Smart data exchange in profile manufacturing

Nikolay Biba* highlights the advantages of ExtrusionLink, a smart data exchange process that enables greater analysis and optimisation for diemakers and extruders.

The design of extrusion dies for complex aluminium profiles is now commonly developed and validated using numerical simulation.

For this purpose, die makers create digital twins of the extrusion process in QForm Extrusion.

Our new concept of smart data exchange, ExtrusionLink, enables the transfer of these digital process models from die makers to extruders.

If any issues are identified, the connection provides immediate feedback to the die maker for corrective actions.

The extrusion process model can also be transferred to the end user of the profile, as it contains predictions of key product properties, such as seam-weld location and strength, as well as mechanical and aesthetic properties, and expected geometrical accuracy.

Importantly, the digital model is created only once and subsequently reused by all stakeholders, which reduces time and increases efficiency.

The ExtrusionLink concept adheres to the fundamental principles of Industry 4.0, where extrusion dies and process technology are linked to a digital twin that accompanies the product throughout multiple stages of manufacturing till the end user.

Advantages

Designing extrusion dies, especially for large, complex, and hollow profiles, is a challenging task. Unlike the forging industry, where dies are usually designed and manufactured in-house, most extruders rely on specialised die-making companies that possess decades of accumulated expertise.

In recent years, QForm Extrusion simulation software has been widely adopted by die-making companies to accelerate die development and improve tool quality and service life.

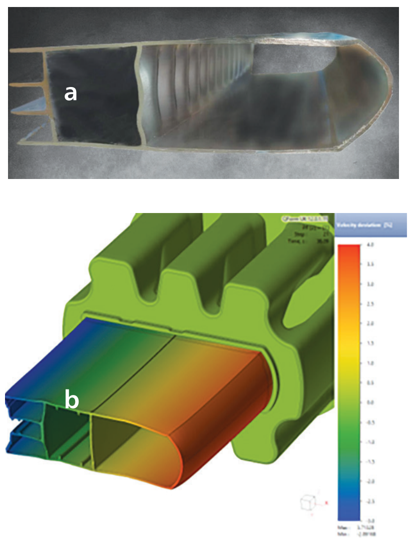

Fig 1. Velocity deviation obtained in simulation shows that the central web of the profile at the beginning of extrusion goes slower than the peripheral zone (a); in practice, the waving of the central web develops after a certain extrusion length (b).

The experience of die design and optimisation based on simulation has been summarised in [1]. During tool development, die makers typically perform multiple geometry modifications, including adjustments to porthole shapes and positions, bridges, welding chambers, pre-chambers, and bearings. Each variant is evaluated by simulation.

The final simulation results can be formalised in an Extrusion Die Digital Certificate (ExDDC), which includes:

- Profile drawing
- Geometry of the manufactured die set
- Complete list of technological parameters used for simulation
- Material flow analysis (velocity deviation, profile distortion)
- Profile quality assessment (avoiding streaking lines, seam weld quality and location, charge weld propagation, temperature distribution, etc.)
- Die stress and deformation analysis, and die life estimation
- Overall die performance evaluation and recommendations

Many die makers supply such simulation reports together with the delivered dies, which increases confidence in the expected die performance.

However, certain critical drawbacks may still be overlooked because die makers cannot fully anticipate the specific production conditions at the extrusion plant.

These include variations in extrusion speed, billet material and temperature, die and container temperatures, and other operational parameters.

Moreover, some defects appear only after a significant portion of the billet has been extruded, or after several billet cycles.

These defects are caused by heat accumulation in local regions due to intense deformation, which significantly affects the temperature distribution and material flow [2].

For example, **Fig. 1** illustrates the formation of a waving defect that appears only in the second half of the extrusion length. This is caused by the gradual heating of the billet core, leading to accelerated material flow in the central web of the profile (**Fig. 2, overleaf**).

Similarly, the reliable detection of billet skin contamination and back-end defects requires simulating the full billet length, which is rarely performed by die makers due to time constraints. However, this can be effectively achieved in cooperation with the extruder, as demonstrated in [3].

The extruders also benefit from precise predictions of longitudinal seam weld locations and quality, as they can examine them prior to actual production (**Fig. 3**).

Simulation

To achieve zero-trial production when

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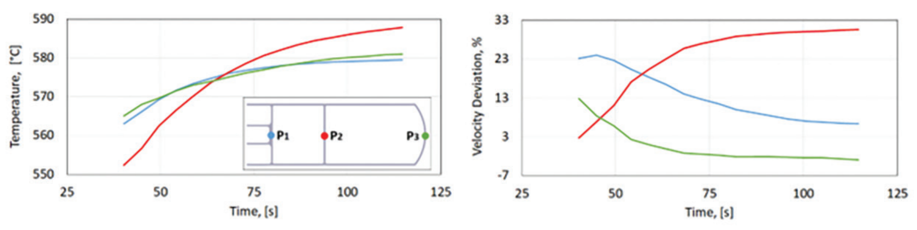

Fig 2. Temperature (left) and velocity (right) variation in three points in the profile during the whole billet extrusion. Due to heating up, the velocity sharply rises in the middle web (P2), causing its waviness.

introducing new profiles, extruders must be able to perform virtual process validation under varying production conditions, including different extrusion speeds, temperatures, and alloys.

Until recently, the use of simulation at extrusion plants was limited by restricted access to die geometry, which is usually considered intellectual property of die makers. ExtrusionLink, introduced with QForm UK Extrusion version 12, resolves this limitation by enabling secure data exchange without exposing proprietary CAD models. Instead, the die is transferred as a protected numerical digital twin of the extrusion process.

This ensures full protection of the die maker's know-how while providing extruders with complete transparency regarding die performance during the technological process.

Extruders can perform simulations under different production scenarios and evaluate product quality in terms of geometry, surface condition, and mechanical properties.

Since the process model is created only once by the die maker, the extruder does not need to rebuild it.

They only modify technological parameters and analyse results. This significantly reduces preparation time and requires only minimal training.

Most importantly, this analysis can be performed before the die manufacturing and production start, providing valuable feedback to the die maker and avoiding costly corrections and production trials.

Using the digital extrusion model, extruders can optimise the entire process chain:

- *Billet heating strategy:* optimisation of taper heating and temperature profiles.
- *Skin contamination prevention:* prediction of billet skin flow and optimal discard length.
- *Waving defect elimination:* analysis of transient thermal and flow effects along the billet.
- *Seam and charge welds:* prediction of seam weld location and strength, and propagation of charge welds to minimise the discards.
- *Quenching optimisation:* optimisation of cooling regimes by simulation using a special module to prevent distortion, predict the microstructure and ensure the required mechanical properties.
- *Strategic advantages:* fewer trials, improved stability, reduced scrap, increased customer confidence, and full Industry 4.0 integration.

Levels of connection

Highest Level - The die maker transfers the simulation results together with the embedded CAD geometry.

The extruder can modify die features (e.g., bearings), test them by simulation, and send proposed corrections back to the die maker. This level requires a high degree of mutual trust regarding intellectual property.

Medium Level - The die maker transfers the simulation file without disclosing CAD geometry. The extruder can perform parameter variations and simulations but cannot access or modify the geometry.

Entry Level - The die maker transfers the simulation file without CAD geometry, and the extruder uses QForm Viewer only.

This allows for a detailed analysis of the results, but no new simulations are conducted.

The entry level provides a low-cost introduction to simulation interpretation. Users can later upgrade to higher levels when deeper involvement is required.

Summary

This paper presents ExtrusionLink, a smart data-exchange concept that enables the secure transfer of extrusion process digital twins between die makers, extruders, and profile end-users.

By allowing a single simulation model to accompany the die and product through all stages of manufacturing, ExtrusionLink improves process transparency, reduces trial production, protects intellectual property, and supports Industry 4.0 integration.

The concept enhances die validation, process optimisation, product quality, and collaboration across the aluminium extrusion value chain, bringing economic benefits to all its participants. ■

References

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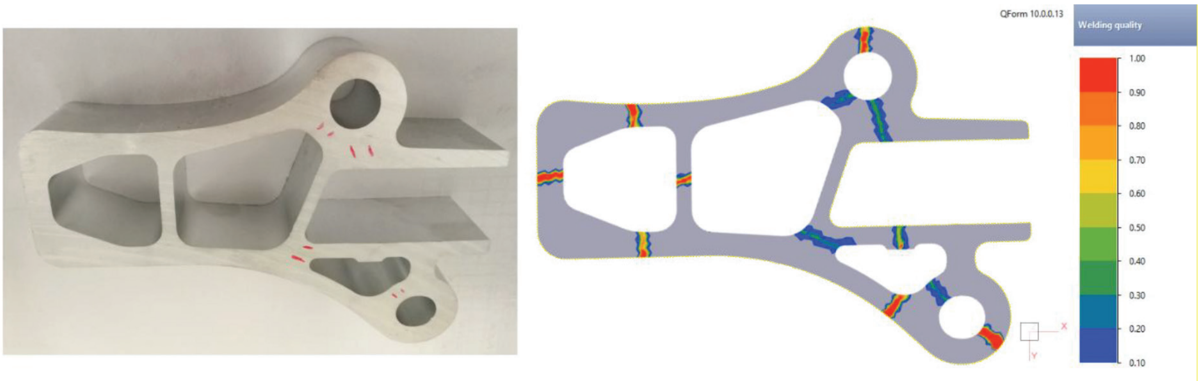

Fig. 3. The predicted locations and ranking of the strength of the seam welds: photo of the profile crosscut with marked poor quality welds (left), and weld shown by simulation, where blue colour indicates welds of insufficient quality (right).