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Aluminum Roll Formed Profiles for Vehicle Crash Safety

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Aluminum Roll Formed Profiles for Vehicle Crash Safety

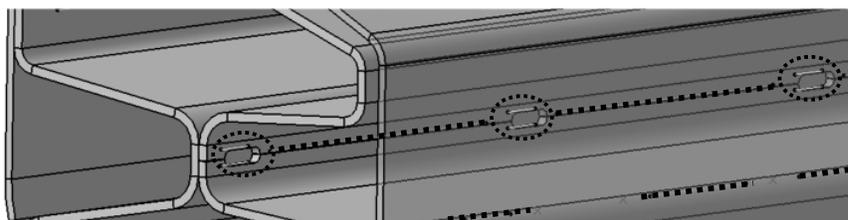
[0001] Car usage continues to trend upwards, and as more and more people take to the roads to drive, high throughput of car production and greater safety tolerances become more and more desirable. Current car frame profiles for electric vehicles include steel roll-formed frames, which are heavy, or aluminum extruded profiles to reinforce hollow structures or to form side-crash protection structures, which are lighter, but expensive to produce up to the safety tolerances of steel.

[0002] Disclosed are aluminum roll-formed profiles for reinforcing straight or bent hollow vehicle structures, such as rockers or battery frames, or for directly forming vehicle body structures. Aluminum rolled profiles offer unique advantages over some of the aforementioned frame profiles. Aluminum rolled profiles may be manufactured from various high strength aluminum sheet alloys, such as 6xxx or 7xxx alloys. In some cases, the aluminum rolled profiles may be tempered at T4, T61, T6, or T7x. The aluminum rolled profiles may have wall thicknesses from 1 mm to 6 mm. Relatively small bending radii allow for manufacturing efficient sections with tailored properties. Optionally, the aluminum rolled profiles may be artificially aged after forming. Furthermore, aluminum rolled profiles can have high volume throughput of about 30 meters of profile per minute.

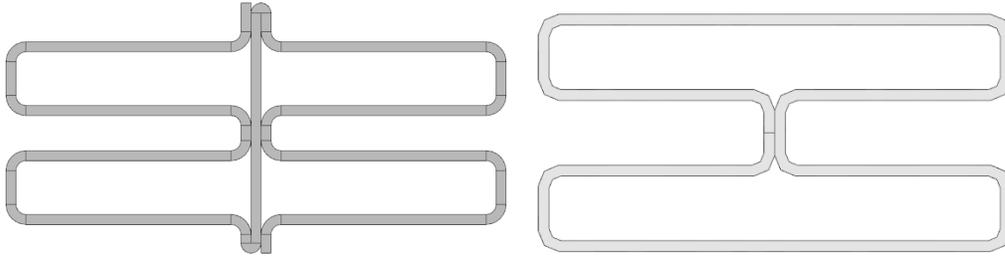
[0003] Aluminum roll-formed profiles provide structural strength and crash protection, and may provide structural protection to both vehicle occupants as well as batteries, such as in electric vehicles which implement a larger, more vulnerable battery. The roll-formed profiles may also provide strength and high degrees of energy absorption in the event of a crash.

[0004] Aluminum roll-formed profiles also provide flexibility in manufacturing methods. For example, an aluminum roll-formed profile can be manufactured with both open or closed sections. Of these, the closed sections can be created by a number of joining methods to obtain a desired shape, such as, e.g., roller seam welding, spot welding, continuous laser welding, stitch laser welding, adhesive bonding, or any combination of the above such as combining laser remote fillet welding with stitch bonding. Furthermore, the profiles can be manufactured with internal ribs, external flanges and/or have beads or holes introduced by stamping to tailor properties over the length of the profile. The roll-formed profiles can be put together to obtain a desired profile by a number of ways, such as by stacking, assembling, stamping, etc. and the final frame can be comprised of one or several continuous profiles, with discrete reinforcements.

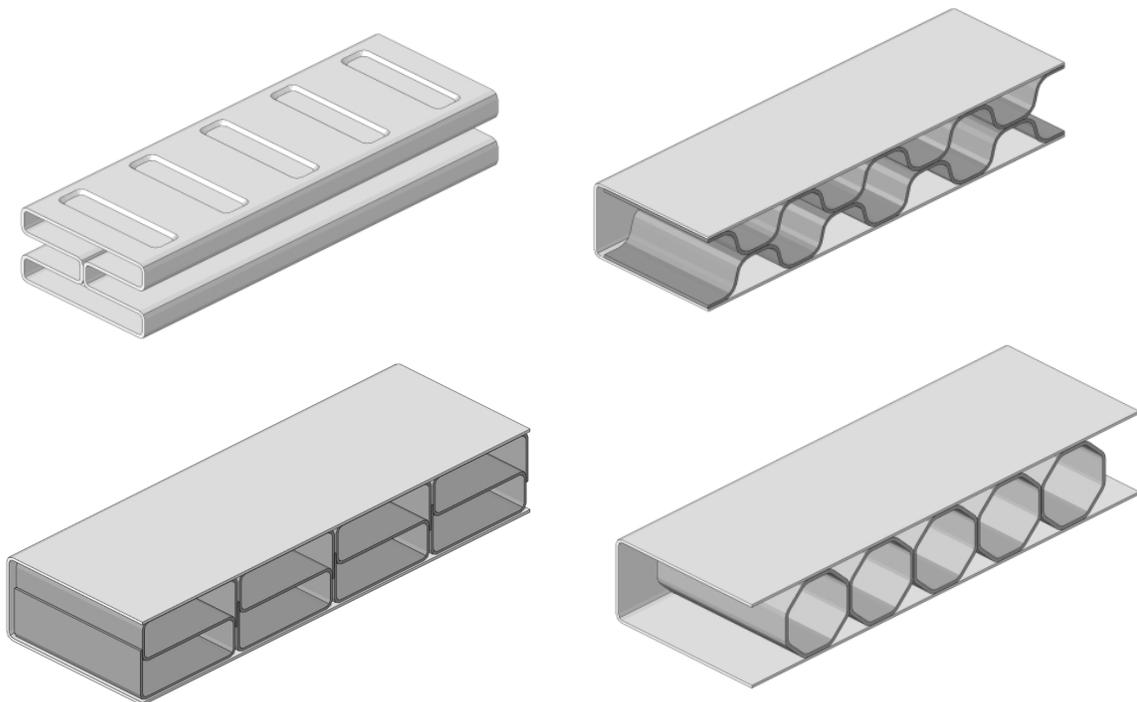
[0005] Implementing aluminum roll formed profiles and reducing production costs can be done by hybrid joining. The figure below shows an example of hybrid joining. In hybrid joining, periodic notches or slots can be inserted at predetermined distances into the sheet, prior to joining, either by punching, drilling, or cutting with a laser. Remote laser welding can then be used on the upper and lower fillet of the notches, circled in dashed lines, either simultaneously or sequentially. Along the dashed lines, an adhesive can be applied as a stitched bead or otherwise between the notches and then cured. The welded notches secure fixation of the joint until the adhesive is cured.



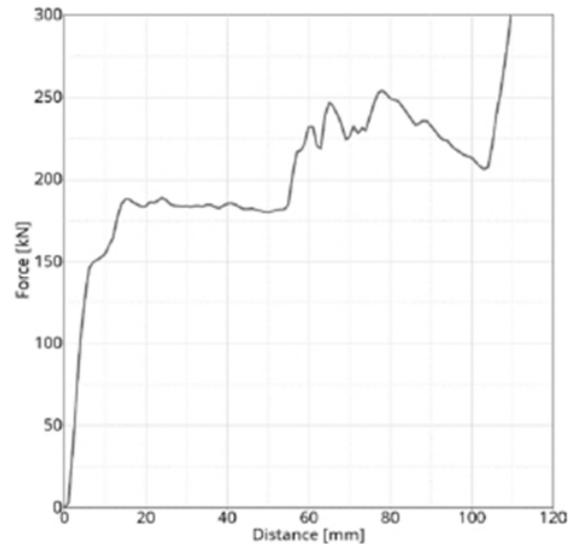
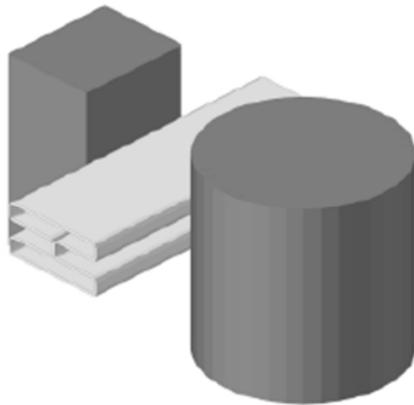
[0006] Aluminum roll-formed profiles can implement a unique shape to help improve their crash strength. An example of such a shape can be seen in the figures below, which is a closed profile shape resembling a figure 8, with (left) and without (right) an internal rib. The energy absorption of the figures below can exceed 16 kJ/kg of profile, and until fully crushed, deformation can provide reaction forces exceeding 170 kN. Inserting internal ribs and/or stamping beads into profile sheets before rolling forming operations can help tailor performance.



[0007] The profiles above can also be combined with additional continuous or discontinuous structures that are oriented 90° to the rolling direction, to form multi-directional profiles. The additional structures may be structures made by means such as roll-forming, stamping, etc. The resultant multi-directional profiles may be able to bear significantly higher loads during deformation, and can have a higher energy absorption per kg of profile in the affected deformation area, as the multi-directional design with transversally oriented structures are compressed instead of bent which leads to better crash performance. The figures below show non-limiting uses of multi-directional profiles. Clockwise from the top left, the below examples are: a closed flat 8-shape profile with beads; a bi-directional open profile with continuous double-wave reinforcement; an open profile with discontinuous S-shape axial reinforcement; and an open profile with discontinuous axial octagonal reinforcement.



[0008] A simulation of an impact on an aluminum roll-formed profile demonstrates reaction forces as a function of deformation distance as plotted in the below graph. The reaction forces quickly exceed 150 kN of force for minute deformation under quasi-static loading, using a simulated 10-inch pole impactor against the aluminum roll-formed profile supported by a 155 mm wide barrier. The simulation underlines the strength and energy absorption capacity of aluminum-rolled profiles as reinforcing straight or bent, hollow vehicle structures.



[0009] Aluminum roll-formed profiles can be implemented across different portions of a vehicle that may require high crash loads, such as any straight/slightly bent body in white structure, for example the front bumper, rear bumper, roof rail, upper A-pillar, front and rear longitudinals, seat cross members, frame structures for commercial vehicles, trucks, busses, vans, railway cars and more. Such aluminum roll formed profiles are lighter than steel and provide cost saving potential over aluminum extrusions at similar or lower weight. Different arrangements of the components described above, as well as components not shown or described, are possible.