WORKABILITY OF TAILOR WELDED BLANKS

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Abstract. The application of tailor welded blanks offers significant potential for reducing the weight of future automobiles and improvements are being made in the development and understanding of the welding process. There are several geometric and internal weld features that make the complete numerical description of tailor welded blank forming challenging. The variation of the experimental formability results found in the literature for tailor welded blanks appears to be large, and a combined theoretical tensile instability and statistical analysis of internal weld porosity may explain at least some of the variation reported.

Keywords: tailor welded blanks, automotive, construction.

1. INTRODUCTION

The sheet metal industry is an extremely competitive global market that is continuously challenged to improve its products and operations. Customers demand high performance at minimal cost, which often conflict with the ever constricting government environmental regulations. These requirements force the manufacturer to come up with innovative solutions to reduce manufacturing costs, improve product performance, and reduce its weight. Tailor welded blanks offer a unique opportunity to meet all of these goals simultaneously.

In the conventional fabrication of automobile body component assemblies, several stampings are formed individually and subsequently spot welded together in order to obtain the material and strength requirements at various locations in the assembly. Alternatively, the various materials can be welded together prior to the forming process to produce what are known as tailor-welded blanks. This term is derived from the notion that the automobile designer will be able to "tailor" the location in the stamping where special material properties are desired. These differences can be in the material's grade, gauge thickness, strength, or coating, for example galvanized versus ungalvanized [1].

Although the tailored blank process was first developed as a method for utilizing collectible offal and improving blank nesting possibilities, its greatest potential lies in the area of blank composites made of blanks with different thickness, coatings and material grades or strength levels. Thus, most tailored blanks today are made from prime stock as nested blanks rather than from collectible offal [2].

Tailored blanks can improve material yield both by making use of collectible offal, as a result of a product design optimising the material for the specific requirements of a given section of a part. Material utilization rates are affected by product design, draw die development and blank nesting. Vehicle and part weight reduction through the use of tailored blanks are derived from optimisation of material, such as the application of high strength steel in one or more of the blanks that the tailored blank is comprise of, and gauge reduction is specified area of the tailored blank and finished part.

2. APPLICATION DESIGNS

All applications can be categorized as one of the following: single straight line; multiple straight line and angular; non-linear (curvilinear); patch; tailor welded tubes [4].

Simple, one straight-line weld applications are the most common worldwide. These applications are simple to weld when the weld length is short, less than 1.3 meters, and if the two blanks have differing thicknesses as most do. Applications of this type include: front door inners; rear door inners, with shorter welds than the front door; longitudinal rails; pillars, with the B-pillar as the most common; cross rails; reinforcements; and other applications such as floor pans, rocker panels, shock towers, wheelhouse inners, sill panels, etc. Typical objectives for these applications include cost reduction, mass reduction, and structural improvements. An example of a single straight-line part is shown figure 1.

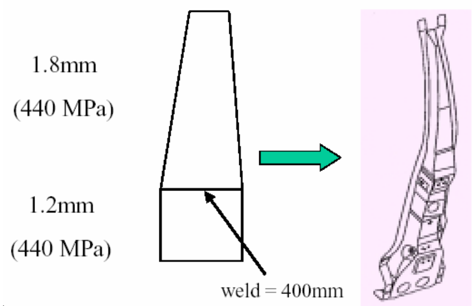

Fig. 1. B-pillar, one straight line weld application.

Multiple, straight line welded blanks have two or more straight welds. (Fig. 2). Some blanks have two to three welds in the same axis, in-line, and others have parallel weldsor welds in different axes, perpendicular or at angles to the first weld. Demand for applications with multiple straight lines is increasing, not only for body sides, but for engine rails as well. The objective for most body side applications is cost and mass reduction, while engine rails have structural objectives including crash management. An US car manufacturer had nine multiple straight line welded body sides in production in 2000 and one multi-weld underbody cross sill [4]. The biggest car maker from France indicated that the main objective for developing their multi-axis jig system was for them a demand for multiple straight line welded blanks now and into the future.

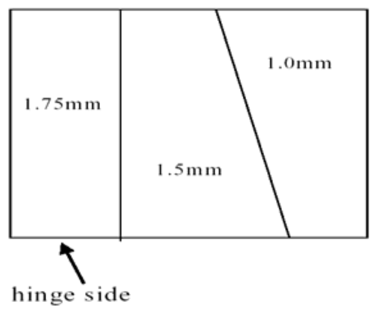

Fig. 2. Multi-straight line weld door inner

Angular straight line welds offer a compromise in benefit over non-linear welds without the welding complexity. Edge fit-up is usually simpler than with curved welds and many of the mass and structural benefits can still be achieved. Systems that provide angular straight line welds often produce a blow-hole at the intersection, often located in a spot that will be trimmed out in the stamping process.
The market for non-linear tailor welded blanks is smaller than that for conventional blanks because the incremental cost is difficult to offset by the marginal advantages. There may be cases, however, where a curved weld is needed because of structural or formability requirements that can determine whether or not an application is feasible.

Several non-linear, or curved, tailor welded blanks have been conceived, but few have reached the development stage. One advantage of a curvilinear weld over a multiple straight-line weld is that there is no blow-hole at the inflection point. There are physical limitations to the size of the weld radius depending upon the welding system. The complexity of circular tailored blank is much less than that of non-defined curves because of edge fit up, where a circular disc can be inserted into a round hole, and tooling for welding in a circular path as can be performed using a rotary table.

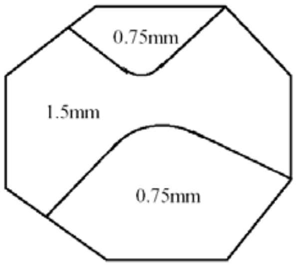

Fig. 3 Curvilinear wheelhouse.

The concept of a patch tailored blank is not new and several applications are in production. A patch tailored blank overlays one blank of material on top of another blank to add strength where it is needed. The two blanks are joined, usually by spot welds, before forming. Tailored blank welding constraints such as edge condition for butt welding and designing blanks for linear welding systems are eliminated. Consequently, patch tailored blacks designs have greater flexibility and generally less cost than the conventional tailor welded blanks counterpart. Major questions regarding patch tailor welded blanks concern structural performance, fatigue, and formability. Evaluating these properties may be more difficult than with conventional welded blanks, where there may be multiple steel blanks, but each blank can be modelled somewhat independently, aside from the weld line. With the patch blank, the performance of multiple layered blanks must be considered and their performance will be affected by the joining design, whether spot welds, adhesives, or another technology. One advantage of patch blanks over conventional, multi-piece assemblies is the superior fit-up that is achieved. Since the multiple pieces are formed in the same die, the fit-up between the reinforcements and larger blank is excellent. This superior fit-up can simplify respot welding and improve the structural performance and quality over a non-tailored blank.

The reinforcement patches on both blanks do not extend to the edge of the larger blank and therefore remain clear of the draw die binder. This simplifies binder design and forming complexity. A second observation is that each patch is joined using either two or three spot welds and the location of these spot welds is on the “flat” area of the finished part. Minimizing the spot welds will allow for material flow on the curved surfaces. Additional spot welds, or respot welds can be added later in the assembly process, as needed.

There are several factors that contribute to the increasing interest in tailor welded tubes. In general, tubes for body-in-white applications are hydroformed. Currently available tubes have limitations regarding their diameter to wall thickness ratio and relatively low formability due to conventional tube production processes and the resulting weld quality. Tube shapes and tailor welded tubes can come in a variety of shapes, and can be welded with mash or laser. Some types of tubes are: cylindrical tubes; tailor tubes (varied wall thickness); oval tubes, and conical tubes[4]. Tailor welded tube applications are feasible wherever hydroformed tubular applications are considered. As in flat applications, the tailor welded tubes allow for added optimization of material use. Examples of possible tailor welded tubes include: exhaust manifolds; A-pillar; engine compartment rails; light truck side rails; rollbars, and side rails.

3. OTHER APPLICATION OF TAILOR WELDED BLANKS

Metal sheets are used widely for the manufacture of products in the electrical goods, packing and construction markets and some of those application may benefit from the advantages offered by tailor welded blanks.

Actually, any product that requires a modification in material properties within a metal sheet part can be improved by making it from tailor welded blanks.

The mechanism of a garage door is a examples of process that could take advantage of tailor welded blanks, using strengthen material at the door edge where the brackets, runners and additional operating equipment are located. This would also improve the strength of the sheet material, reducing the need for strengthening using roll-formed stiffeners [3].

Tailor welded blanks could by used also in the white goods industry. For instance, in the manufacture of washing machines where steel with extra corrosion resistance obtained by using thicker galvanised coatings could be located on the lower section of the machine casing or on vulnerable area surrounding doors, seal and draws [3]. This will provide an improvement in corrosion resistance where it is most needed while still retaining the good forming properties required by the upper section where tight radii and multiple bends make the use of thick protection coatings difficult.

4. CONCLUSIONS

Tailor welded blanks offer a real opportunity for optimizing the design and production of high quality structural components for automakers industry, white goods industry and construction industry. Cost and limitation on the size of the elements that can currently be fabricated restrict their implementation but as their use and efficiency is further developed it is envisaged that these drawbacks will be overcome.

In the future, more products from different industry areas may benefit from the advantages offered by the use of tailor welded blanks. The development of the sheet welding process in addition with the sophisticated demands of the final user determine the manufacturers to choose tailor welded blanks instead of homogenous metal sheets.

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