CUSTOMER STORY

WORKING WITH MATERIAL MECHANICS

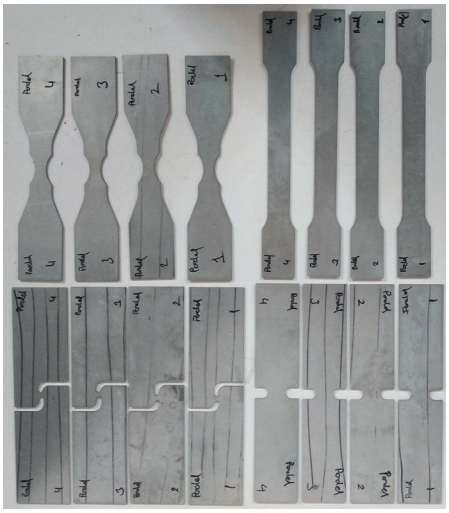
DUCTILE FRACTURE MODELING OF HIGH-STRENGTH GALVANIZED STEELS AT BORÇELIK WITH ALTAIR

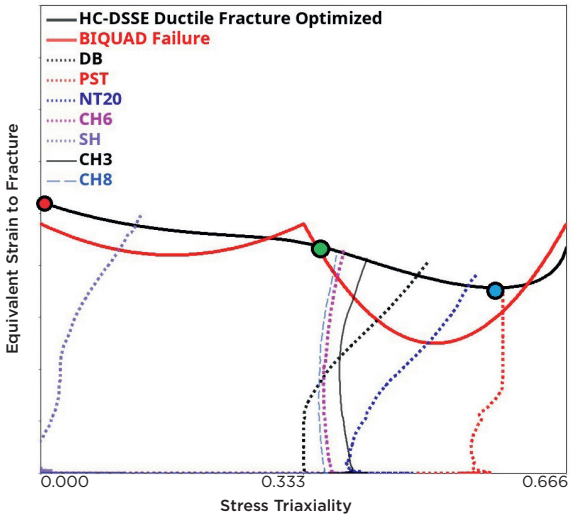
About the Customer

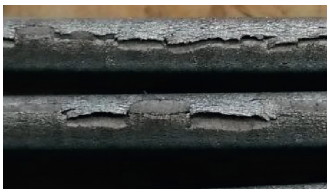
Established in the early 1990s and headquartered in Gemlik, Borçelik is the highest quality galvanized steel producer with the largest production capacity in Turkey. Borçelik operates as a partnership of Borusan Holding and ArcelorMittal, one of the world's leading integrated steel and mining companies.

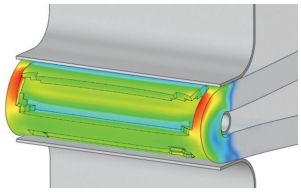
Borçelik is engaged in manufacturing in hot dip galvanized steel, cold-rolled steel and hot-rolled (pickled and oiled) steel groups all of which are industrial raw material inputs.

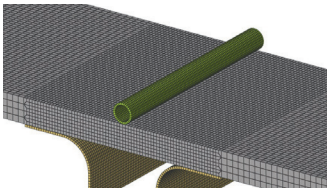
> By modeling the ductile fracture in the material in finite element analysis, we have been able to obtain more reliable and accurate results for solutions with high plastic deformation such as metal forming, vehicle safety, drop, and impact cases.
>
> Ibrahim Yelek M.Sc, Design Development Engineer, Borçelik R&D











Offering a wide range of products, the company meets manufacturer needs in industries like household appliances, automotive (OEM and Tier 1/2), panel radiators, construction, color coating, pipe and profile, packaging, metal goods, and steel service centers. Borçelik has a total production capacity of 1.5 million tons under the Borçelik brand and a metal processing capacity of 500 thousand tons under the Kerim Çelik brand.

LEFT: Tensile test specimens for different stress states **MIDDLE:** Fracture locus of high strength steel generated with BIQUAD and Hosford-Coulomb ductile fracture initiation criterias **TOP RIGHT:** Ductile fracture on bending surface of material **MIDDLE RIGHT:** Finite element analysis results of process **BOTTOM RIGHT:** Finite element modelling

Their Challenge

Reducing emissions and fuel consumption drives the development of advanced materials and production processes in the automotive industry. Fuel efficiency relies on the successful design of vehicles and developing technologies that reduce the weight of vehicle body structure. There is always a need for research and development to maintain passenger safety while reducing the mass of the vehicle structure. The main idea of this study is to investigate the ductile fracture behavior of the high-strength galvanized flat steel that forms the vehicle body structure.

Our Solution

With Altair® Radioss™, users can perform in-depth simulations and fatigue analyses of designs, capitalizing on machine learning (ML) and optimization techniques built into the software. With structural analysis software, users can predict part behavior under various loads. The data derived from experimental tests can be applied to numerical calculations using different fracture models relating variables like stress triaxiality, lode angle, or equivalent plastic strain to material fracture. Particularly, thanks to the /FAIL/BIQUAD failure model, which gives fast and accurate results, users can create fracture locus for materials with data from material libraries using only tensile test results. A Hosford-Coulomb ductile material fracture can be modeled with the /FAIL/EMC failure criterion, which supports 3D elements, especially for detailed fracture modeling. Failure criteria for 2D elements can be used with Strain-based Ductile Failure Model: Hosford-Coulomb with Domain of Shell-to-Solid Equivalence /FAIL/HC_DSSE card. The Johnson-Cook fracture criterion, widely used in the industry, can be used in numerical calculations using the /FAIL/JOHNSON failure card. In addition to all these damage models, the /FAIL/FLD failure model can be employed to define the forming limit diagram (FLD), which represents the formability of the material, especially in sheet metal forming analysis.

Results

Borçelik's worldwide customers come from various industries, ranging from car manufacturers to home appliance manufacturers. To reduce the analysis calculation time, mass scaling was applied using the /DT/NODA/CST option which controls the nodal time step, and **reduced the simulation time by nearly 50%.** In terms of quality-related challenges, Borçelik **saved nearly 10% of scrap material** and **reduced costs by 5%** after working with the design of experiments and applying numerical calculations through Altair simulation solutions.