ENGINSOFT

WHITE PAPER

Development of new shaped Ring Rolling process through FORGE NxT Numerical Simulation

Felb Srl has been established since 2006 from a demand of the market for medium weight forgings up to 10 tons. Reference market sector refers to medium size forgings (maximum length of 6 meters, maximum diameter of 2500 mm and maximum width of 2000 mm) and to rings and bushes(up to a maximum diameter of 4000 mm and a maximum height of 870 mm). The special equipment allows the production of shaped forgings according to drawings, bars of various sectional sizes, discs, shafts, rollers, molds forms, bushes and flanges. All manufactured pieces can be submitted to mechanical machining and heat treatment processes. Furthermore they can be tested by official authorities in the internal homologated test laboratory. The orders are usually based on few items, hence an high flexibility is mandatory to satisfy the customers' requests.

The requirements

FELB received an order from a new customer concerning the supply of about two hundred A105 steel shaped rings (Fig.1). Approx. dimensions of the machined part are 900 mm (diameter) and 500 mm (height).

The part could be produced by the traditional process composed by ring rolling and subsequent machining. The size of the request (one order of magnitude bigger than usual) led the management to evaluate the possibility to roll a shaped ring, in order to optimize material usage and to provide a final part with better in-service performances. Due to its limited experience on the shaped rolling process, the company evaluated FEM code FORGE NxT, developed by Transvalor S.A., and involving EnginSoft, Italy distributor and FORGE user for 20 years, in order to speed-up the training and to obtain the best results in very short period.

The approach

Fabio Fioletti, material engineer and technical manager at FELB with extensive experience on design and simulation of forging processes with FORGE, developed the preliminary numerical analysis of the ring rolling process, in collaboration with the "Metal Forming Team" of EnginSoft. The aim of these analysis was the evaluation of the technical feasibility, particularly to obtain the upper flange starting from different preformed rings. Based on the company know-how on ring rolling process, the studies and simulations of several lamination curves (Fig.2) and geometries on king roll allowed the validation of the right feasibility by using the company equipment.

On specific terms, the required maximum torque on king roll and axial force on mandrel were verified, as reported in Fig.3.

These preliminary evaluations were completed in less than one week and allowed the order concerning the equipment supply (mandrel and king roll) to be issued. At the same time, simulation activities were focused on the evaluation of the best forging sequence to obtain the optimal preform, in order to reduce the required material. From this point of view, several modifications on flange height, both internal and external diameters have been evaluated. All the solutions have been subsequently validated by numerical simulations of ring rolling processes.

The equipment arrived within a few days after the completion of all the FEM activities and the production started immediately, with

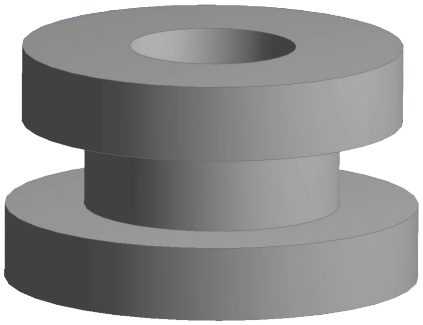


Figure 1 – Flanged body ordered by the costumer

results very similar to the expected one (Fig. 5). The developed simulations allowed for a very fast fine-tuning phase, highlighting the causes of some filling defects on the flanges and suggesting the best actions to be performed in order to complete the profile on the real process. FELB immediately started the production of the ordered batch, respecting the agreed delivery terms.

Obtained results from Forge Simulation

The numerical simulations allowed to evaluate the technical feasibility of the part by forging and shaped ring rolling processes, besides the sensible differences on the part quality. Traditional process involved a massive machining which led to high material waste. Furthermore, machining trimmed the material fibres, leading to lower capacity of the ring to withstand to in-service loads. The innovative developed process leads to a minimum oversize and a better fibers distribution (Fig.6), more compacted and with no trims, for higher overall performances.

Verification on the final part showed a sensible increase on hardness (+ 40HB), that led to a revision of the heat treatment process. Heat treatment cycles have been evaluated by using FORGE NxT.

Benefits arised by the new approach

The implementation of the shaped ring rolling by using the usual trial & error approach should lead to 4 or 5 times longer development times for FELB, with considerable costs on real tests and equipment. The collaboration between FELB's know-how, Ing. Fioletti's experience and numerical design process experience provided by the Metal Forming Team of EnginSoft has led to a very fast and optimized development of product and related process, with the following advantages:

On FELB's side:

- radical innovation on the production processes, with implementation of shaped ring rolling and drastic reduction on development times (-80%) and costs (-50%) thanks to the numerical simulation;
- possibility to optimize the time plan, approving the equipment orders in less than one week and receiving them at the right time to start the production with an optimized preform (numerically developed during the waiting time for the delivery);
- validation about requirements of the rolling machine: forces and torques are below 70% of the nominal performance;

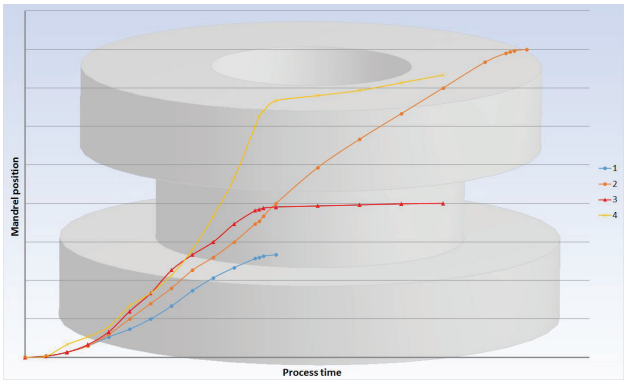
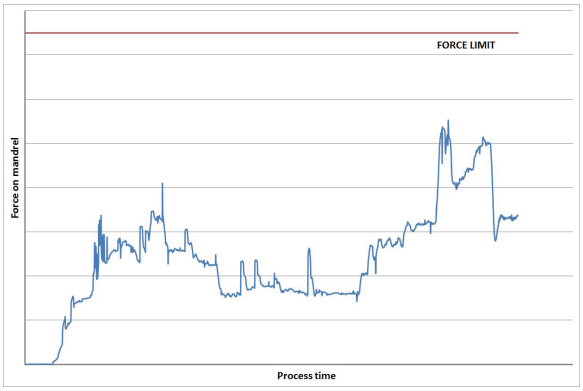


Figure 2 – Lamination curves evaluated on FORGE



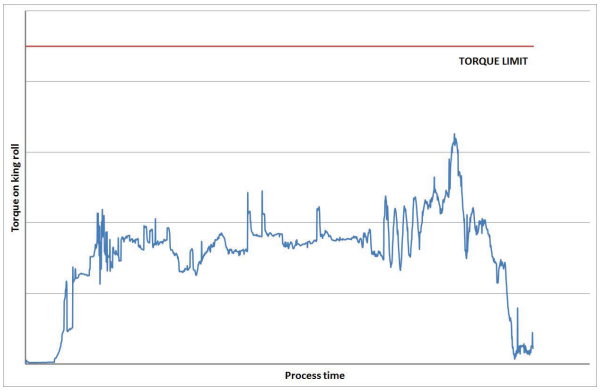


Figure 3 – Axial force on mandrel (left) and torque on king roll (right)

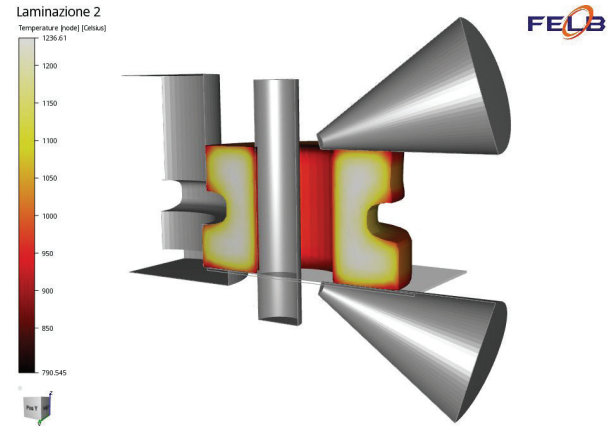


Figure 4 – Numerical simulation of shaped ring rolling process

- optimization on material usage, with lower oversize material: weight reduction higher than 15% in comparison with the previous solution;

For the end customer:

- faster reply to quotation request, with evidences of the results obtained by the proposed process – possibility to develop co-design activities;
- higher performances on the final parts, due to the better compaction of the material and to the optimized fibres distribution provided by the shaped ring rolling process;
- relevant reduction on time and cost related to machining operations (up to -40%)

Conclusion and future developments

Thanks to the knowledge developed with FORGE NxT and the collaboration with EnginSoft, FELB was able to understand the advantages of the numerical simulation. Beside this case, FELB wants to use this approach in a very focused manner, referring to specific parts which will create new business, looking for for higher magnitude orders and increasing the overall efficiency.
FELB is now developing similar offers to other customers and prospects, with high value proposal supported by the contribution of numerical simulation. This approach has already led to returns on business, as reported by the sales manager in FELB: "The obtained results confirm that the use of FORGE for the numerical simulation is definitely a good business card for our company, also talking on pure commercial terms. It allows us to differentiate in a very positive way, anticipating customers' objections and offering a sensible cost reduction and quality increase".
From the economic side, FELB and EnginSoft evaluated a Return Of Investment shorter than one year, by developing four or five parts similar to that one evaluated in the reported case, and taken into account the costs concerning hardware, software and employed people.

The support provided by the Metal Forming Team of EnginSoft was decisive to speed up the training phase, in particularly the shaped ring rolling process, which was developed and fine-tuned in less than one week.

Furthermore, FELB is spreading the use of FORGE also in heat treatment processes of forged and rolled parts, in order to perform a complete integration of numerical simulation in all the main company processes. The aim is to provide even higher quality to the end customers, which often operate in application fields, such as Oil&Gas and Energy, where metallurgical aspects (e.g. hardness, grain size, metallurgical phases) have a key role.

Fabio Fioletti, Felb
Federico Fracasso, Marcello Gabrielli - EnginSoft

I verified on the real case how the numerical simulation developed with FORGE was helpful to support the technical decisions, early in the proposal estimation. Thanks to FORGE, to mine and Ing. Fioletti's knowledge, and to the EnginSoft's support, we were able to offer a superior quality part, with a considerably increase on efficiency. I rediscovered in FORGE what I did in the past with the modelling clay, trying to understand the movement of the material. FORGE allows me to see in a very detailed way what happens to the material and the causes of specific defects, suggesting the best way to solve them. From a CEO point of view, I'm even now noticing interesting returns: we can now expand our business, in terms of batch size and/or complexity of the parts. Advantages on the efficiency on my production processes could be the key to establishing us on these new markets.
I would like to thank Ing. Fracasso, Ing. Capuzzo and Ing. Gabrielli of EnginSoft for their extensive knowledge and capability: they allowed us to transfer our real process on FORGE and to obtain crucial results in a very limited period, leading to important choices for the future development of my company.

Luigi Catalini, CEO FELB

EnginSoft "Metal Forming Team"

EnginSoft has been dealing with productive processes simulation for over 20 years with a group of engineers specifically specialized in metal deformation processes simulation. The activity carried out by this group ranges from the daily support to the over 70 Italian customers using Transvalor products Forge and ColdForm, to the training of those companies interested in undertaking simulation activities, to the performance of commissioned engineering works, up to the development of tailor-made models meeting customers' needs. The group competences extend from hot forging of steel and non-ferrous materials (brass, aluminum, titanium, …) for pieces of just few kilos, to open-die forging and circular lamination of steel for ingots of several tons, in addition to the simulation of cold rapid processes, such as bolts and screws and small parts forging.

The integrated approach provides the means to follow the material from the production phases of the billet/ingot (with the simulation of the continuous casting or of the ingot mould casting), to the heating, cutting, deformation, trimming and the heat treatment, carrying the stress accumulated in the part, as well as the porosity, the grain size and the related micro-structural phases. The objective of all these activities is to support the achievement of the best possible value of the simulation, measuring its benefits on the real improvement of the process/product quality: considerable results can be obtain in the first weeks of simulation activities, with a ROI within a year, thanks to the method setting up along the years and with continuous assistance.

For further information and to understand the benefits applied to your specific requirements:

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EnginSoft is a premier consulting firm in the field of Simulation Based Engineering Science (SBES) with a global presence. It was founded in 1984, but its founder and initial employees had been working in SBES since the mid '70s. Throughout its long history it has been at the forefront of technological innovation and remains a catalyst for change in the way SBES and CAE technologies in general are applied to solve even the most complex industrial problems with a high degree of reliability.

Today, EnginSoft is comprised of groups of highly qualified engineers, with expertise in a variety of engineering simulation technologies including FEM Analysis and CFD, working in synergic companies across the globe. We are present in Italy, France, Germany, the UK, Turkey and the U.S.A. and have a close partnership with synergetic companies located in Greece, Spain, Israel, Portugal, Brazil, Japan and the U.S.A.

EnginSoft works across a broad range of industries that include the automotive, aerospace, defense, energy, civil engineering, consumer goods and biomechanics industries to help them get the most out of existing engineering simulation technologies.