize hardening distortion and ensures ideal repeatability of results throughout the gears series. It is a compact system designed for high-volume heat treatment of gears in a lean manufacturing configuration ready for implementation within machining centers. Additionally the article will discuss the operational aspects, process costs and productivity.

The use of production-integrated vacuum heat treatment for serial production of transmissions in an automotive plant

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To secure the required properties, highly stressed gear components for automotive applications need to be case-hardened. In many cases, vacuum heat treatment technologies are used for that purpose. Besides advantages with respect to the part quality, these technologies allow for the integration of heat treatment in the direct production environment, which offers significant logistic advantages and cost savings.

The paper reports about the use of vacuum heat treatment in the process-chain of gear production in a new transmission plant of an automobile manufacturer. There, gear components of a dual clutch transmission are low-pressure carburized and high-pressure gas quenched in a modular heat treatment system. The final drive rings gears of the transmission are fully automatic heat treated in an OPF-style heat treatment equipment where they are low-pressure carburized at high temperatures and press quenched in oil. Besides a description of the manufacturing flow in the production, the heat treatment process- and system technology will be presented and the resulting properties of the gear parts are reported.

Advanced modular and continuous heat treatment concepts

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There are many requirements on modern heat treatment equipment. In addition to high operational reliability, reproducible material quality and maximum productivity there are also requirements for high energy efficiency which have to be realized by sophisticated technical solutions.

The presentation shows different technical developments to meet the future demands as well as the expectations of the furnace operators regarding flexibility, decrease of running costs and very short down time for maintenance.

IVA retort furnaces can be used in many ways, for tempering and annealing of tools that have been previously processed in vacuum hardening furnaces, also for a number of other different treatments

like recristallization, stress relieving, solution annealing, thermal aging as well as thermochemical heat treatment processes. These include in particular the process gas nitriding, nitrocarburizing in combination with anti-corrosive treatment (oxidizing).

Our retort furnaces are available in various variants. You have the choice of electrically heated and gas-heated versions. The systems consist of the oven housing with modern, good insulation and the horizontally inserted retort with circulation unit. Optional built-in cooling systems in different versions and with different cooling intensities allow each economic, energy-efficient and process-optimized batch cooling.For rapid generation of optimum process conditions the retort can be evacuated both, at the beginning, as well as within the batch cycle. In this way a rapid and complete change of atmosphere with small amounts of inert gas and cost is possible.

For these retort furnaces, IVA invented a new solution for reducing the unwanted chemical interaction of the nitriding atmosphere and the retort surface. The companies which decide to operate such an installation benefit from this invention as it facilitates a longer retort lifetime and lower process costs amongst other positive aspects.

The application range of the IVA- sealed quench furnaces is varied and includes a variety of methods of heat treatment. The systems are distinguished by a robust design - guarantee of reliable long-term operation. Used for hardening, gas carburizing or carbonitriding , case hardening, perlitizing or for simple annealing tasks with protective gas up to 1.000 °C, this type of furnace is one main product since decades and hence well developed.

The new sealed quench furnace has been redesigned at IVA. The cooperation with experts from the heat treatment industry resulted in a list of contemporary and practical requirements.

These requirements have been implemented by our engineers and technicians using modern, partly revolutionary technical means in the most advanced chamber furnace in the world - InnoVA 4.0.
Some of the special features of InnoVA 4.0 are:
• High temperature uniformity
• Max. Batch weight of 2000 kg
• Optimal use of the batch volume by elimination of the base grid
• Exact reproducibility of the heat treatment results
• Minimal installation time

As a member of a worldwide operating group in combination with the courage to create new challenging concepts, IVA is a reliable partner for current and future tasks in heat treatment industry.

Influence of the base material hardenability on effective case depth and core hardness

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In the large volume production of highly performant mechanical components , carburizing is still the most widely used heat treatment.
In order to continuously improve an guarantee the quality there is a need for tighter controls on both dimensional and heat treatment specifications.

Therefore it is imperative that the variables affecting case depth and core hardness are thoroughly understood and controlled.
This paper shows the relative significance of the critical parameters: carburizing time and temperature, carbon potential, cooling rate and steel hardenability. The relationship between base material hardenability and effective case depth and core hardness is very strong. Based on this relationship is easily understood that the use of steels with controlled and reduced hardenability is really necessary to realize the general goal of less variation in the "after heat treatment state".
Establishing an optimal combination between carburizing practice and the use of steel with controlled hardenability also offers a significant potential to reduce the heat treatment cost.
In order to realize this a close cooperation between all people that are involved is necessary.

Optimization of carburizing treatment for Nb-modified SAE 1022 carbon steel

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Carburization is widely applied to the low carbon steel to increase the surface hardness and wear capability. For energy saving and high efficiency, increasing the carburizing temperature in order to reduce the treatment time during the carburizing process is a feasible technology. However, grain coarsening accompanying the elevated temperature carburizing process deteriorate the final mechanical properties and make the dimensional accuracy worse induced by the heat treatment distortion. Niobium micro-alloying helps to prevent grain coarsening during elevated temperature carburizing. In this study, the relationships between carburizing temperature, treatment time and carbon potential in gas carburizing process would be analyzed for both SAE 1022 steel and Nb-modified one. By means of elevated carburizing temperature, the Nb-modified steel showed the faster carbon atom diffusion and deeper case depth than the SAE 1022 steel. Finally, an optimization of gas carburizing process for Nb-modified SAE 1020 steel would be developed to improve productivity and cost saving.

Properties of nitrided surfaces including post processes

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Nitriding processes reduce environmental impact both in production and during a product's life. Surface properties, fatigue strength and corrosion resistance can be improved significantly. Compared to case hardening advantages are less distortion and reduced energy consumption.

In order to meet requirements for lower fuel consumption, low friction powertrain-components are needed. In the case of wear and friction, compound layer properties e.g. hardness, porosity and phase composition are crucial. The aim in this study has been surfaces suitable for components such as gear wheels and pistons. These are components requiring high strength and excellent friction and wear properties.

In this work the tribological properties in a series of seizure experiments has been compared for different steel grades and nitriding processes. Opportunities to further enhance the properties by post-treatments, eg post-oxidation and PVD coating, has been examined. The influence of surface topography, before and after heat treatment, has been included.

NITROPULS© - A new technology of sensor controlled gas nitriding with variable nitriding potential

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For gas nitriding processes the nitriding effect of the process gas is quantitatively defined by the nitriding potential KN. The value of KN significantly influences the phase structure, the chemical composition and the growth rate of the compound layer. In the case of nitriding with a formation of compound layer the time and temperature dependent growth of the diffusion layer is determined by the nitrogen activity at the interface between compound layer and diffusion layer. Hence, the composition of the process gas is not affecting the nitriding hardness depth. These relations open up possibilities for a new process control by means of a variation of KN.

The present work shows results of a new process technology during gas nitriding treatments applying a cyclic variation of the nitriding potential and gas flow rate. It focuses on the controlled setting of the compound layer by using a material- and component specific, time dependent cyclic variation of KN. Simultaneously the ammonia consumption during the process is reduced up to 80 % compared to industrially applied nitriding processes with constant KN. The new developed nitriding technology is proved for classical gas nitriding and gasoxi-nitriding in order to evaluate the possibilities and limits of both process variants.

On the example of different steels it is shown that the variable time dependent change of KN directly affects the growth rate and the phase composition of the compound layer. Thereby, the height of the pulse level and the frequency of the pulsation cycle permit the controlled setting of the compound layer structure and growth rate. The resulting nitriding hardness depth as well as case hardness is kept constant.

Towards the in-line control of the active screen plasma nitrocarburizing using infrared laser absorption spectroscopy

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A novel active screen plasma nitriding (ASPN) process provided excellent temperature homogeneity in the load and showed further progress in the control of nitriding potential. The main difference of the ASPN to conventional plasma process is the replacement of the glow discharge from the components to a separate metal mesh screen (active screen) surrounding the entire workload. Highly reactive gas species are produced on the active screen and directed towards the component surface. The principles of the ASPN process are based on the well known phenomenon of nitriding in "after glow". Excited neutrals in different excitation states, such as N_2, N, NH, etc., were found to exhibit high reactivity to the metal surface and therefore play a decisive role in the nitriding process during the post-discharge. The active screen plasma nitrocarburising (ASPNC) technology is an extension of the ASPN method in that different carbon-bearing gases such as CH_4 or CO_2 are admixed to the N_2-H_2 process gas. The use of gaseous medium containing both carbon and nitrogen results in further complexity of possible chemical reactions in plasma providing new mechanisms of mass transfer from the gaseous phase to the metal surface. A growing interest in application of advanced non-intrusive in-situ plasma diagnostic methods is stimulated by the need of quantitative information about absolute concentrations of stable and transient molecular species monitored direct in process.

Methods of laser absorption spectroscopy (LAS) in the midinfrared spectral range have been proven to be a versatile diagnostic approach for a better understanding of the plasma chemical phenomena. Recent development and successful applications of new generation of laser source – quantum cascade (QC) laser opened new perspectives for industrial process monitoring and control.

In the present work the evolution of the concentrations of six stable molecules, of the carbon containing precursors CH_4 and CO_2, and of the reaction products NH_3, HCN, CO and H_2O, has been monitored by QC-LAS diagnostics during plasma nitrocarburizing in the large industrial scale ASPN-system. One of the main objectives was to determine the reaction pathways for the gas species including the fragmentation rates of the precursor molecules and the conversion rates for the produced molecular species. Correlations to the process parameters, such as the plasma power at the active screen and the process gas composition, as well as a correlation to the metallurgical results of nitriding experiments were analyzed and discussed. A concept for the in-line control of the ASPNC process was proposed.

Increasing the service life of the extrusion dies for hot extruding of aluminum profiles through controlled gas nitriding ZeroFlow

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The aim of the tests conducted both in laboratory and industrial conditions, was to increase the service life of the extrusions dies for hot extruding of aluminum profiles through controlled gas nitriding ZeroFlow. Wear mechanisms of the dies have been analyzed, stating that it occurs through: the formation of cracks on the working surfaces due to thermo-mechanical fatigue, brittleness of the material as a result of growth of the above mentioned cracks, frictional and chemical wear, breaking of internal elements of the dies.

It has been ascertained that the reason of the rapid wear of many dies is improper, in terms of phase structure, thickness and hardness, nitrided layer.

It has been demonstrated that by the use of controlled gas nitriding ZeroFlow developed by SECO/WARWICK Europe and University of Technology Poznan/Poland, one can form permanent diffusion layers on the dies. In the operation conditions the best, in terms of durability, and economy of the nitriding process, layer should consist of the near-surface γ′ zone and the precipitation zone, not include the nitride network on the grain boundaries and in the corners of friction pieces. After wear of the layer the dies can be nitrided again several times.

Mobile laser hardening system for industrial application

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The mobile laser hardening system is the ideal tool for targeted partial hardening of metallic surfaces; for example, on cutting edges or bend radii of heavy casting molds.

With its self-driving caterpillar truck, the robot can effortlessly be driven directly into the thick of the action. On site, the flexible robot arm moves in free 3D movements, reaching even the most demanding, three-dimensional work pieces without issue. Therefore, there is no need to remove the components to be hardened.

Due to the temperature-based laser control, the heat can be applied precisely to the desired spot. This makes it possible to achieve exactly the required degree of hardness, without material distortion in the surrounding area.

During hardening, the quality assurance process is documented precisely. The mobile laser hardening system therefore offers the highest process security and reproducibility.

Keywords: laser hardening, mobile laser system, industrial application, forming dies, cutting tools, aut

One step ahead - Innovative usage of laser beam in vacuum for automotive applications

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In the production of gear wheels usually wheel and synchronizer ring are welded, followed by case-hardening and final machining. For conventional laser welding so far CO2 laser sources are often used. However today the use of solid-state lasers is required by industry more frequently but increased spattering makes it most challenging. Weld beads and other residuals from processing cause serious troubles.

pro-beam, in cooperation with partners, has developed a new process combining the advantages of welding in vacuum with laser welding using solid-state laser sources. Therefore the focus was on weld spattering, weld seam quality, part's cleanliness and energy efficiency. Selective process development made it possible to achieve the economic advantages of laser welding on the one side and the quality benefits of welding in vacuum on the other side.

The technology guarantees high quality welding results even for materials with limited weldability. The reduced spattering and the improved energy transfer makes the laser welding under reduced pressure suitable to use for mass production machines with low maintenance requirements. To be efficient the gear wheel production lines combine several process steps like pressing, preheating before welding and cooling, brushing and testing after welding. For flexibility of the production the systems are designed to process a variety of different gears without additional setup effort.
Due to the achieved quality of the seam with very small seam width an low power input it is now possible to laser weld case-hardened parts. This at the end reduces the required final machining effort of the parts and thereby the total production costs.

Together with a German OEM this worldwide new process was realized first time in 2015 in the mass production of gear wheels.

The report will show how the new technology "Laser Welding under Reduced Pressure" was implemented in the mass production of gear wheels. The innovative machine concept will be demonstrated and the new process as well as the required equipment will be compared to electron beam welding as well as to conventional laser welding.

Process development and control for serial production with the VHM and HHM type induction hardening equipments

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With more than 25 years experience in behind, AAGES Ltd. designs and produces large range of induction hardening machines, with state of the art frequency converters, as well as full digital control for the machine and process.

The huge diversity of the applications, which include case hardening in hardening workshops, dedicated machines for in-house hardening, where the automotive industry is the most exciting area, trough hardening for steel industry and even more, all these has some common requirements, asking for fast process development, very good process control and certainly the highest possible production rate.

With solid theoretical and practical background, having its own hardening workshop and test field, AAGES Ltd. offers solution for elaborating new process which can be applied on the universal or custom designed hardening machines produced in his workshop.

The developing process starts with the specification for the hardened parts and is considered closed when the parts produced with the equipments manufactured by AAGES Ltd. are passed through the final acceptance of the end user.

Process optimization by multiple frequency design of induction hardening processes for automotive parts

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Induction heat treatment of automotive parts is one of the core businesses in induction hardening machine industry. Providing hardening machines for a desired process is only one half of the challenge. It becomes more and more important to provide a complete process chain starting with development of hardening machine, material handling concepts up to delivery of a complete hardening process.

In a classical manner this process development is done by trial and error combined with experience from earlier development projects. In many cases this leads to extended costs due to increased necessary effort. Inductors have to be crafted and adapted in more than only two development and design cycles. Especially manufacturing complicated single shot coils is a time-consuming job.
Besides

all technological advantages of a single shot process in some cases a realization is not suitable for 2 reasons of part geometry. A good example of such geometry is a camshaft used in automotive industry. Here a single shot approach is often hard to achieve, if this job is not done with a SharpC concept.

In this paper an approach is shown, where a Cam Shaft with different types of hardening zones like bearings of different diameters, lobes and a taper will be hardened in one setting without flipping the part or pass the part to a second hardening station. By an additional optimization of frequency for each different hardening zone it will be shown, that heat treatment timing of the related scan hardening process is minimized and high quality hardening results can be gained by a flexible machine and process concept. For each zone the frequency will be changed step less during the hardening process. Variations of part length can be handled by adaption of the hardening CNC program instead of adaption of the coil geometry.

Further a second process, a single shot hardening process based on Inductoheat SharpC concept of a similar part will be shown and a comparison will be drawn between the scanning approach and the single shot SharpC-process discussing the benefits and limits of each of the two hardening concepts for Cam Shafts.

Numerical results of a 2D simulation of heating process will close the paper.

Investigation on the effect of short heat impulses on the microstructure and mechanical properties of peak aged AW-6082

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Optimal material properties for the production process and during the component lifetime are often in conflict and lead to compromise. Induction heating provides a tool for tailoring of the mechanical properties, according to the local loads and manufacturing steps.

In this study the effect of short heat impulses on the mechanical properties of a peak-aged Al-Mg-Si alloy were investigated. The specimens were heat treated by induction heating within a dilatometer. Heat impulses with maximum temperatures between 200°C and 450°C and heating rates between 10°C/s and 500°C/s were tested. After the heat treatment their hardness as well as their deformation behavior was determined. Using the generated data, an empirical model describing the change of the material properties based on the Hollomon-Jaffe parameter, usually used for the prediction of the response of steels to a tempering treatment, was established and validated.

It could be demonstrated that shortest heat impulses can halve the hardness and strength of a peak aged aluminum alloy. The change of the material properties after such a treatment can be sufficiently described by an approach based on the Hollomon-Jaffe parameter. The model can be used easily for FEM-simulations in the development process of tailored heat treated blanks.

Performance and properties of an additive manufactured coil for MHZ-application in inductive heat treatment

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In inductive heat treatment processes the induction coil design plays an important role in localization of heat generation. Furthermore, modern high frequency generators allow a controlled and tailored hardness depth profile in the workpiece via skin effect. Therefore, the combination of an optimized coil geometry and frequency choice determines the workpiece properties and applicability of close-to-contour inductive hardening for small parts or thin hardened layers.

Hence, high current, high frequency and short duration are necessary in the heating process to harden small parts and thin layers.

For increasing frequency and current, the skin effect starts to be relevant in the coil itself, so that current concentration and consequential heat generation underneath the surface of the coil limits power of heating and thus speed of the process. Therefore, the relation of wall thickness to size of the cooling channel in the coil has to be well defined.

Conventional manufacturing methods are reaching their limitations with these conflicting specifications of geometry at applied frequency.

Additive manufacturing of copper in a selective laser melting process offers an innovative method to build very small coils with high design flexibility.

One difficulty in this process is the porosity underneath the surface which leads to an increasing resistance and structural weakness.

In the present work, a microstructural and a mechanical characterization are presented and the performance of an additive manufactured induction coil in MHz induction application of small surface hardened wires of steel is examined.

Efficient process control for induction hardening

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In many industries, the use of non-contact temperature measurement has become essential for efficiently monitoring and controlling production processes. In fact, high quality standards can only be guaranteed by precisely controlling temperature for even the smallest components.

During induction hardening and tempering, a particular spot of the workpiece (e.g. precision parts made of steel or cast steel) is heated up and subsequently quenched rapidly. For such contactless heating methods, usually only a specially defined area on the surface of the workpiece is heated.

This method of selectively heating and quenching a workpiece is critical in achieving the desired hardness of the material. If the temperature is too low, it will lead to insufficient surface hardness. However, if the temperature is too high, it may damage the workpiece so it becomes unusable. To optimize the inductor power and heating rate, pyrometers and thermal imagers working in the near infrared spectrum can accurately measure the workpiece profile during warm-up.

This guarantees that no overheating of the workpiece takes place, allowing to achieve a uniform hardness.

For efficient process monitoring and control through temperature measurement, there are dedicated infrared measurement solutions available from standard-pyrometers and two-color pyrometers to composite solutions, which consist of pyrometers with integrated thermal imaging functionality.

Conclusion:
The use of pyrometers or thermal imagers for controlling induction processes provides significant advantages for the user:

- quick and easy process optimization
- maintaining exact quality-standards
- creation of robust, repeatable processes for monitoring of production
- enabling gapless process documentation for proofing process-safety

Utilization of PVD hard coating after electron beam surface treatment for highly loaded cast iron components

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Wear protection plays an important role for highly loaded automotive components. Therefore, PVD hard coatings with very high hardness have become well established in industrial applications for steel components. As an alternative to steels, currently efforts are focused on cast irons for automotive components because of less or better machining, reduced weight, and lower costs. But due to the insufficient load support of this soft base material and/or of individual microstructural constituents (graphite) the use of hard coatings on cast irons for wear protection is limited.

The present contribution deals with the possibilities of electron beam (EB) liquid phase surface treatments without (remelting) and with Ni base additive (alloying) to improve the conditions for deposition and load support of the thin PVD hard coatings. The main interest of investigations is payed to the Ni dependent microstructure of the EB treated layers and the resulting hardness levels before and after the thermal cycle of PVD hard coating. Beside the hardness of the EB treated layer, the toughness of the specific microstructural constituents influences substantially the properties of the composite layer.

Comparative studies of single (PVD hard coating of base materials) and duplex treatment (EB treated and subsequent PVD hard coated) were carried out. For characterization the different load capacities of the single and duplex treated coatings hardness measurements and unlubricated pin-on-disc wear tests using different normal loads were realized. Beside the influence of EB layer configuration different PVD hard coatings (TiN, TiAlN) were also taken into consideration for wear testing.

The investigations prove that it is possible to use PVD hard coatings with all its outstanding properties for cast iron components using duplex surface treatment technologies.

Tribological advantages of DLC coatings for highly loaded applications: Bearings

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Technical data about tribological behaviours of thin film (like TiN, CrN, DLC...) are not always easily usable for industrial applications. Indeed, these laboratory tests data were performed under conditions rarely representative of real parts stresses, especially for highly loaded parts.

In order to help manufacturers in the selection of DLC coatings (Diamond Like Carbon), CETIM has performed a study to better understand the influence of the structural parameters of thin films (thickness, adhesion, composition...) on the friction behavior and wear resistance of some carbon-coatings (DLC, WC/C).

For this study, the bearings are particularly suitable because of their superfinished surfaces (races and rolling-elements). Indeed, the DLC coatings performances are very dependent on the roughness of substrate. Moreover, the surface of bearings has the interest to be stressed mechanically (high contact pressure) and tribologically (friction, fretting).

Ten tradenames of DLC coatings (a-C:H, a-C:H:Si and WC/C) were deposited on bearings superfinished (production) or tribofinished (optimised) and were evaluated on specific tests for friction behavior, fretting wear resistance, high load resistance and corrosion.

Most of the coatings have shown too low resistance to bearing application with the highest load. However, for lower contact pressures, DLC coatings have shown remarkable performance for fretting wear resistance (Brinelling) and the reduction of bearing torque.

Keywords:
DLC, Diamond Like Carbon, Bearing, Tribology, Coating

Oxidation resistance and structural stability of superhard PVD coatings

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Increasing demands on manufacturing processes related to the production of parts in automotive industry lead to the need of continuous improvement in machining technologies. Especially due to need for improvement of the productivity, decrease of the processing costs and increase of products demands, machining operations such as hard machining, dry machining, high speed machining and precision machining have experienced significant growth, while generating higher stresses on tools. Advanced coating systems are aimed at improving the tool wear behaviour significantly and to enhance the tool performance. The contribution deals with the analysis of the oxidation resistance and structural stability of superhard PVD coatings deposited on the AISI M36 high speed steel. Four types of coatings, namely CrN and AlTiCrN monocoatings, AlCrN/CrAlN multilayer with the AlXN3® trade name and nACo3® triple nanocomposite coating were deposited onto suggested HSS using LARC® (LAteral Rotating Cathodes) process. PLATIT π311 deposition unit was utilized for evaporation of individual coatings. Following analytical techniques, namely: scanning electron microscopy (SEM) fitted with energy dispersive (EDX) and wavelength dispersive (WDX) spectroscopy, x – ray diffraction analysis with the possibility of "In – Situ" specimen heating were used for analysis of all types of coatings deposited on the tool steel surface before and after heat treatment.

Keywords:
PVD coatings, cutting tools, oxidation resistance, structural stability

The principles of creation and selection of hardmetal consisting hardfacings for different abrasive wear conditions

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Tungsten carbide based thermal sprayed coatings and carbide consisting PTA-welded hardfacings are prospective for protection against abrasive wear. At the same time for selection of abrasive wear resistant composite hardfacings for intensive abrasive wear conditions as the structure (composition, hardness etc) as well the wear conditions (abrasion, low or high energy impact etc.) at different scales (nano-, micro- or macroscale) must be considered.

It is demonstrated, that at abrasion with micrometrical abrasives (abrasive particle size up to some hundreds μm) the HVOF-sprayed coatings and PTA-welded composite hardfacings with the same size of hard-phase demonstrated excellent wear resistance. At the same time at extreme abrasive wear conditions (high energy impact wear – at high velocities of millimetrical size abrasive particles) the wear resistance of above mentioned composite coatings is low.

The recent research is devoted to the study of influence of hard-phase particles size, shape and content in metal matrix hardfacings to their abrasive wear resistance. The recycled Wo-Co hardmetal powder with particles size about some hundreds micrometres and some millimetres were used as reinforcement in iron based composite hardfacings. Hard-phase particle shape was angular, rounded and spherical, amount of reinforcment in iron-based FeCrSiB-matrix varied from 10 to 70 vol%.

From the deposition methods powder metallurgy (PM) and plasma-transferred acc (PTA) welding technologies were used.

The microstructure, macro- and microhardness and wear resistance at abrasion, erosion and impact

wear conditions were studied. The influence of hard-phase content particles size and shape as well deposition technologies to abrasive wear resistance was clarified. The optimum content of hard-phase and reinforcement particles size for hardfacings for different wear modes were proposed and potential application areas of studied hardfacings are recommended.

Keywords:
hardfacings, PTA-welding, powder metallurgy, wear resistance.

Neural network assisted design and optimization of hot work tool steel heat treatment

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Tool material properties including hardness and fracture toughness depend on the microstructure, mainly defined by heat treatment conditions. Traditionally trade-off between high fracture toughness and sufficient hardness and wear resistance is required. However, in the case of vacuum heat treatment proper combination of austenitizing and tempering time and temperature allows optimization of microstructure, resulting in improved fracture toughness while maintaining high hardness. Response of tool steel in terms of fracture toughness and hardness on vacuum heat treatment conditions depends on tool steel type and processing route, but mainly on the steel composition and alloying elements involved in the precipitation of secondary carbides. However, with the modification of the composition and alloying elements content effect of heat treatment conditions on the tool steel properties will change, requiring tremendous experimental work and design of tempering diagrams.

The aim of the work, which will be presented at the conference was to explore the potential and possibilities of neural network based modelling, in order to select and optimize vacuum heat treatment conditions depending on the hot work tool steel composition and required properties. Training of the feedforward neural network with error backpropagation training scheme and four layers of neurons (8-20-20-2) scheme was based on the experimentally obtained tempering diagrams (540°C – 630°C) for seven different hot work tool steel compositions and at least two austenitizing temperatures (176 data points). Due to the radial symmetry and possibility to simultaneously measure different properties (fracture toughness, hardness, compression and bending strength, etc.) circumferentially notched and fatigue pre-cracked tensile bar specimens (CNPTB) were used to prepare tempering diagrams. Finally, neural network assisted selection and optimization of vacuum heat treatment conditions was experimentally verified using low Si content ESR hot work tool steel. By comparing the measured values to the model prediction, the model can be constantly corrected and improved with each new material composition, providing better predictions and optimization of parameters.

Keywords:
hot work tool steel, heat treatment, neural network, composition, fracture toughness, hardness

Estimation of temporospatial heat transfer coefficients by parallelized PSO approach

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The parallelized the Particle Swarm Optimization (PSO) method has been developed to solve Inverse Heat Transfer Problems. Temporal and spatial dependent Heat Transfer coefficient functions obtained on the surfaces of axis-symmetrical work pieces are estimated by applying the novel technic. The goal function to be minimized by the PSO approach is defined by the deviation of the measurements and the calculated temperatures. The PSO algorithm has been parallelized and implemented on a GPU architecture. Numerical results are demonstrated that the determination of Heat Transfer Coefficient functions can be performed by using the parallelized PSO method, as well as, the GPU implementation; provide a less time consuming and accurate estimation.

Keywords:
IHCP, Heat Transfer Coefficients, Particle Swarm Optimization

Numerical modelling of steel quenching

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Numerical modelling of phase transformations and hardness distribution in non-monotonic quenched steel specimen was developed based on the results of simple experimental test i.e. Jominy test. The hardness in specimen points was estimated by the conversion of cooling time results to hardness by using both, the relation between cooling time and distance from the quenched end of Jominy specimen, and by using the Jominy hardenability curve. Microstructure composition and other mechanical properties were predicted based on predicted as-quenched hardness and characteristic cooling time. The cooling curve at the specimen point was predicted by numerical modelling of cooling by using the finite volume method. Developed numerical model for computer simulation of quenching was also experimentally verified. Limitations of proposed numerical model were found out as well. It has been shown that proposed numerical model can be successfully applied for purposes of simulation of quenching of carbon and low alloyed steel specimens.

Keywords:
Numerical modelling, Steel, Quenching

A combined finite element - phase field model approach on the bainitic transformation

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Tailored tempering [1] allows creating work pieces which differ locally in properties in order to combine regions with high strength with others of high ductility. In this process martensitic and bainitic microstructures can be obtained. The latter offers higher ductility zones and is the main focus of this study. The simulation of this manufacturing process requires a model for the bainitic transformation, such as the Johnson-Mehl-Avrami one, where his fitting parameters are commonly experimentally obtained [2]. On the other hand,the phase field method is a powerful numerical tool able to describe the most relevant metal-physical mechanisms during, e.g., phase transformations such as the aforementioned [3]. It is the goal of this article, to establish a link between the mesoscopic scale accounted through the phase field method and the macroscopic behavior of the bainitic transformation. A dilatometer test is used in this first attempt as base for comparison of the numerical results, where a coupling of the finite element and the phase field method is proposed.

Keywords: bainitic transformation, 22MnB5, phase field model, press-hardening.

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Utilizing the internet of things to enhance lean manufacturitn in gear heat treatment

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The heat treatment of automotive gears transmission components is at turning point. The new Ipsen Low Pressure Carburizing system - Argos has potential to unlock a new ways of managing heat treatment variables and enhance gear making productivity. The new LPC system optimizing heat treatment operations through the data collection, data computation and maximize production schedule. The new Argos, Low Pressure Carburizing production system not only is optimizing operations but also improves maintenance and spare parts inventory. The new system is modular designed and is customized for every customer specific layout requirements. Universal LPC system can be expend by adding additional module as the production increases in the future.

Electrochemical boronizing of medium carbon DIN CK45 steels and its effects on corrosion behavior

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Boronizing, or boriding, is a thermo-chemical surface treatment in which boron atoms diffuse into ferrous or non-ferrous substrates to form hard boride layers. It is a promising surface hardening process performed on a lot of engineering materials to enhance their wear, fatigue, corrosion, oxidation and scratch endurance. In this study, electrochemical boronizing processes were carried out on DIN Ck45 steel, which is frequently utilized for component parts for vehicles, shafts, bushings, crankshafts and parts for the machine building industry. Experiments were conducted in molten salt bath containing borax at different temperatures (900-950-1000-1100˚C), process durations (30-60-90-120 min) and current densities (0,05-0,1-0,2 A/cm2). X-ray diffraction (XRD) and optic microscope (OM) were used to examine boride layers. Hardness values of boride layers were measured by Vickers micro-hardness test equipment under load of 1N. Hardness tests and XRD analysis revealed that single-type Fe2B layers were created on steel substrate. The results of the study showed that boronizing duration, operation temperature and current density influenced positively total boride layer thickness. Compared to traditional boronizing techniques, electrochemical boronizing was very fast and that property can be quite desirable in view of competitiveness in manufacturing sectors. The corrosion behaviours of borided and non-borided steels in HCl and H2SO4 (15% vol.) media were investigated by means of immersion tests. The experimental results indicated that electrochemically boronized steel had better corrosion resistance to the both acid solutions than non-boronized DIN Ck45 steel.

Keywords:
Electrochemical boronizing; Thermo-chemical treatment; Surface hardening; Boride layer; Corrosion resistance

In-situ monitoring of the microstructure evolution

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Steels that can obtain their desired microstructure directly from the forging heat (e.g. AFP or HDB steels) are increasingly employed for manufacturing automotive components in order to reduce process times and process costs. However, due to the high number of process parameters that influence the material transformation, reliable predictions about the microstructure evolution using computational simulations or CCT diagrams are problematic.

A new monitoring system, based on eddy-current technology and the detection of characteristic changes in the electric and magnetic properties during the cooling from the austenite, enables a contact-free and non-destructive in situ monitoring of the materials transformation as well as the phase and microstructures evolution. Owing to its robustness the system can be used in industrial forging and heat treatment lines and enables an online quality assurance as well as an online regulation of the cooling parameters to specifically set the components properties and optimize process times.

Keywords:
In situ monitoring system, material transformation, microstructure evolution, online quality assurance, eddy-current technology

Total quality in heat treatment: a global view and critical points for the future

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Quality is one of the key factors of success in modern industry. The way we manage the quality is and remains changing in order to align with the demands which become more and more stringent.

The majority of the quality management methods are applicable but some methods need an adaptation on certain points in order to be effective for heat treatment.

The heat treatment is characterized by a large variability in number and type of processes , in volume and quantity of parts to be treated, in the way of integration in the total production chain.

Very typical for heat treatments are:
- The important influence of the base material
- The difficulty for determination of specifications adapted to the function
- The translation of demands into specifications adapted for the use and measurement in the shop
- Measuring equipment with a relatively reduced precision
- The importance of a tight control of the deformations who limit rework possibilities

The quality management is the result of a close collaboration between all parties involved. The evolution and possibilities of the newer simulation systems form a real asset in order to obtain an environment of continuous improvement. All this form the basic conditions in order to proceed step by step towards "zero defects" situation with an acceptable cost for all parties involved.

RQP1: Heat treatment system survey and quality control

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RQP1 defines the quality requirements applicable to heat treatment on mechanical parts intended to be used mainly in the car manufacturing industry. It provides a reference for quality audit and for inspection of heat treatment workshops, whether these are integrated or belonging to subprime contractors. This document may also be used as basis for discussion and development of specifications.

RQP1 has been wrote by a French working group managed by the CETIM (French Technical Center of Mechanical Industry) and composed by contractors and subcontractors of automotive industry (PSA Peugeot Citroën, Renault, Faurecia, Valeo, SKF, NTN-SNR, Delphi) and by heat-treaters (Bodycote, Thermi Lyon, Metatherm, Hacer). Thus, it is in agreement with the industrial reality of the heat treatment. At the instigation of contractors and following the very favorable feedback from the RQP1's users, this document has been transcribed in a French standard (NF A 02-053) published in 2014.

In October 2014, France made a new ISO standard proposal on "control of quality of heat treatment". A draft, based on French standard NF A 02-053, has been proposed for the development of this new standard and the establishment of an ISO working group is expected for the end of 2016.

Keywords:
RQP1, Quality, Control, ISO, Standard

Information about quality system management requirements from heat treatment processes

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Thermal processing always significantly affect the properties of the product. Compliance with the principles of the quality management system and the application of standards of quality requirements, and verification of conformity can facilitate the achievement of the lasting reialbility of the prcesses of heat treatments.

Failure analysis of an automotive crankshaft

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A crankshaft and timing belt pulley bolt failed in service in a 1.6L 86KW automotive engine resulting in extensive repairs. The crankshaft and bolt were analyzed to determine the cause of failure. The failed crankshaft and filed bolt were examined visually, metallographically and using electron microscopy. The crankshaft failure initiated at the keyway, while the timing belt pulley bolt initiated in the threads. Crack propagation was by fatigue. The sources for fatigue initiation and subsequent failure of the bolt and crankshaft are discussed.

Optimizations of hardmetal reinforcement content in Fe-based hardfacings for abrasive-impact wear conditions

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The aim of the present research is to find out the optimal hardmetal reinforcement content for the Fe-based self-fluxing alloy matrix hardfacings, intended for abrasive-impact wear conditions. The hardfacings are produced of disintegrator milled hardmetal scrap (hardmetal content is 20 wt%, 40 wt%, 60 wt%, and 80 wt%, respectively) and commercial Fe-based self-fluxing alloy powder by liquid phase sintering in vacuum. Microstructure of the hardfacings is studied by the optical microscope, and Vickers hardness is measured at their surface. The studied hardfacings are subjected to abrasive-impact wear test, developed at Tallinn University of Technology [1] (abrasive - granite gravel, velocity - 80 m/s, angle of impingement - 90 degrees). After the test, volumetric wear of hardfacings is determined, and wear mechanisms are studied under the scanning electron microscope.

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Note:
To authors\' opinion, the topic of the present research corresponds with the 3rd conference topic proposed (3.Surface hardening technology (induction hardening, laser, electron beam), coating technology (thermal spraying, coating, PVD, CVD, plasma,..)).

In-Line X ray residual stress measuring on shot peening process

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Shot peening a method of cold working that can expand fatigue life by induced residual stress. It is often applied to auto motive parts such as gear, spring, and connecting rod. Arc height is used for process control how hard the shot peening process by almen strip. On the other hand, the fatigue strength of parts is depend on residual stress. Then, evaluation of residual stress is necessary.
Recent year, Japanese auto motive industry chooses individual process for quality control and parts trace ability. Naturally, there is potential demand in order to measure the residual stress in-line of shot peening process. In the case of in-line use, conventional method does not optimal. Because, it need over 10 minutes for measuring residual stress.
In this paper, we report the difference between process control of arc height and in-line residual stress measuring apparatus that can measure residual stress that can measure lower than cycle time.

Investigation of grain boundaries in alloy 263 after special heat treatment

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Alloy 263 is well known for its very good creep resistance and also for its weldability. These kinds of properties are appreciated in power plant industry where Alloy 263 is used for shafts in high pressure circle. One of the possible ways to increase properties of superalloys, including Alloy 263 is the effect of the grain boundary serration (GBS) which, as research indicates, is associated with improvement of creep resistance that can lead to increased efficiency of the coal power plants. Grain boundary serration was observed in different kinds of superalloys although formation mechanism of the serration has not been clearly explained yet. Some researchers reported that the formation of serration is associated with the change in the character of precipitates at grain boundaries. This paper deals with the investigation of the grain boundaries in Alloy 263 with two different kinds of heat treatment. To form serrated grain boundaries in Material A (MA), slow controlled cooling from temperature of solution annealing to 800°C was carried out. Standard heat treatment was performed for Alloy 263 on the Material B (MB). The experimental techniques of the scanning electron microscopy (SEM), and transmission electron microscopy (TEM), including electron diffraction (ED) were used to analyse the microstructure, determine the character of the grain boundaries and identify the secondary particles at the grain boundaries.

KEYWORDS: ALLOY 263, GRAIN BOUNDARY SERRATION, PRECIPITATES

Preparation of high entropy alloy for wear resistant applications by powder metallurgy route

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High entropy alloys (HEA) are a new class of materials distinguished by containing more than 5 elements with near-equiatomic portions, bearing simple FCC or BCC solid solution structures. In the last decade their potencial for industrial application was recognized. Their excellent mechanical properties determines them to be an alternative for traditionally used structural materials.
CoCrFeNiTi base HEA alloy produced by lost wax casting, already used in severe bearing conditions is capable of ouperforming Stellite 6 alloy in wear resistance, corrosion resistance and hot hardness. By using powder metallurgy manufacturing route, bearing properties can be easilly increased by introduction of solid lubricants, porosity penetration by oil etc. In our research attempt we obtained before mention alloy from elemental powders by a combination of mechanical alloying and induction hot pressing processes, with desired microstructure and hardness revealed by scanning electron microscope, X-ray diffraction and vickers microhardness test methods.

Protective paints for heat treatment - New developments in regards to requirements of health and safety as well as environmental regulations

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If steel components are heat treated by all kinds of carburising or nitriding processes according to one of the many different technologies which are meanwhile used for steel hardening, it is in many cases required to finish some areas of the hardened parts by machining, turning, drilling, broaching, cold¬forming, laser or electronic beam welding.

To leave areas unhardened is possible by coating through protective paints. This paints have been successfully used for decades to protect heat treated steel parts locally from carbon and nitrogen pickup by providing a gas tight layer on the surface of the workpiece. Also protective paints are applied to prevent parts from decarburisation, oxidation and scaling during heat treatment.

This presentation describes the most commonly used protective paints for carburizing and nitriding processes with particular emphasis on newly developed water base products considering and redeeming valid requirements in regards to health and safety as well as environmental regulations.

Moreover this poster will give a survey of the major industries where protective paints are used successfully, and state-of-the-art automatic / semi-automatic equipment is shown to achieve this in a safe and economic way.

Investigation of fracture resistance of subzero-treated Cr-V cold work tool steel

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Influence of sub-zero treatment on fracture toughness of Cr-V ledeburitic steel Vanadis 6 was examined with reference to the same material processed without the sub-zero period. Samples were austenitized and quenched from a temperature of 1050 °C, sub-zero treated in liquid nitrogen for 17 h and double tempered at the temperatures from the range 100 – 600 °C. Each tempering cycle was 2 h. Microstructures were characterized using light microscopy and scanning electron microscopy. Morphology of fracture surface was studied by means of laser confocal microscopy. Hardness and nanohardness were measured by Vickers method under a load of 98.1 N (HV 10) and Berkowich method under a load of 300 mN, respectively. Fracture toughness was determined by three-point bend tests, using chevron-notched specimens with dimensions of 10x10x50 mm. Measurement of fracture toughness values was supplemented by the examination of fracture surfaces. Microstructure of the material consists of the matrix and several types of carbides – eutectic carbides (ECs), secondary carbides (SCs), and small globular carbides (SGCs), irrespectively to the heat treatment applied. Small amounts of retained austenite were also presented in the microstructure, but only in no-tempered or low temperature tempered steel. Sub-zero treatment increases the amount of small globular carbides. On the other hand, tempering results in decrease in population density of these particles. Fracture toughness of conventionally heat treated steel firstly increases with tempering, but it decreases rapidly when tempered at the temperature of secondary hardening. In the case of sub-zero treated material, the fracture toughness is correspondingly lower when tempered at low temperatures, but it becomes slightly higher in the temperature range normally used for secondary hardening. Generally, one can express that the fracture toughness follows well the values of hardness of the material, excepting a narrow temperature range in case of sub-zero treated steel, where a "window" for simultaneous enhancement of hardness and toughness exists.

Influence of heat treatment on the thermal conductivity of copper infiltrated tool steels

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The infiltration of tool steels with liquid copper is a suitable and cheap method to create dense parts using powder metallurgy. In this work, the effect of heat treatment on the thermal conductivity of these materials is investigated. It is shown that the copper network that forms inside the pre-sintered steel skeleton during infiltration enhances the thermal conductivity of the resulting composite. The level of enhancement is mainly dependent on the thermal conductivity of the copper phase and its volume fraction. By applying multiple heat treatments, a strong influence on the thermal conductivity of the composite was revealed. This influence depends on the solution state of iron in copper, which was analyzed by means of SEM-Analysis and EDS.

To allow the transfer of the results to other volume fractions of copper and other steels, the single contribution of the copper phase was investigated. For this purpose, a model alloy was manufactured which replicates the copper phase after infiltration. The conductivities of both components, steel and copper, were measured and put into a simplified FEM model. Using this model, the overall conductivity of the composite could be simulated. The results are compared with other analytical mixture rules as well as the measured values. This approach enables the application of a calculation model for the conductivity of infiltrated steels.

Local electron beam heat treatment of forging dies

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The usage of the high-energetic source electron beam can enable the repeated surface quenching of chosen areas of a surface. This treatment leads to a local hardness improvement, resulting in the local wear damage decrease. The possibility to increase the hardness of a surface with the electron beam treatment of dies was the main goal of the applied development performed on the alloyed steel X37CrMoV51 (1.2343). Such increase in the critical areas of dies should prolong their lifespan and thus decrease their renovation frequency. The article deals with the influence of the particular technological parameters of this treatment on the final properties of the treated areas. The electron beam surface quenching resulted in a very fine martensitic microstructure with the hardness of 800 HV. The maximum quenched depth was 1.00 mm and 0.75 mm for the trace width of 20 mm and 40 mm, respectively. The hardness values continuously decrease from the surface level to the material volume.

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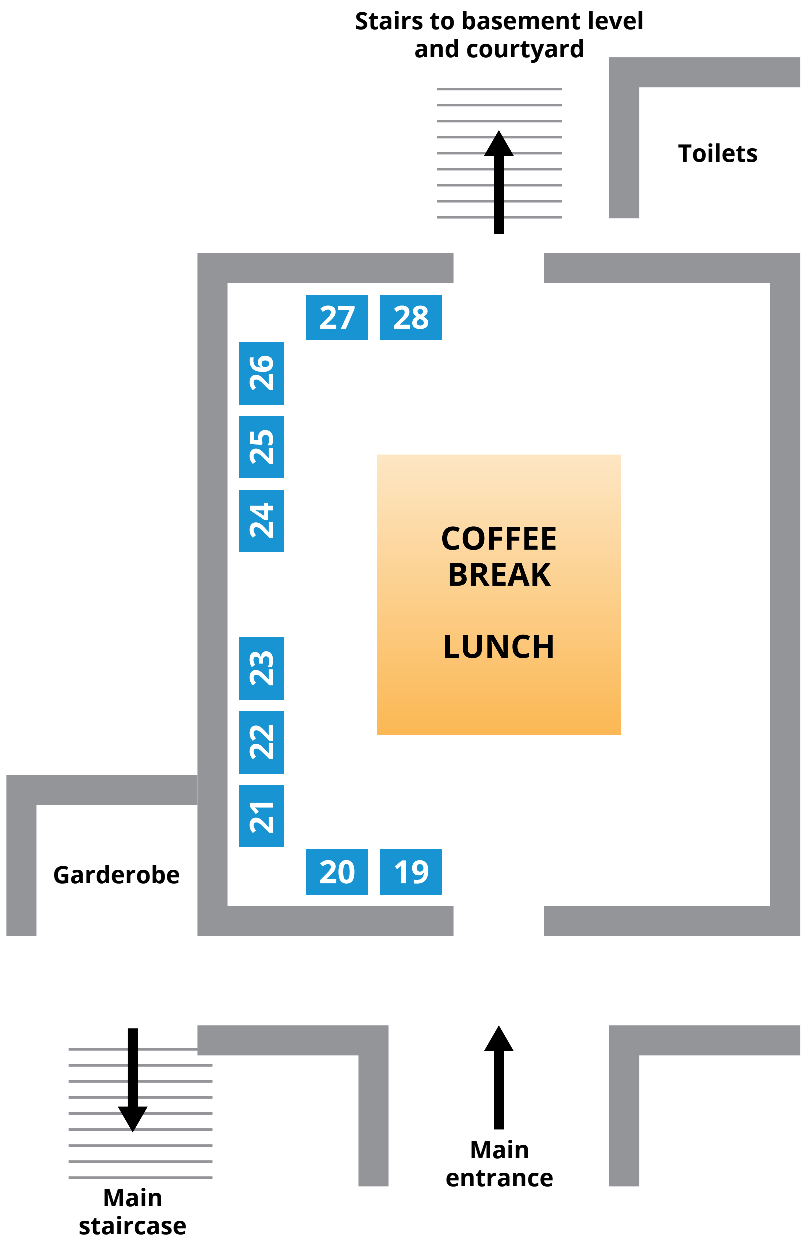

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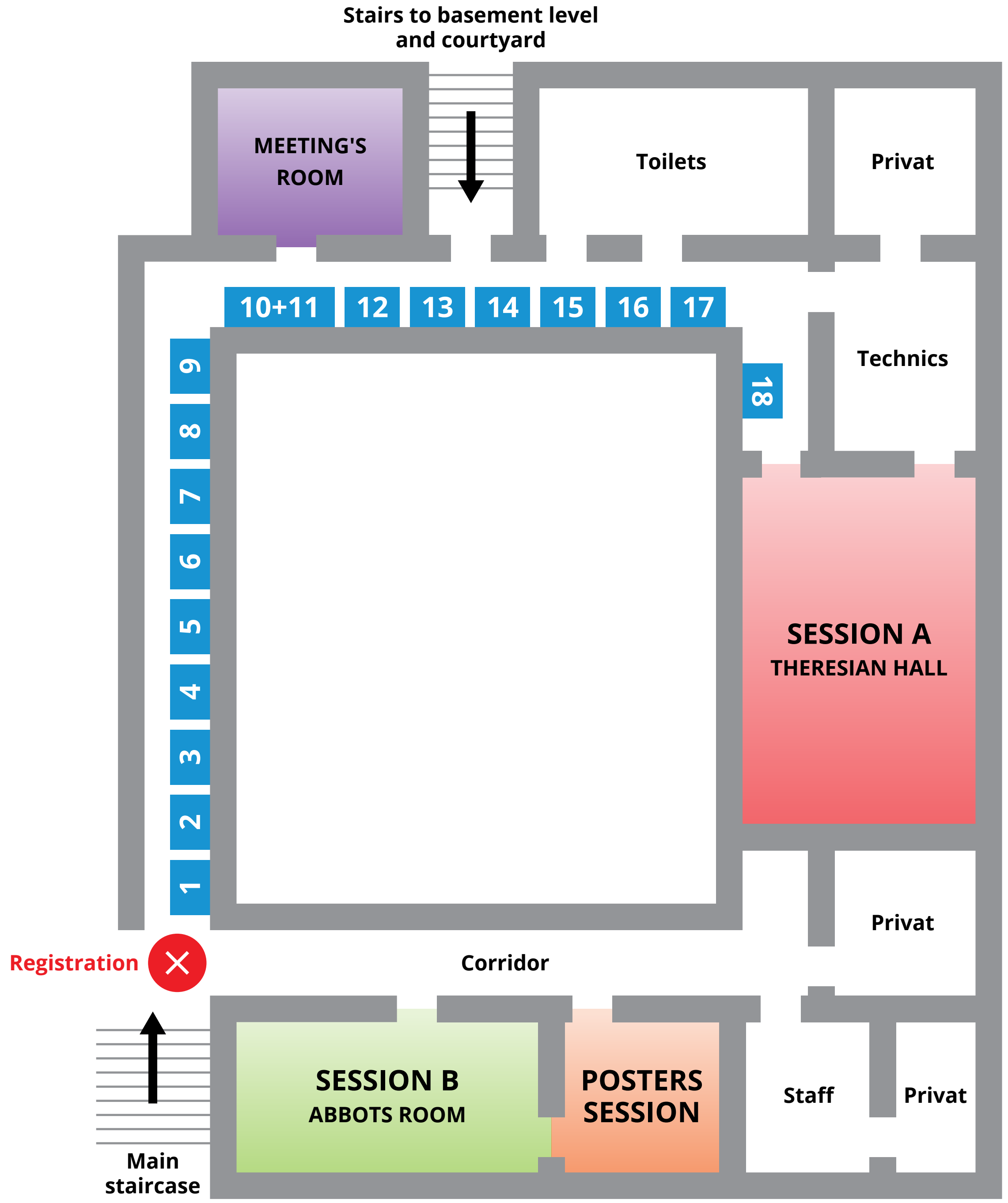

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EMO Oberflächentechnik GmbH
www.emo-ot.de

EMO Oberflächentechnik is your competent partner when it comes to parts cleaning – from design and planning to manufacture and commissioning and finally service and maintenance of the systems.

Stand 27

TAVENGINEERING S.p.A.
www.tav-engineering.com

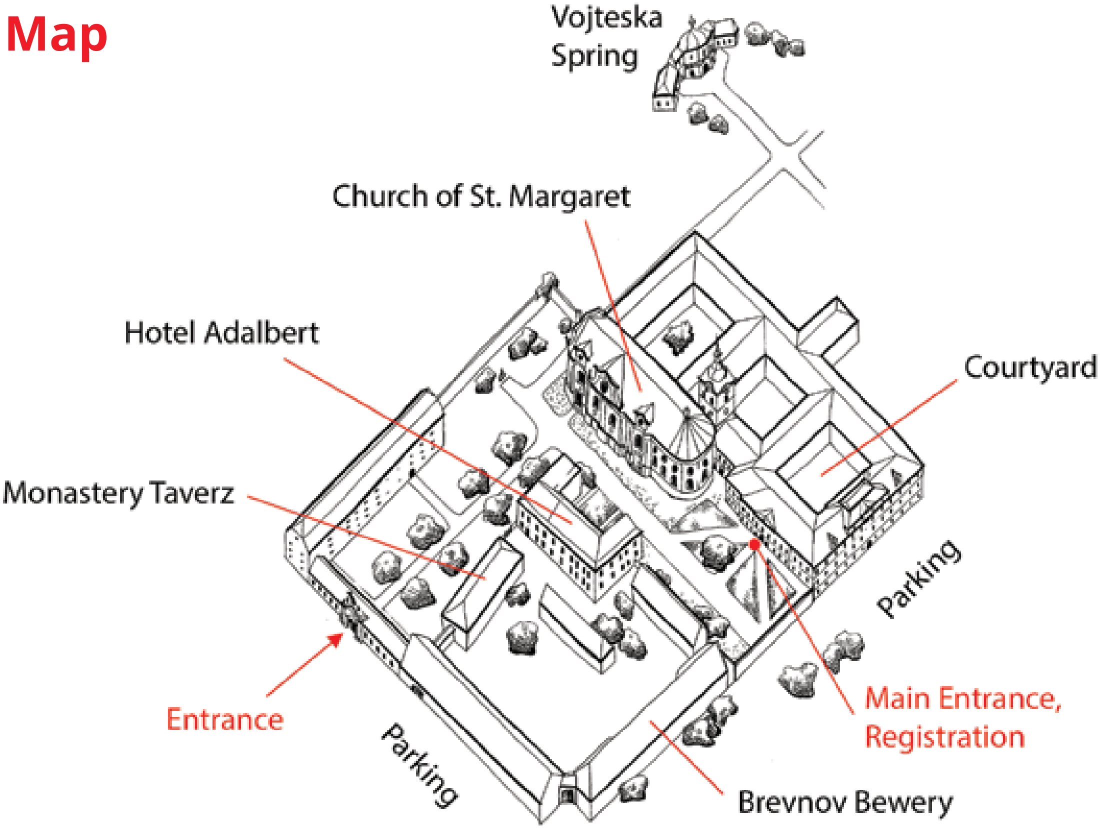
Since 1999 TAVEngineering is fully dedicated to provide technical assistance and spare parts for the maintenance, renewal and repair of vacuum furnaces of any type and brand. Routine maintenances and emergency services are performed on site in the shortest possible time. TAVEngineering is a solid and reliable partner which can count on a motivated and highly qualified staff of engineers and technicians.

Stand 28

Ipsen International GmbH
www.ipsen.de

High quality standards and increasing raw material costs require us to be passionately committed to developing new heat treatment solutions. The outcome of our work: energy-efficient Ipsen furnaces and plant systems, as well as unrivaled products that are in demand all over the world and used by leading companies in the Automotive, Aviation and Aerospace sectors, to name a few.

Map


Vojteska
Spring
Church of St. Margaret
Hotel Adalbert
Courtyard
Monastery Taverz
Parking
Entrance
Parking
Main Entrance,
Registration
Brevnov Bewery


Vojteska Spring
Church of St. Margaret
ECHT 2016 Brevnov Brewery
Hotel Adalbert
Monastery Tavern
U Vojtěšky Street
Markétská Street
Patočkova S
Centrum
TRAM
22,25,57
Bělohorská
Street
Plzeň/Airport
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ATZK ASSOCIATION
FOR THE HEAT TREATMENT OF METALS

WHO WE ARE

The Association for the Heat Treatment of Metals (ATZK) is an independent professional organization originating from the voluntary union of legal entities. ATZK was established in order to bring together professional interests in the fi eld of the heat treatment of metals and in the advancement of the level of this entire branch of technology. ATZK establishes and maintains organizational and professional contacts with foreign associations, primarily the International Federation for Heat Treatment and Surface Engineering (IFHTSE) and the German company Arbeitsgemeinschaft Wärmebehandlung und Werkstofftechnik (AWT). ATZK produces a triannual bulletin with information from the branch, which keeps its members updated on its activities and events.

Ing. Pavel Stolař, CSc.
ATZK President

Ing. Alexandra Musilová
ATZK Executive Secretary

WHAT WE OFFER TO OUR MEMBERS

- An advantageous participation fee for technical ATZK seminars
- Participation in organizing professional seminars
- Training aimed at professional development in the fi eld of heat treatment
- An advantageous participation fee for professional conferences
- Advertising opportunities in the ATZK bulletin
- Information, perspectives, and expert opinions or their inclusion in the full service provided by ATZK
- Information acquired from both foreign and domestic professional publications
- The application of knowledge and materials obtained through the international contacts of ATZK
- Information on events organized by ATZK and their foreign partners
- The opportunity to submit proposals concerning the organization of other (new) educational events of ATZK

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