Simulation process of thick plates manufacturing

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Abstract
The construction of increasingly powerful hydraulic plants added to the ongoing research to cut manufacturing costs, requires the power station suppliers to develop and control new production technologies without delay. Therefore JSC TYAZHMASH in a continuous effort of R&D, has turned to numerical simulation using the Simufact.Forming software to define their production process for turbine blades. Modelling the forming operation allows manufacturing difficulties and die modifications to be anticipated.

Keywords: hydraulic turbines, blade, forming, Simufact.Forming

Introduction
The present competitive situation in the deregulated energy markets makes great demands on the economic assessment of existing and new power plants. In this surrounding the upgrading and refurbishment of existing hydroelectric power plants becomes of increasing importance.

In modernisation projects it is mostly only the key parts of the machine, which are replaced by new ones while the others are kept and renovated. Furthermore this process is often coupled with an increase in turbine output and also with an increase in flow rate. To utilise the whole potential of upgrading, excellent hydraulic behaviour in terms of efficiency and smooth operation as well as in cavitation is necessary. In order to minimise the delivery time of the new runner and the outage time of the old units the modernisation work has to be performed in an extremely short time. Therefore modernisation projects make high demands on planing, hydraulic design, manufacturing process and installation of new components especially the new runners. For the success of the upgrading procedure rapid and efficient processes are of the essence. The processes of hydraulic layout, hydraulic and mechanical design, manufacturing and installation have to be well established and organised. The development and the thorough application of highly advanced design tools for the design of Francis runners enable the manufacturer to meet these great demands. In rehabilitation projects these tools have to be flexible and have to be quickly adapted to different geometrical boundary conditions.

Mechanical Design
The 3D geometric description of the hydraulic profile, optimised in the CFD Design, will then be processed to obtain a 3D file, forming the basis for the construction design, fig. 1 and 2. In order to verify the runner structure, a stress analysis is made using the finite element method (FEM); the 3D calculation model comes from the 3D design, whereas the pressure loading is based on the foregoing CFD analysis.
Runner manufacturing

To ensure the hydraulic quality and the lifetime of the new runner a high quality of the manufacturing process is essential. Therefore the well-proven JSC TYAZHMASH technology of welded design is generally applied to the replacement runners. The main advantages of a welded design compared to a monolithic casting are:

- Precise geometry due to five-axis CNC milling of the complete runner blades from the leading to the trailing edge
- Precise geometry due to NC-turning of water passage profile on crown and band
- High quality of materials due to the production’s method and even more to easier checking and repairing on the single components
- Less unbalance to be corrected for smoother operation behaviour
- Shorter delivery time and competitive costs, resulting in more benefits for the customer

Pressing of Blades

The necessary engineering steps are best shown in a control-loop diagram, fig. 3:
Figure 3: Pressing process for blades

Simufact.forming was used for flattening of the shape of the blade, fig.4.

Figure 4: Flattening of the blade

The lower and upper dies is designed on dimensions of the flattened blade. Simufact. Forming helps to simulate preform laying down in a lower die. Blade preform has fixed width. During blade deformation there is an unequal extension of a material. Simufact. Forming allows to simulate process of forming of the blade and to return the shape of the stamped blade in CAD system. It allows to fabricate compensation of the shape of dies. If not to fabricate compensation of dies will occur undeforming. Also it is necessary to consider cooling of the heated preform from an oven prior to the beginning of press forming. At preform heat its width is augmented. Preform is delivered with the tolerance, it also needs to be considered. After heat of preform to 1100 °C on metal appears oxide scale. These effects are necessary for considering at design of dies, fig. 5-11.
Figure 6: Result of simulation

Figure 7: Compensation shape of dies in CAD after result of simulation
Figure. 8: Result of stamping

Figure. 9: Checking shape of stamped blades on CMM machine

Figure. 10: CNC machining of stamped blades
Conclusion

Computer simulation by means of Simufact. Forming processes of press forming of details of thick sheets of type of lobes allows to design quickly dies not demanding finishing and to receive excellence in short periods.