Tube bending and hydroforming

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For the production of low-weight, high-energy absorbent and cost-effective structural automotive components, the hydroforming of aluminium extrusions is now regarded as the only method in many cases. The hydroforming of aluminium extrusions has also demonstrated significant potential in other applications.

The principle of tube hydroforming is shown in Fig. 1. The hydroforming operation is either force-controlled (the axial forces are varied with the internal pressure) or stroke-controlled (the strokes are varied with the internal pressure), see Fig. 1. See also refs. [1 and 2].

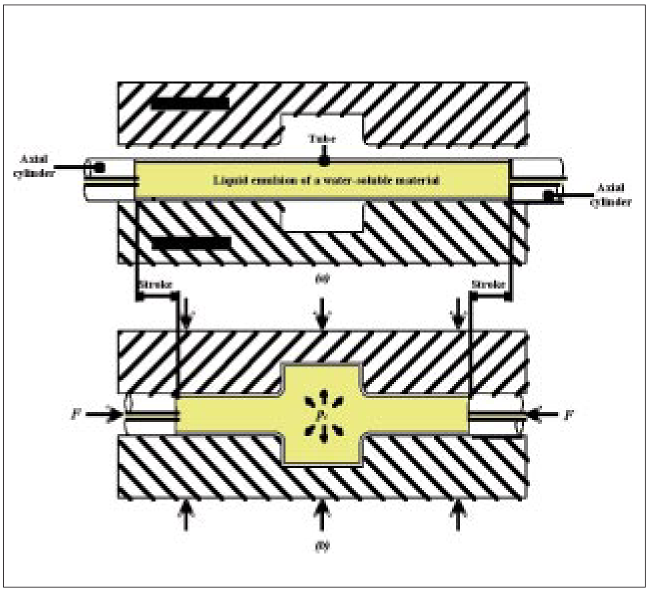

Figure 1

Figure 2

Tube hydroforming offers both technical and economic benefits compared with conventional fabrication. The Ford Mondeo engine cradle can be mentioned as a good example. Studies conducted at Ford (on the above-mentioned engine cradle) have shown that (ref. [3])

- the number of pieces was reduced from six to one
- the number of process stages was decreased from 32 to three
- the component weight was reduced from 12 kg to 8 kg and
- the cost per component was reduced from £ 20 to £ 10 as tube hydroforming was selected instead of conventional fabrication.

Sapa has been working on tube bending and hydroforming for many years. In one of the ongoing projects, Sapa and its partners – AP&T and Swepart Verktyg AB

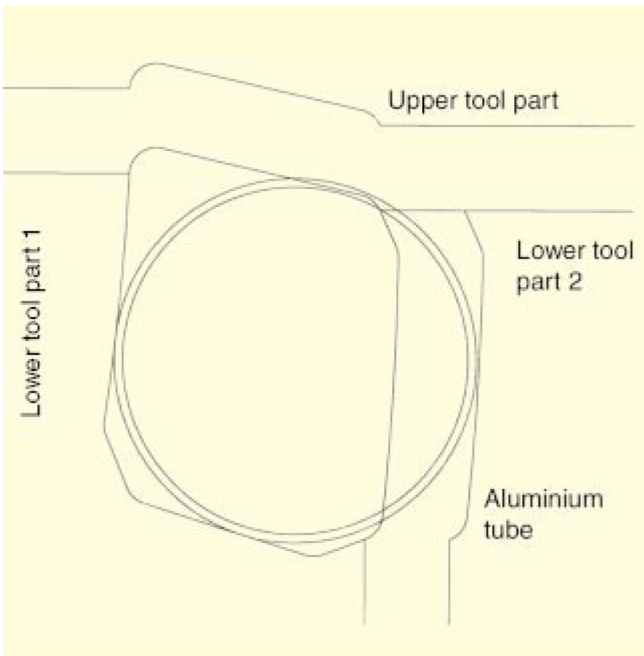

Figure 3

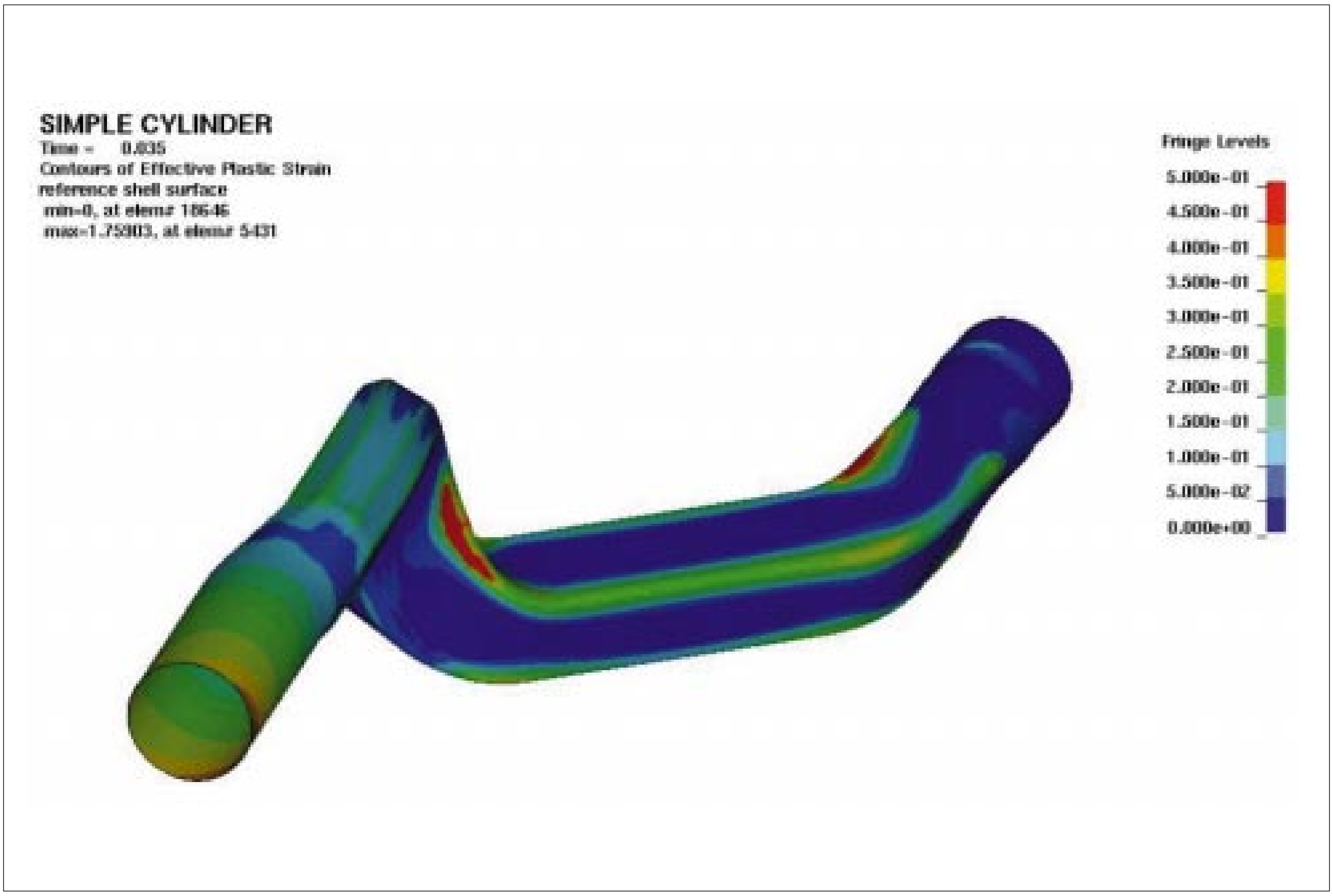

Figure 4

– are prototyping a number of bent and hydroformed components for the automotive industry, Fig. 2.

The starting tube was a straight aluminium extrusion with a circular cross-section, as the component shown in Fig. 2 was produced. This straight tube was first bent and then placed in the hydroforming tool. Fig. 3 shows a section of the bent tube and the hydroforming tool (both when the tool is open and as it is closed). After placing the bent tube in the tool (Fig. 3), the tube was hydroformed. The hydroforming was conducted in the following fashion:

I. a preforming internal pressure of 30-35 bar was built up
II. the tool was closed and the press force increased to 1,800 metric tonnes and
III. the internal pressure was increased to 950 bar

The whole process was modelled by finite-element simulation. The simulation results were used to identify the critical zones (the zones in which the risk of fracture was high) where tool adjustments could be regarded as necessary. Fig. 4 shows the effective plastic strains after tube bending and hydroforming predicted by finite-element simulation.

Sapa regards the bending and hydroforming of aluminium extrusions as significant forming methods which offer great potential and intends to continue using these methods in future commercial projects.

References

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About the author

Dr. Nader Asnafi was graduated from Luleå University of Technology (LUTH) in 1984. He has been working at Esselte Dymo, LUTH, Swedish Institute for Metals Research and Industrial Development Centre in Olofström. Since April 1999, Dr. Asnafi is Technology Area Manager at Sapa Technology. He is currently involved in hydroforming projects at Sapa.