Development of a variable warm forging process chain

Final Report Summary - DEVAPRO (Development of a variable warm forging process chain)

Against the background of rising market opportunities for high quality warm forged products, in the project DEVAPRO, a warm forging process is developed, enabling the forges to produce more complex long flat geometries and thus making the warm forging technology more variable. Warm forging is an economical alternative to the conventional forging technology:

1. reduced energy input;
2. no scale and reduced decarburisation improving the product quality;
3. reduced surface roughness; and
4. closer tolerances.

Additionally, the replacement of heat-treatable steels by low alloy steels due to improved work piece properties of warm forged products and the potential for light weight design is investigated. To reach those
goals, new technologies, namely a warm rolling operation and an induction reheating process are developed and embedded within an established warm forging process chain. The integration of these operations enables the forges to increase the output, improve the final work piece properties and broaden the spectrum of producible geometries. For two model products, the production sequences are developed and tested based on two warm rolling technologies - cross wedge rolling (CWR) and forge rolling - to evaluate the qualification of both rolling technologies concerning application at lowered temperatures.

A definition of part groups enables small and medium sized enterprises (SMEs) to deduce the possibility of the developed warm forming process chain for other parts of their spectrum. This definition includes distinctive features, to assess the transferability easy and quick. In addition to finite element method (FEM) simulations, a model test is developed to investigate the process limits of CWR of three different materials representing three steel classes. A model test is used for experimental tests for the rolling operation. The design of the model test equipment and tools is modular subdivided according to the knifing, guiding, stretching and sizing zone. In the design, the sensors for force and velocity measurement are integrated. The experimental tests deliver the basis for the process chain and allow detailed analyses.

After the warm rolling operation, an intermediate heating is necessary. A main goal for heating for forging is to reach a certain constant temperature throughout the work piece within a minimum time and a maximum of efficiency. The heating line can be adapted very flexible to different work piece diameters and production rates. The whole heating process is controlled by special design software and digital controllers.

Project context and objectives:

In work package one (WP1), an overview about the product portfolios of the forges has been worked out (see deliverable D1). In the next step, the two model products steering link and connecting rod have been chosen by the consortium for the subsequent work packages (see D2).

WP2 is divided into the two subchapters 2.1 and 2.2. The process chains for the two example parts each consist of a rolling operation. In WP2.1 (see D5), the basic design of the tool geometries and the geometry of the work pieces is developed. The impact of different temperatures and at the cross wedged part the wedge angle on the rolling process forces are described. In WP2.2 (see D4), the preforming operations (hot cross wedge and forge rolling) have been conducted at temperatures between 1 200 and 900 °C. The properties of the samples forged according to the existing technologies, both forge rolling at OMTAS and CWR at VIVA, were analysed. The tests and analyses were conducted in order to study the effect of the temperature reduction on the mechanical and structural characteristics of the slugs. For the connecting rod, the material C70S6BY and for the steering link 38MnSiVS5 were suggested by METAV and approved by the forges OMTAS and VIVA. Both steels meet with the requirements of the forges (see D4). The trial-materials were modified from three materials to two materials because of the economical relevance for the forges (see details in D2).

In WP 2.2 a model testing tool was developed by IPH to investigate the process limits of CWR of two different materials representing two steel classes identified in WP 1.1. The flat wedge rolling process developed in WP 2.1 is downscaled and the impact on the process conditions was documented.
Due to a delay in manufacturing the tools, the planned CWR trials at IPH could not be performed in time. The trials were finished in August 2010 (planned February 2010). The results show that it is possible to perform CWR at temperature below 900 °C (please see D6 and D7). With the help of an experimental plan, the process limits for the parameters a, β, ρ for different steels, slug diameters, surface roughness, temperatures and velocities were determined. The rolled pieces were investigated by METAV for their structure and the formation of voids.

In WP3, the hot workability during simple loading and cycling loading process for the two steels C70S6BY and 38MnSiV5 were evaluated (see D8). The tests were high temperature tensile tests, high temperature low cycle fatigue, microscopic examinations of fracture surfaces and microstructural analysis of longitudinal section, near the fracture surface. The results as shown in D8 evidence the applicability of these two steels for the forging.

In WP4, ETP developed a numerical model of electromagnetic and nonstationary thermal field that fully describes the reheating process. The results of the numerical investigations have provided all input data needed for designing the reheating unit. The construction and dimensioning of the system, the selection of a suitable power supply and the definition of the electrical and water connection characteristics were performed. A function prototype of the induction coil was built at the ETP workshop and the functionality of the suggested heating system as well as the suitability of its parameters were verified. The transport of the induction heater was not determined exactly in the description of work. After discussing the possibilities for the transportation the best solution seems to be that ETP takes the induction heater from EMA-TEC and transports it to Zlin by lorry.

Two new warm forging process chains are taken into operation: One at VIVA using CWR as preforming and one at OMTAS using forge rolling as preforming.

At VIVA a complete forging sequence of steering link was forged and a variable induction reheating system was installed. The reheating system was able to reheat the rolled billets in order to compensate temperature loss during CWR. The CWR operation at 850 °C and lower using the CWR-machine UL45 was not safe: Blocking of tools occurred. To guarantee a safe CWR-machine operation with the UL45 it is recommended to take 950 °C as minimum temperature.

At OMTAS a complete forging sequence of connecting rod was forged and a reheating system was installed. Trials with and without reheating were performed and the temperature distribution of the billet along the longitudinal axis was measured. No blocking of the tools occurred at 900 °C. The reheating system was able to reheat the rolled billets in order to compensate temperature loss during CWR.

The description of carrying out the trials is given in D12. The detailed results are presented in D13. The material analyses results are presented in D14.

Based on the data provided by the partners and the data collected during the tests, an environmental performance evaluation took place. Additionally, an economical evaluation was performed comparing the properties of both developed processes with the current hot forming production sequences. The scientific results and conclusions are reported in D11.
knowledge collected during the development on the warm forge rolling and warm CWR technology as well as the reheating technology is documented in a guideline. The data from the testing (WP 5.2) was evaluated regarding the transferability of the technology. The guideline comprises a resume of results and a critical analysis of process reliability. The guideline allows the transfer of the researched technology on other parts and parts groups. Definition of part groups enables the SMEs to deduce the possibility of the developed warm forming process chain for other parts of their spectrum. Definition includes distinctive features, which enables the SME to assess the transferability easy and quick. Features are identified with orientation to SMEs' needs. IPH and ETP create a feature list together with the two forges. The feasibility of using the new warm technology for industrial use is mainly described in deliverables D15 and D16.

Project results:

Two new warm forging process chains are taken into operation: One at VIVA using CWR as preforming and one at OMTAS using forge rolling as preforming. At VIVA a complete forging sequence of steering link was forged and a variable induction reheating system was installed. The reheating system was able to reheat the rolled billets in order to compensate temperature loss during CWR. The CWR operation at 850 °C and lower using the CWR-machine UL45 was not safe: Blocking of tools occurred. To guarantee a safe CWR-machine operation with the UL45 it is recommended to take 950 °C as minimum temperature. At OMTAS a complete forging sequence of connecting rod was forged and a reheating system was installed. Trials with and without reheating were performed and the temperature distribution of the billet along the longitudinal axis was measured. No blocking of the tools occurred at 900 °C. The reheating system was able to reheat the rolled billets in order to compensate temperature loss during CWR.

CWR at VIVA

At VIVA, a warm forging process chain with warm CWR, reheating and die forging was installed. In a first step, warm CWR and reheating were run-in and in a second step a batch production added by die forging was performed. In WP 5.1 the CWR machine UL45 with the developed tools and the developed induction reheater were took into operation. The focus was on the working on the CWR-tools, CWR-machine limit and adjusting of reheater parameters.

In the CWR-machine UL45 at VIVA two similar CWR-tools are mounted. The tool geometry is derived from the FEA-simulation and experimental trials with the model test at IPH:

1. wedge angle 7°;
2. forming angle 25°.

After connecting the machine to the power measurement and monitoring system at VIVA, the guiding system in the CWR-machine was adjusted according to binned diameter, length and area reduction. This system has to fix the billet in the middle between upper and lower roller (cross beam) during the rolling operation in order to prevent the billet from ejecting out of the machine before the whole forming is done.

During the trials at temperatures of 850 °C and below, the overload protection system (safety device) of the machine operated, stopped the machine and opened the guiding system. To prevent the machine from stop operation in these condition, an overload protection system confirmed to be adjusted to the CWR-machine was added.
damage, only some parts were rolled at 850 °C. Furthermore, VIVA decided to increase the temperature for trials in the following WP 5.2.

The induction reheating system consists of the power supply EMA-TEC FUP with 50 kW output power, the heating station and the water cooling compartment. The process parameter (heating time, output power) are set by the operator according to the current work piece temperature after rolling. The temperature monitoring is being done online before and after the reheating process by means of infrared camera and the measured data are evaluated and stored by the control system. The electrical parameters are measured both directly by the reheating system itself (output power) as well as centrally in the main forge shop power distribution system (input power) in order to evaluate the energy consumption and electrical efficiency of the system. Furthermore, the power consumption of primary heater and CWR-machine is measured centrally in the forge shop distribution system.

For a particular rolling temperature, the work piece is manually transported from the CRW-machine and put into the feeding unit of the reheating station. The temperature distribution is measured and the output power used for reheating is set by the operator. The work piece is moved in into the defined position within the inductor and the reheating starts. After a defined heating time (10 sec) the generator is switched off and the work piece is taken out from the inductor. The temperature is measured and the work piece can be transported into the press.

A decrease of temperature from the common hot forging temperature field to warm temperatures increases the forming force and consequently the power consumption of the CWR-machine. Furthermore, the power consumption of the rolling machine depends from the rolling speed: The maximum power consumption at a rolling speed of 12 min-1 is 60 kW and the maximum power consumption at rolling speed 16 min-1 is 40 kW. All work pieces at 1220 and 970 °C are rolled successfully and the maximum power consumption of the CWR-machine is around the limit. At 900, 880 and 850 °C the maximum power consumption is detached above the limit, because of blocking of the tools. These peaks of the power measurement are up to 25 kW higher than the maximum power consumption/limit.

An increase of temperature in the middle section of the billets can be identified for higher rolling speeds (16 min-1) at temperatures 950 and 900 °C. This effect can be explained by the higher forming energy, which is necessary at higher forming speeds and is converted into heat energy. Trials at 16 min-1 and 850 °C were not possible, because of machine blocking. Thus, the temperature was increased to 880 °C in order to decrease the forming force and prevent the machine from blocking. At 850 °C and 12 min-1 a significant increase of temperature in the middle section can be detected in comparison to 950 °C. To calculate the electrical efficiency of the reheater, input and output power are measured. The focus is on the temperatures 970, 900 and 850 °C, because these are in the interest of VIVA. The results of the energy consumption measurement show that an average total electrical efficiency of the reheating installation is very high (approx. 95 %) and remains stable for different loads and power outputs. The following intermediate conclusions can be made:

CWR:

1. lower temperature limit of CWR-machine UL45 is 950 °C at billet diameter: 42 mm, area reduction: 49
% and material: 38MnVS6;
2. the lowest rolling speed of the CWR-machine (12 min-1) is recommended for warm temperatures to use the maximum torque of the machine.

General remarks on thermal behaviour:

1. temperature decrease due to rolling observed during the test (average): 100 °C;
2. temperature losses due to the rolling depend on starting temperature; and
3. rolling speed (influence of forming energy and contact time);
4. temperature profile after rolling unstable especially in deformed area - negative influence of surface treatment (machining) on infrared temperature measurement.

Induction reheating:

1. reheating by induction within the required time is possible;
2. approximate generator power needed for compensation of temperature losses (average temperature difference 100 °C): 20 - 25 kW;
3. good agreement with data provided by numerical simulation.

The preform was geometrically measured in order to identify the variation of the mass on the side areas, where some flash occurs. These measurements show that the mass in the middle of the work piece is not varying and all have the same shape of the die. On the sides, some flash occurs and is varying between 9 and 7 mm. This is not critical, because the shape of the main form is filled. To evaluate the tolerances of the preform, points of five parts are identified and measured: Minimum difference is 0.020 mm and maximum difference is 9139 mm on the side. The final form after clipping was geometrically measured in order to identify the variation of the mass on the side areas above the clipping line: Minimum difference is 0.121 mm and maximum difference is 0.384 mm.

The material consumption is an important factor in the forging industry due to rising costs of steel. To evaluate the mass utilisation, of each forming step in the forging sequence four parts at minimum were measured concerning the mass. The average weight of the rolled part is 1658 kg and of the clipped final form is 1521 kg. So a mass utilisation of 92.52 % results, which is a quite good ratio.

Forge rolling at OMTAS

At OMTAS a warm forging process chain with warm forge rolling, reheating and die forging was installed and batch production was performed. In the following the results concerning temperature distribution, tolerances and material utilisation are shown.

In frame of the batch production at OMTAS, the temperature monitoring of all production steps has been performed. The testing procedure starts by primary heating up to the required work piece temperature of 900 °C followed by consequent forge rolling operation. The online temperature measurement starts immediately after heating and includes all operation within the forge rolling process. In this way, a detailed identification of thermal losses in the work piece due to the forge rolling is possible. The reheating process
is done in a standard inductor that is not optimised for work piece geometries with variable cross-section. Therefore, the reheating time has been significantly prolonged in order to get an admissible uniform temperature profile before the forging operations. Although the standard cycle time cannot be reached in this way, such a production test allows determining the influence of the intermediate heating on the forging process as well as a detailed evaluation of the overall thermal cycle. Consequently, the work piece temperature is monitored during the forging sequence and trimming operation.

The primary heater provides the initial heating of billets up to the selected forming temperature and is directly followed by the forge rolling operation. As the heating is realised in a batch mode being controlled manually there can be seen some temperature deviation along the work piece axis but the temperature homogeneity is sufficient for the test purposes. Due to the continuous monitoring of temperature during the whole process, the influence of initial conditions before the forming operations can be respected within the process evaluation. Due to the forging rolling, the work piece surface is cooled down by the contact with tools. During the rolling process, the work piece is repeatedly formed to provide the required mass distribution. Looking at the infrared picture, three typical sections can be identified. At the left side cooling of the work piece surface due to the manual holding during the forming steps can be observed while the neighbouring section is neither in contact with tools nor with handling device. Therefore an increased temperature is visible in this area. On the right side, the remaining part of the work piece being exposed to the contact with tools is characterised by a temperature decrease between 70 °C and 100 °C.

The forge rolled parts were measured using a three dimensional (3D) coordinate measuring machine at IPH. Billets at temperature class 900 °C were analysed. The parts are measured in a x-y-plane and y-z-plane (like the cross wedge rolled parts). Due to an exact mass distribution, the rolling tools are working in the aimed geometry spectrum. A geometry variation of about 5 mm was identified at the end of the parts. Five parts were chosen as representative geometries. The final form after clipping was geometrically measured in order to identify the variation of the mass on the side areas above the clipping line. The form of the connecting rod is completely filled in the forging sequences. To evaluate the tolerances of the final form (after clipping), 18 points of five parts are selected and measured: Minimum difference is 0.084 mm and maximum difference is 0.277 mm.

To evaluate the mass utilisation, five parts of each forming step in the forging sequence were measured concerning the mass. The average weight of the rolled part is 1.597 kg and of the clipped final form is 1160 kg. So a mass utilisation of 73.05 % results. Due to the more complicated geometry of the connecting rod in comparison the steering link, the material utilisation of the connecting rod is lower.

Material investigation

The parts were analysed concerning the material characteristics. During the hot tension testing several parameters of the test can give useful information about workability of the steels and their ability to withstand deformation process. The reduction of area is the primary parameter which assesses the ability of materials to resist to cracks' formation and propagation. Reduction of area detects even small ductility variations, caused by composition or deformation process. According to B. Taylor a correlation of hot workability of a metallic alloy with reduction of area during hot tensile test can be made.
The reduction of area for steel grade C70S6 was 52.62 %; for values ranging within 50 to 60 %, the workability is good, with very few cracks; the rolling process can be done with normal reductions and strain rate. The steel grade 38MnVSi5 had a reduction of area 73.7 %, which means excellent workability, rare cracks, good ductility, the deformation can be done with higher strain rates and heavy reduction. Considering the shape of engineering tensile curves (stress-strain), the two steels had similar behaviour: very short range of uniform plastic deformation (elongation, without necking) until the maximum load. This denotes a high tendency of materials to reach local plastic deformation in the very early stage of the process.

In addition to ductility measurement, other parameters of the testing, like true stress at maximum load, true fracture stress and true fracture strain will give a measure of load and deformation which can be applied to the analysed steels without aparition of internal defects.

Concerning the load necessary to induce the plastic deformation, 38MnVSi5 steel proved a better plasticity, the value of maximum load and of 0,2 yield stress being 211.9 respectively 174.7 MPa. Between these values the steel is in a plastic condition. The levels of plasticity characteristics were relatively high for the first steel (about 26 % elongation and 73 % reduction of area).

The steel grade C70S6 has a lower plasticity and the plastic deformation load is higher within 408 and 361 MPa, plastic deformation at 900 °C occurs. The low cycle fatigue tests confirmed the plastic behaviour for the two steels at 900 °C.

For the stress in the range of yield stress determined by monotonic tensile tests (up to 230 MPa for 38MnVSi5 and 400MPa for C70S6), the number of cycles to failure is rather high (around 2000/38MnVSi5 and 1800/C70S6). Increasing of the load during fatigue tests lead to dramatic decreasing of number of cycles to failure, up to 40/38MnVSi5, 300/C70S6, respectively. It is important to mention that the third level of load was chosen to simulate a very severe complex of conditions, using values much higher that the yield stress in monotonic tensile tests, predicting that in dynamic cycling tensile - materials supports higher stresses until failure.

The 38MnVSi5 fracture surface examination has showed a ductile aspect, with fine craters nucleated on ferrite grains. Many tubular voids were observed, uniform distributed on all surface. No central macroscopic voids were observed. The mechanism of fracture were the initiation, growth and coalescence of small voids (10 to 30 µm diameter) inducing the reduction of transversal area of the specimen. This fact is confirmed by the microstructure evaluation on the longitudinal section near the fracture surface. Semnificativ defects were observed in the necking area, until 2 mm distance from the fracture surface. We can conclude that until about 60 % local plastic deformation, no semnificative defects appear in the material under tension.

A different mechanism of fracture was observed on C70S6 steel. More brittle at 900 °C, the fracture surface has both ductile and brittle aspects. The predominant mechanism of fracture was by growing of microcracks initiated on the brittle volumes and the secondary way was the initiation, growth and coalescence of microvoids, nucleated on small area of ferrite. The microstructure on the longitudinal section show the presence of defects near the fracture surfaces, at local plastic deformation levels over 37 %.
Economical and environmental evaluation

The electrical efficiency is generally determined by the relationship between the work piece (billet) diameter and the heating coil diameter. These diameters should be approximately matched to achieve high electrical efficiency. For ideal energy efficiency, there would be a dedicated inductor for each and every billet diameter in the production schedule. A more practical approach is to examine the production schedule and designate a family of induction coils, where each coil is suitable for a range of billet diameters. The number and size of the coil represent a compromise between the competing objectives of optimal inductor / work piece matching and operational flexibility. Thermal efficiency is primarily influenced by the heating cycle time and the induction heating train length. Recall that the rate of heat loss by radiation is proportional to the fourth power of the surface temperature (Bolzmann law). Thermal efficiency is therefore improved by minimising the heating interval that work piece is held at elevated temperatures. The goal is therefore to heat the billet quickly and briefly, subject to process requirements for reliable, accurate and uniform billet heating. Radiation heat losses can also be reduced by insulating and/or lining the heater coils. In any case, optimal thermal efficiency requires optimisation of induction heater train.

Inductor efficiency strongly influences the total system efficiency. Heating steel to the enthalpy temperature of 1250 °C requires a specific energy input of about 240 kWh/ton. In the most industrial applications, depending on the adjustment between the inductor and work piece, the required system input power from the grid is between 380 and 550 kWh/ton. For the following comparison an average value of 450 kWh/ton will be used, corresponding to the inductor efficiency greater 75 %.

The resonance circuit efficiency should be at least 97 % and is determined by the design and sizing of the capacitor battery and associated bus work.

Since transformers with off the shell efficiencies of 99 % are already available, there is little opportunity to improve the operational productivity through additional transformer.

Energy evaluation - warm forging

In the new warm forging process investigated in the frame of the project DEVAPRO, primary heating up to 900 °C takes place before the preforming operation. Compared to the hot forging technology, this reduction of the forging temperature leads to a significant reduction of energy consumption based on:

1. lower specific energy input;
2. lower thermal losses.

While the required specific energy input decreases proportionally to the temperature difference of approximately 350 °C, the reduction of thermal losses is more significant due to its proportionality to the fourth power of the surface temperature. Having considered these factors, an ideal consumption of 0.30 kWh/kg for the heating process up to 900 °C can be estimated. Energy consumption of the reheating process has been evaluated experimentally during the forging and heating tests at VIVA in February 2009.
and June 2010. The temperature recordings performed in the forging line have shown an average temperature decrease of 100 °C due to the rolling operation. It has been proven, that the new reheating system is able to compensate the thermal losses in very short time. In particular, total time for reheating operation has been set to 10 sec, the average power taken by the generator from the grid during the heating process was about 25 kW. By help of these values, a nominal energy consumption of 0.045 kWh/kg can be estimated for the reheating process. The total energy consumption is given by sum of the both values for primary heating and reheating process.

During the forging operations, some material is lost due to scale occurrence. The warm / hot material on the surface is in contact to air and reacts with oxygen. Increasing the temperature increases scale, especially at hot temperatures. Using warm forging decreases the temperature. So scale and material can be saved:

Hot forging:

1. The scale formation at hot forging is 1 % of the sheared weight: 17 g/part.

Warm forging:

1. The scale formation at warm forging is 0.3 % of the sheared weight: 5 g/part;
2. Saving: 70 %.

In order to compare the die life between hot and warm forging of the connecting rod, it is necessary to make a serial production of connecting rod at warm forging condition. During warm forging the trials of the con rod, approximately 500 parts were forged and there was no defect determined on the die surfaces. However, the total die life needs to be determined at serial production conditions. The expectation is the increasing forging force of the warm forging method can be compensated with higher die life by the support of optimal die. The energy consumption of the warm forging method is 23 % less than hot forging method. By applying the forge rolling preform method at the warm forging, the material consumption has decreased 6 %. The scale is a common accepted problem of the hot forging method which cannot be removed. This hard oxidation layer has negative effects on to the die life, die filling and the environmental cleanliness. The cost of the storage and the elimination of the accumulated scale are high. Because of the lower temperature level of warm forming method, the surface oxidation and scale formation are 70 % less than the hot forging conditions. Also the surface cleaning process (shot blasting) time and cost of the warm forged parts are 50 % lower than hot forged parts. Additionally, lower scale means better surface quality and a low decarburisation layer on to the surface of the forged parts whereby less machining stock can be considered by the designers of the Automotive industry. According to the final calculation of the connecting rod forging cost, the total cost saving of the final forged connecting rod is between 3 and 5 % in comparison to hot forging method. Such saving possibility is very important while the competition is very hard in steel forging and automotive industry. The next target is to apply this method in to the serial production of the connecting rods.

Potential impact:
The consortium discussed the use of the plan for the use and dissemination of foreground during its final meeting on 07 December 2010 in Kaarst-Büttgen (Germany) at Bemers company. Every partner showed how it plans to use the results achieved in the project. Thereafter all partners had the chance to make comments on or to make their objections against the planned way of disseminating the results. The planned actions below are agreed by all partners will be performed within 2011.

In the following, the planned dissemination activities are described for each SME and research and technological development (RTD) partner.

IPH

Distributing CWR tool technology together with a partner in this field of industry

The presentation of DEVAPRO results to IPH's partners out of DEVAPRO showed a large interest of the forging industry on the tool technology IPH used for its CWR tests in DEVAPRO. Therefore IPH looked for a potential partner able to distribute this technology to the industry because IPH alone is not able to produce such machines. Together with Lasco, a manufacturer of e.g. CWR machines, IPH is actually looking for potential customers that are willing to use a first CWR-machine with flat tools designed by Lasco and IPH. Both expect to deliver their first machine within 2011.

Presenting results on a conference

IPH plans to present its results of DEVAPRO on CARV 2011 in Montreal, Canada, from 2 to 5 of October 2011. It offers a forum for engineers, scientists and researchers from academia and industry to discuss current practices and future challenges germane to the success and survival of manufacturing in a changing and globally competitive environment.

Publication in two scientific journals

IPH is going to make at least more publications. Up to now IPH made publications in magazines that have a high reputation in industry. Within 2011 the results of DEVAPRO will be published in scientific journals. This indeed will lead to spread the knowledge on DEVAPRO in the industry on the one hand and in international science on the other hand. The planned journals are 'Journal of materials processing technology' and Wissenschaftliche Gesellschaft für Produktionstechnik (WGP) 'Production Engineering - Research and Development'.

Presenting results of CWR on the industrial fair 'Hannover fair'

'Hannover fair' takes place from 4 to 8 April 2011 in Hannover, Germany. It is the most important and largest fair for the industry in the field of production. IPH plans to show the results of DEVAPRO by presenting its results on IPH's exhibition stand. Furthermore, IPH's engineers will actively make discussions about DEVAPRO results by visiting the exhibition stands of companies that could be interested in DEVAPRO results.
The project website http://www.devapro.de will stay online for at least one year. IPH will update the website with new publications made by the partners to show the results of the project DEVAPRO.

Furthermore, the download area of http://www.devapro.de will stay the safe platform for important internal data of the project like general project issues deliverables and data of project meetings.

VIVA

Use of gained knowledge for new warm CWR tool

CWR tests at temperatures below 950 °C could not successfully be performed by VIVA within the duration time of DEVAPRO. Anyway VIVA will go on in developing warm forming processes with using CWR.

VIVA purchased new CWR tools from SMERAL company (Czech Republic). Using the gained knowledge of DEVAPRO ("Training of about six VIVA engineers by ETP and IPH"), which will also be available for SMERAL, the new tools are designed.

Furthermore, VIVA is planning to order a new CWR-machine with larger rollers and more power. This new machine can assure applying the new warm rolling technology at larger parts.

Presentation of DEVAPRO results on a national forging conference

VIVA is going to present the DEVAPRO results and the influence on itself on a national Czech conference in May 2011. VIVA expects an increase in reputation according to presenting itself as an innovative manufacturer of forging parts and acquiring new customers on the conference.

Publication in a Czech forging magazine

Additionally to the presentation of DEVAPRO results on a conference, VIVA plans to write an article for a national forging magazine. VIVA expects the same positive influence as from making the presentation on the conference but the magazine is distributed to more people in forging industry and therefore an even wider spread of the results and the positive influence on VIVA is expected.

Training of about six VIVA engineers by ETP and IPH (February 2011)

One engineer of IPH and one engineer of ETP will travel to Zlin in order to train a group of VIVA’s engineers in designing forming processes via finite element analysis (FEA), including forging and CWR, adapting induction heating processes and analysing forming processes with analytical methods in science. The training will last approximately two days and will take place in March or April 2011.

OMTAS

Negotiation with a large customer on usability of warm forging processes including forge rolling
At the end of 2011, OMTAS will make discussion with one of its largest customers for connecting rods about delivering warm forged parts. OMTAS will use the results of DEVAPRO (written down in deliverables) for convincing that customer of the warm forming technology including warm forge rolling. The better quality of the parts should increase the price OMTAS gets for selling and by the way OMTAS should be able to reduce their costs for production.

Training of OMTAS engineers

In September 2010, Prof. Baake and Martin Mach from ETP have been to OMTAS for training their engineers in electrothermal processing. Fifteen engineers of OMTAS joined this meeting which showed a good combination between scientific progress and practical use.

Publication in a Turkish magazine (2011)

OMTAS will publish an article in a Turkish forging magazine within 2011. The article will deal with the results of DEVAPRO - especially the warm forge rolling process.

Presentation at Yildiz Technical University, Istanbul

Mr Güzey plans to make a presentation at Yildiz Technical University in summer / autumn 2011. This presentation reflects the results of the whole project as well as the influence of the project on OMTAS. Besides showing the students interesting results of DEVAPRO projects, an increase in student reputation of OMTAS is expected, which could have a positive influence in canvassing new employees from university.

ETP

Lecture on conference on steels in cars and trucks (SCT) 2011 in Salzburg

ETP will make a lecture on the third international conference SCT 2011 in Salzburg, Austria, from 5 to 9 June 2011. On the second SCT in June 2008, over 300 visitors (40 % international) attended the conference which was organised jointly by the Steel Institute VDEh and the VDA. The ratio of steel producers to representatives from the automotive / supplier industry was 50:50. The goal of initiating and further developing the network between steel producers, automobile manufacturers and automotive suppliers was successfully achieved.

Publications in two journals together with EMA-TEC

ETP plans to make two more publications in 2011. Together with EMA-TEC publications in 'Heat Processing' and 'Elektrowärme international' will be made. 'Heat Processing' is a technical journal in English for the entire field of industrial furnace, heat treatment plants, the efficient use of energy in thermoprocessing systems, as well as being the international forum for interchange of knowledge and experience between heat-process industry suppliers and users. 'Elektrowärme international' deals with all kinds of using electronic thermoprocessing in industry and manufacturing the equipment as well as...
industrial use of this equipment.

Open workshop for academia and industry together with EMA-TEC

On 17 and 18 March, ETP will hold up its annual meeting named 'Elektrothermische Prozesstechnik'. More than 20 participants will join that meeting which is on a non-commercial basis. EMA-TEC will also present the variable reheater ETP had built within DEVAPRO.

Integration of project contents in a student lecture for Master degree named 'Electrothermal processing' at Leibniz Universität Hannover

The lecture deals with all kinds of electrothermal processing and gives the students a wide view on the state of the art in this field of industry and takes a whole semester. The results of DEVAPRO will be integrated as an innovative new technique for heating up the billets with different geometries.

Integration of project contents in student lectures at other universities

The results of DEVAPRO will also be distributed to other institutes dealing with electrothermal processing. Therefore technical university (TU) Clausthal, TU Darmstadt and TU Braunschweig (all located in Germany) will be able to use this knowledge for their lectures.

METAV

Open workshop for academia and industry

In February 2011, METAV organises an open workshop for academia and industry in Bucharest. It is expected that 18 people will join that open workshop. DEVAPRO results, especially the material analyses, will be shown on that workshop. Other projects from METAV CD will also be presented there.

Integration of project contents in student lectures

For distributing the results of DEVAPRO in a wide range METAV CD will also integrate DEVAPRO into student lectures. This will show the students interesting research results on the one hand. On the other hand it will increase the reputation of the European Community (EC) as an active research funding institution.

Publication in another magazine

METAV will write another publication about the DEVAPRO results in 2011 dealing with the whole project from the field of material analysis.

Bemers

Presentation of DEVAPRO results in bilateral meetings with customers and potential customers
Bemers has many contacts to many companies in the field of forging industries and is a favourable supplier of lubrication system. Therefore, BEMERS has many bilateral meetings with its customers and potential customers which will also be used to present the idea and results of DEVAPRO using warm forming with the integration of rolling processes for long flat pieces.

Innovation Price IHK

Bemers presented DEVAPRO project at Development and Innovation Prize of the Chamber of Industry and Commerce of the region 'Mittlerer Niederrhein' in July 2010. Bemers did not only present results of their lubrication system but also of the whole project idea and the advantages of warm forming processes including rolling operations.

EMA-TEC

Commercial use of variable re-heating technology

EMA-TEC will try to acquire new customers by selling them heating or re-heating inductors that are able to heat up parts that vary in their geometry. EMA-TEC will start to make discussions at their existing customer basis to further develop the idea of the variable re-heater and then start to acquire new customers.

Publications in two journals together with ETP

Please read paragraph 'Publications in two journals together with EMA-TEC' from ETP.

Open workshop for academia and industry together with ETP

Please read paragraph ‘Open workshop for academia and industry together with EMA-TEC’ from ETP.

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