Smart Forging – Processing ingots by autonomic forging and sustainable heat treatment processes to premium bars

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The paper provides an overview of the revamping steps to install an autonomous ingot forging process at BGH Edelstahl Siegen. Further the optimization of the complete production process chain from an ingot to a heat-treated bar is shown.

KEYWORDS: FORGING PRESS, AUTOMATIZED FORGING LINE, REPEATABILITY, ENERGY EFFICIENCY, MAINTAINABILITY

INTRODUCTION

BGH Edelstahl GmbH has a history of forging steel of different grades for more than 550 years. Long products in different dimensions are manufactured at different locations in Germany and Poland, with each factory having its own dimensional range. The Plant in Weidenau of BGH Edelstahl Siegen produces bars with a diameter of 120 – 400 mm. The smart forging line consist of an 20MN open die forging press followed by an GFM forging machine and an in-line heat treatment facility. This setup allows optimal temperature control through the entire process to ensure highest product quality for the widespread material portfolio, which ranges from low-alloy structural steels, tool steels, duplex and austenitic steels to nickel-based alloys. Monitoring and documentation of all relevant parameters during forging (e.g., dimensions and temperatures) and heat treatment (temperature and times) guaranty conformity with the most demanding requirements of BGH customers. Furthermore, all products in the production line are marked with an individual stamping to ensure traceability for every single bar.

The foundation stone for the smart forging line was laid in 2002 with the installation of the GFM RF45 radial forging machine. In the following years, the smart forging line was continually expanded to respond to increasing demands on products, for example the installation of the inductive reheating installation in 2016 [1]. While the final forging process line is fully automatized with including

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process steps of forging, cropping, marking, inductive re-hearing and quenching, therefore, extending automation to pre-forging was the logical consequence for the entire forming process. With the last revamp of the key components of the pre-forging unit autonomous forging was implemented also. Now the complete smart forging line, starting with the pre-forging of the ingot and the final forging of the billet and ending with the heat-treatment of the produced bar is 100 percent automated.

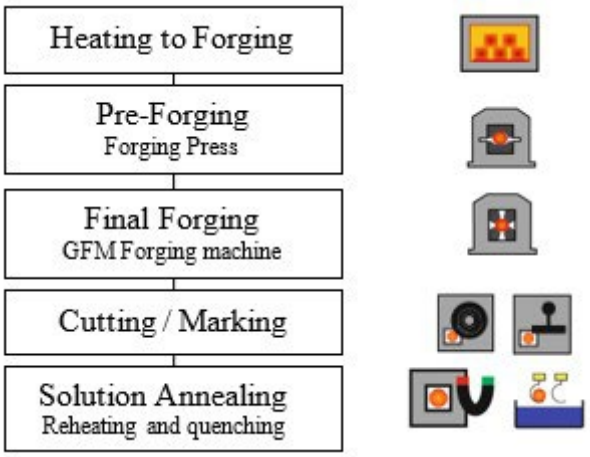

Fig.1 - Process steps of smart forging line.

Besides new software solutions the hardware of the 20 MN open die forging press had to be updated. A new forging manipulator and a turntable for ingots were installed. The electrical and hydraulically control system was also partially replaced. In addition, the material transfer to the forging machine was optimized by a second ingot wagon. With this major upgrade, the pre-forging process of ingots can be further optimized based on data mining and analysis. In addition, a more repeatable processes guarantees improved product quality in closing porosity of ingot, avoidance of segregations and establish a uniform microstructure with fine grain size. Also, energy consumption and CO_2 emissions could be significantly reduced. The Smart Forcing Line combines the repeatability and process stability of a rolling mill with the advantage of being able to produce flexible diameters.

DESCRIPTION OF THE FORGING PRESS

The components of the 20 MN open die forging press are the press, Manipulator, Turning table and Ingot waggon.
The Press is a two-column push-down open die forging press with a force of 20 MN. The max. speed of the crosshead is 300 mm/s.

Tab.1 - Parameters of Press.

Press Type	Push down – 2 columns
Max force	20MN
Drive	Oil hydraulic, 2x 800kW
Nominal pressure	320/160 bar
Height of press stroke	800 mm
Working modus	automatically / manually
Max. forging length	7,5 - 10,5 m
Crosshead speed	300/240/100 mm/s

The rail bound Manipulator has a maximum load of 10 t and the normal usual possibilities of movement: X-, Y-, Z-Directions, turning and tipping.

Tab.2 - Parameters of Manipulator.

Number	1
Nominal capacity	10 t
Drive	12 m
Clamping with diameters	230 - 950
Weight	48,5 t
Working modus	automatically / manually in combination with the press

With the turntable the ingots could be turned. Because only one manipulator is available and the gripping end of the Ingot has been forged also, the ingots should be turned during forging. Due to the limited space, the turntable cannot move in sideways, so it moves in a vertical direction to move out of the manipulator's travel range.

The new ingot wagon transports the billets after pre-forging to the GFM forging line using additional existing transportation table. To keep the ingot waggon simple and without an additional movement in high, the manipulator should be able for a movement in vertical direction very low above the ground, to reach the given height of the roller tables from the GFM forging machine.

PROCESS DESCRIPTION

The Ingots from in house steel mill, which has been heated to forging temperature should be pre-forged at the open die forging press followed by the final forging at the GFM RF 45 forging machine.

Fig. 2 - Picture of pre-forging complex.

For each Ingot size, output diameter and forming group exists a fixed program. A program includes all required information for the forging process: For the Manipular are the required parameter the total ways, step size and directions in X-axis as well as turning angle and direction around X-axis. The intermediate and final diameters of the billet, speed, and oscillation path of the cross head of the press is also necessary parameters of the press (see Figure 3). The programs are based on the theoretical dimension, the weight of the ingots and the principle of conservation of mass. Therefore, it is imperative that these parameters are adhered to, which is achieved with defined and fixed ingot sizes from in-house steel mill. Therefore, automatic forging works completely without any additional measuring equipment. Omitting such sensors is cheaper and less prone to failure.

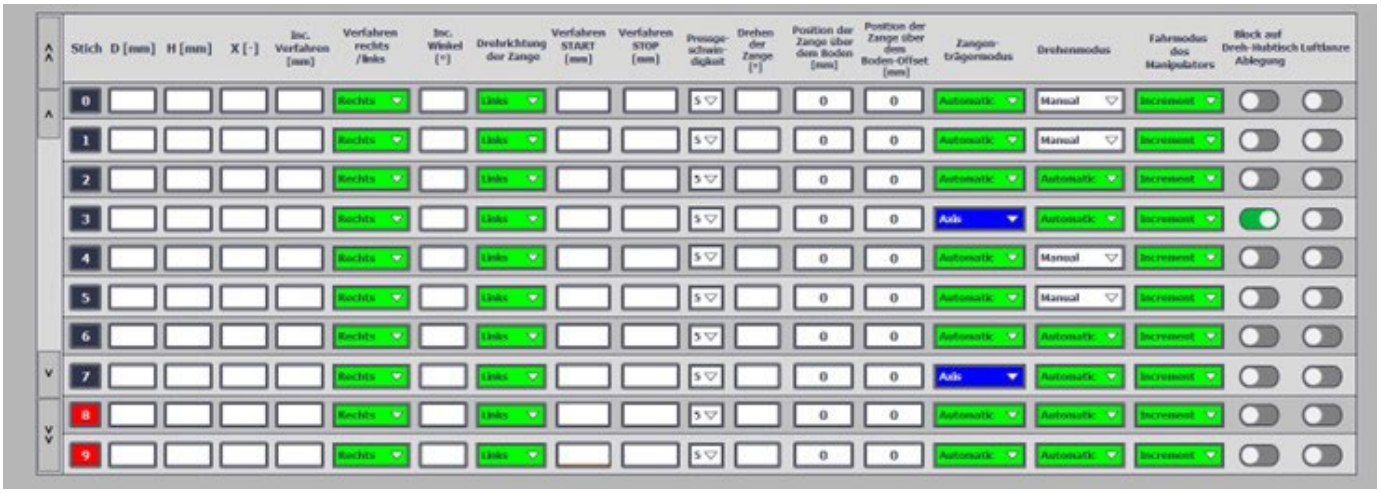

Fig. 3 - Forging Parameters.

The pre-forging process starts with picking the ingots from the forging furnace with a crane and take them with the manipulator. This should be done manually, because the operator must ensure that the ingot is completely in the tongs of the manipulator. The stop of the tongs is the necessary fixed point. Then the operator could start the programme and the automatic forging starts with processing the steps of the program. When one side is forged the manipulator places the billet automatically on the upcoming turning table. After turning the billet should be picked up from the table manually by the operator to ensure a fixed position of the billet in the tongs. Afterwards the automatic programme could be continued. After the pre forging is finalised, the billet is placed either at the ingot waggon or stays in the tongs of the manipulator, depending on if the material getting directly to the GFM forging line or should be re-heated in a forging furnace. Process steps times and temperatures are automatically locked and transferred to the ERP system, so that the important parameter could be checked if an issue appears [2].

At each time at the automatic forging process the operator has the possibility to make small corrections without interrupting the automatic forging process. So, after the correction the program is continued and should not be restarted again which is very user friendly. If there is a main issue, the operator has every time the possibility to interrupt the automatic forging by lifting the crosshead. After solving the issue, the automatic can be restated again by choosing the correct program step.

Before the revamping the crane had to place the billet it on the GFM transportation table first. Only afterwards the crane has the capacity to pick up and the next ingot from the forging furnace and transfer this ingot to pre forging press. With the new ingot waggon, transferring the billet to the forging line and picking up the following ingot from the forging furnace could be done at the same time. This ensures a minimum of off-peak times and a high output.

The press is connected to the internal ERP-System. The program will be chosen by the internal system, dependent

from the ingot size, required pre-forged diameter and the material specific forming group. The press records important parameters like time, temperature and intermediate diameter and transfer it to internal system, so everything is traced.

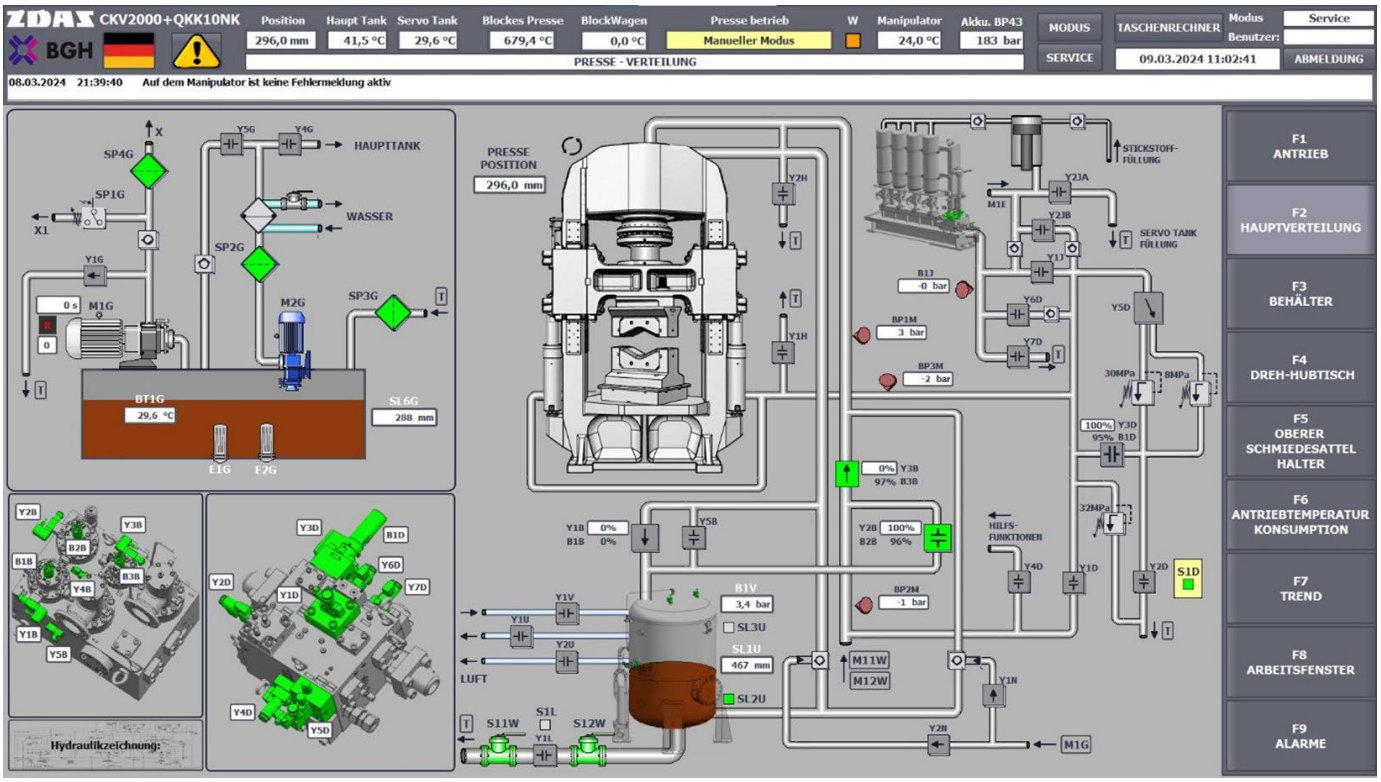

Fig. 4 - Visualisation of Press.

The visualization of the complex is very maintenance friendly because the status of all valves, pumps and engines are animated and could easily change with a click on the symbol. Also, the connections between them are shown and work over several pages of the visualization with Hyperlinks. The valve blocks are shown as a 3D clone like they are in the reality (see Figure 4). This ensures that the maintenance staff could find the parts easily without spending unnecessary time to search for the component based on the designation. This leads to a quick troubleshooting and short downtime. Also, the important parameters of the different tool-sizes could also be easily chosen by one click.

Due to short off-peak times and quick repair times the average output is 23 t per hour, including off-peak times and maintenance breaks.

BENEFITS

Before the revamping the Ingots has been forged manually. Because each operator has made different intermediate diameter, steps in x-Axis and turning angle. Also, the starting point for each forging step is different, the process has had high variations. It was not guaranteed that the forging crosses of the forging steps had the necessary offset. Therefore, areas were the porosity isn´t closed while pre-forging could occur and leads to indications during ultrasonic testing.

The new technology assists the operator so that he can focus on monitoring functions. Due to the wide range of materials with a wide variety of forming properties, a lot of experience is required to be able to accurately assess the material behaviour during forging. It is important to find the optimal path between high productivity and good temperature control on the one hand and an optimal bite ratio and stitch removal on the other hand. Such parameters are stipulated in the programs so that forging can be carried out with the correct parameters even for non-common materials.

In relation to the workforce, the advantage arises that even untrained newcomers can quickly gain the necessary experience without the risk of producing material of poor quality or, worst case scenario, complete scrap material. The required number of highly specialized stuff can be significantly reduced. This is a clear advantage, especially given the shortage of skilled workers.

The benefit of the automatized process with the programmes is the defined forging operations and parameters which ensures a repeatable process, independent of operator. The clear parameter could also use to simulate the process (e.g. with QForm) and the porosity of the forged billet to find systematic issue where the offset of the forging crosses is not optimal. With the simulation a solution could be found and being transferred to optimise the programme of autonomous forging. This results in a homogenization of the structure and the grain size and other quality-relevant properties. By recording the process-relevant parameters, every forging can be traced.

There are also advantages of the revamping to reducing greenhouse gases. On the one hand, increasing quality and minimizing the failure rate always saves energy. At the other hand, the specific electricity consumption for the entire system was reduced by 14% as a result of revamping the system components.

CONCLUSIONS

By revamping the system technology of an open die forging press and the associated components, forging can be carried out autonomous in a user-controlled mode. Previously pre-forging was the only manual process step in the fully automated Smart Forging Line. With the closure of the gap, the process of forming an ingot into the finished heat-treated bar steel for certain materials is completely automated. The quality-relevant parameters of the forged material and the documentation of the process could be improved and there are further advantages for personnel availability, maintenance of the system and energy consumption.

REFERENCES

[1] HIPPENSTIEL, F., JANZ, W., & MÜLLER, M. (2017). 20TH INTERNATIONAL FORGEMASTERS MEETING - IFM 2017. DIRECT QUENCHING AFTER FORGING AND INDUCTIVE REHEATING, (P. 246 - 253). GRAZ, AUSTRIA.

[2] Grosse, A., Schoß, H., Weyl, A., & Klaas, P. (2018). Ingot Casting Rolling Forging. Process Integration of a New 20MN Forging Press at BGH Edelstahl Freital, (P. 407-417). Stockholm.

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