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Application of Tailor Rolled Blank in A-pillar stiffener of a certain automotive body

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Abstract: Tailor Rolled Blank(TRB) can be used for manufacturing A-pillar stiffener in an automotive body in order to achieve the goal of automotive lightweight on the premise of meeting requirements of strength and rigidity. In this paper, forming and springback simulations of A-pillar stiffener made of TRB were carried out. Aiming at springback and thickness transition zone(TTZ) movement defects, annealing and rib were adopted in order to lower springback and TTZ movement. Research findings show that after annealing is adopted, TTZ movement increases slightly, and meanwhile rib can diminish TTZ movement. Rib and annealing can lower springback of TRB A-pillar stiffener, especially springback on the thinner side, and springback of the whole TRB part becomes uniform.

1. Introduction

A-pillar stiffener is an important part in a car. It not only must insure the impact resistance of A-pillar, but also must have sufficient rigidity and strength as the installation location of a car door hinge. Moreover, the flange of A-pillar stiffener will be connected to A-pillar with the requirement of high assembly precision. So the forming quality of A-pillar stiffener not just decides the service performance itself, but affects the assembly precision of the car door. For A-pillar stiffener with the structure of U-channel, springback is one of the main defects, which will greatly affect the assembly precision. Therefore, research on the formability of A-pillar stiffener and the springback control is of practical significance and application value.

Tailor Rolled Blank(TRB) is used for manufacturing A-pillar stiffener in order to realize the automobile lightweight^[1-3]. The thickness on the side of hinge installation is 2.0mm, and the thickness on the other side is 1.2mm. The A-pillar stiffener designed in this paper is demonstrated in Fig.1.

Stamping forming and springback processes are simulated in this paper. The formability of TRB A-pillar stiffener is studied by the evaluating indicators of springback amount and thickness transition



zone(TTZ) movement. Annealing and rib are applied for improving the formability of TRB A-pillar stiffener, and finally a qualified part is acquired.

2. Stamping forming and springback analysis

When 1.2/2.0mm TRB is applied to substitute original 2.0mm steel sheet, the mass of A-pillar stiffener reduces by 18.3%. In the meanwhile, strength and rigidity requirements are considered at the beginning of part design, and FEM is used to verify that TRB part can meet the corresponding requirements. And then, the characteristics of forming and springback of TRB A-pillar stiffener should be analyzed so that TRB part can be successfully applied in a car^[4,5].

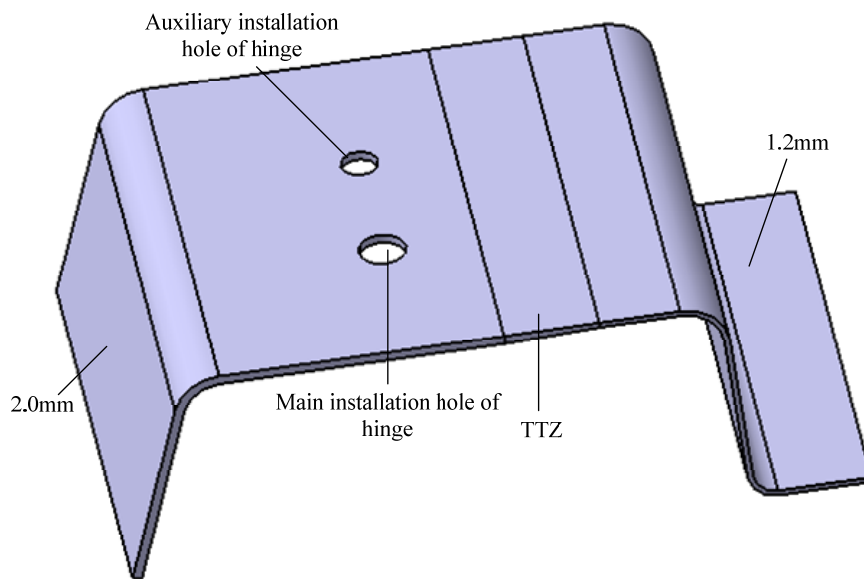


Figure 1. A-pillar stiffener made of TRB

Stamping model of TRB A-pillar stiffener is shown in Fig.2. A polyurethane plate is used to compensate the thickness gap of TRB in order to obtain higher part precision. TRB property parameters are obtained from stress-strain field^[6]. The blank width is much larger than the thickness, so TRB sheet is presumed in the plane strain state. The material model follows the hardening exponent method and the Barlat yield criterion, and the number of integration points through thickness is 9. Belytschko-Tsay shell elements and full-integrated elements are respectively selected for the forming stage and for the springback stage, and mesh size is 2mm×2mm. An explicit FEM code is applied to model the forming simulation, and an implicit code is used to simulate springback. Stamping formability and springback results are presented in Fig.3, Fig.4 and Fig.5.

Fig.3 demonstrates the springback trend of TRB A-pillar stiffener. As known from Fig.3, large springback happens, and especially on the thinner side springback amount is over 2.5mm

Fig.4 shows springback comparison between TRB and monolithic blank parts. It can be seen that TRB springback is between the springback of the thinner monolithic blank part and the springback of the thicker monolithic blank part, and springback on the thinner side is larger than that on the thicker side of TRB part.

Fig.5 describes TTZ movement of TRB A-pillar. According to Fig.5, TTZ movement is no more than 2mm.

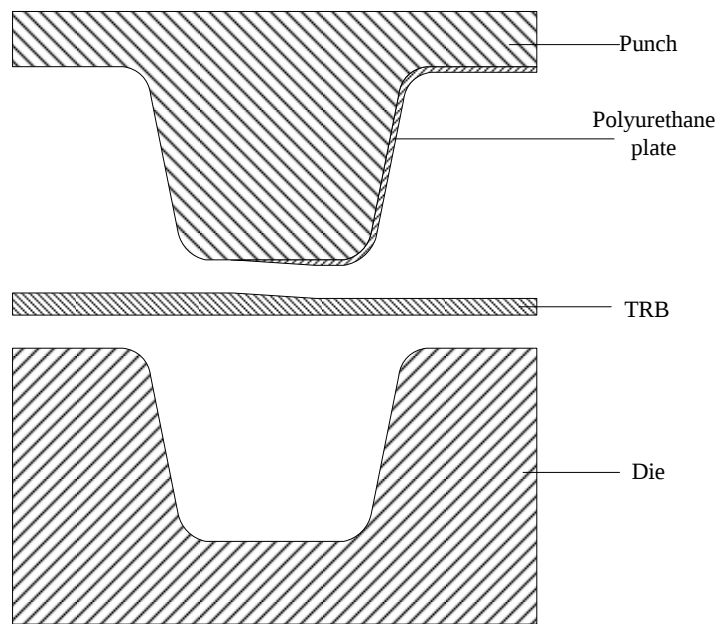


Figure 2. Stamping model of A-pillar stiffener made of TRB

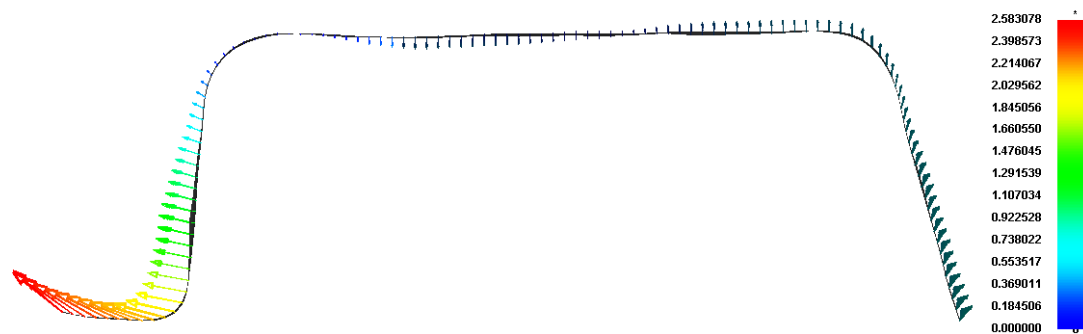


Figure 3. Springback trend of A-pillar stiffener made of TRB

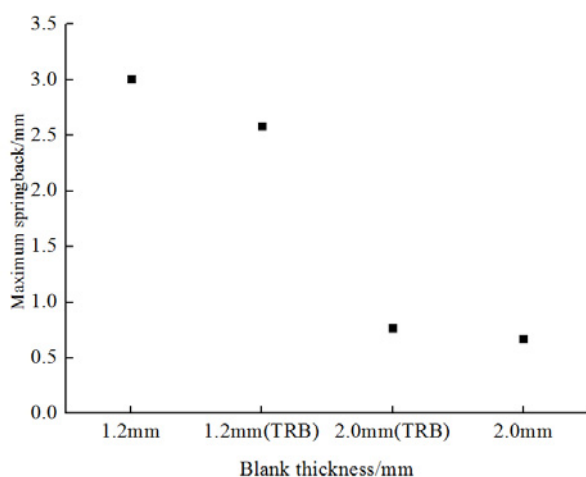


Figure 4. Comparison of springback between A-pillar stiffeners of different thicknesses

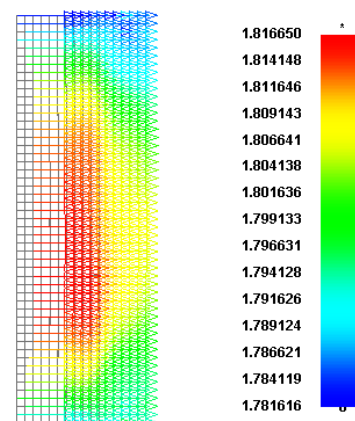


Figure 5. TTZ movement of A-pillar stiffener made of TRB

3. Optimum design

The forming defects of TRB A-pillar stiffener will affect its formability and service performance, so

corresponding measures should be taken to restrict TTZ movement and springback^[7-9]. TTZ movement may be compensated by adjusting the relative position of TRB above the die. Springback can be reduced by annealing^[10,11]. Moreover, rib on the bottom round corners are designed to improve the bending rigidity of TRB part, and to restrain springback, especially springback on the thinner side. The modified TRB A-pillar stiffener is demonstrated in Fig.6.

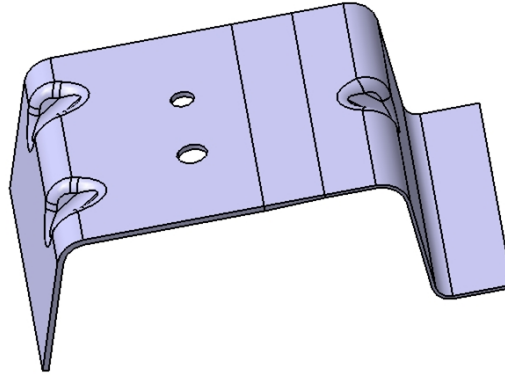


Figure 6. Optimized A-pillar stiffener made of TRB

Table 1 presents the effects of annealing and rib on TTZ movement. According to Table 1, annealing makes TTZ movement increasing, whereas rib can lower TTZ movement. As discussed above, TTZ movement may be compensated by adjusting the relative position of TRB above the die. So TTZ movement is a secondary factor affecting the formability of TRB A-pillar stiffener compared with springback.

Table 1. TTZ movement of A-pillar stiffener made of TRB

	Unannealed		Annealed	
	Without rib	With rib	Without rib	With rib
Maximum TTZ movement/mm	1.82	0.99	2.38	2.00

Fig.7, Fig.8, Fig.9 and Fig.10 describe the springback results of TRB A-pillar stiffener. Fig.7 Fig.8, and Fig.9 respectively demonstrates the effect of rib on springback, the effect of annealing on springback, and the comprehensive effects of them. It can be seen that, rib and annealing can both decrease springback of TRB A-pillar stiffener, especially springback on the thinner side. When rib and annealing are adopted at the same time, springback can be restricted utmostly. Thus, springback of TRB lowers to less than 0.5mm, and springback of the whole TRB part becomes uniform.

Fig.10 demonstrates the springback distribution at the cross section of TRB part. It can be known from Fig.10, after rib is adopted, springback reductions on the thinner side and on the thicker side are close. Annealing has a limited effect on springback on the thicker side, but it can greatly restrain springback on the thinner side. After rib and annealing are adopted at the same time, springback enormously decreases. The springback of whole TRB part is uniform except for small fluctuation at the bottom.

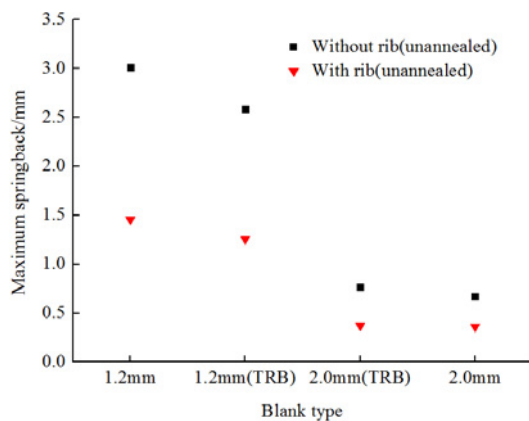


Figure 7. Effect of rib on springback of A-pillar stiffener

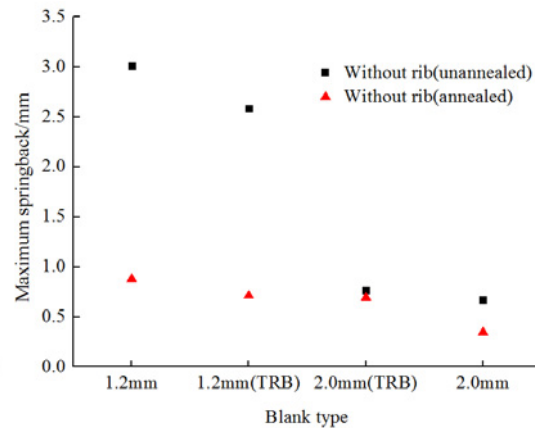


Figure 8. Effect of annealing on springback of A-pillar stiffener

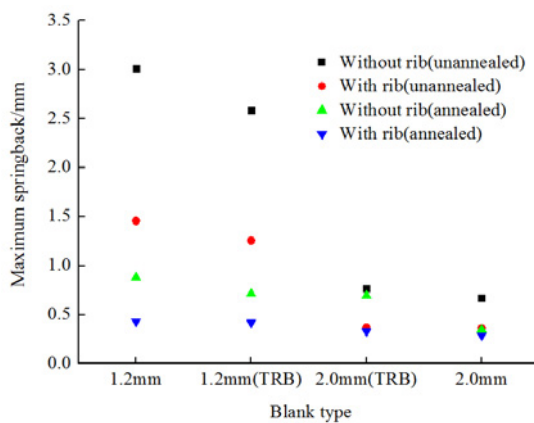


Figure 9. Effects of rib and annealing on springback of A-pillar stiffener

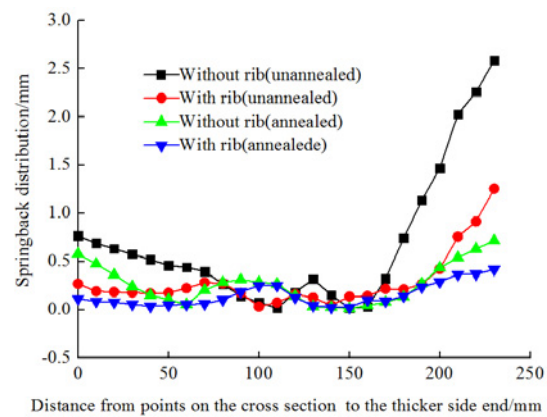


Figure 10. Springback at the cross section of A-pillar stiffener made of TRB

4. Conclusions

When TRB is adopted to manufacture A-pillar stiffener, automobile light weight can be realized on the premise of meeting strength and rigidity requirements. For TRB A-pillar stiffener, TTZ movement also happens expect for severe springback. When annealing is adopted, TTZ movement increases to some extent, whereas rib can decrease TTZ movement. Rib and annealing can both lower springback of TRB A-pillar stiffener, especially springback on the thinner side, and thus make the springback distribution of the whole TRB part uniform.

Acknowledgement

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