THE ANALYSIS OF THE FLOW OF LASER WELDED TAILORED BLANKS BULGED BY LIQUID OR A PUNCH

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ANALÝZA TOKU LASEROVO ZVÁRANÝCH TAILORED BLANKS VYTLAČENÝCH KVAPALINOU, ALEBO LISOVNÍKOM

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Abstrakt

Článok reprezentuje skúšobné výsledky procesu deformovania laserovo zváraných ″ tailored blanks ″ s použitím tuhého lisovníka, alebo kvapaliny. Lokálna distribúcia deformácie vo výtlačkoch bola určená pomocou merania súradníc nanesenej siete. Určenie lokálnej deformácie umožňuje určiť rozdiely v tečení zvarovaných ″ tailored blanks ″, v závislosti na mechanických vlastnostiach prístrihov, ich hrúbke a mieste laserového zvaru. Dosiahnuté výsledky boli dôkazom faktu, že laserové zvary, napriek ich šírke signifikatne menia mechanické vlastnosti v zóne spájania prístrihov. Tvar kalíškov obdržaných v procese vytlačovania pomocou kvapaliny je značne rozdielny pri spojovaní prístrihov rovnakej hrúbky a rovnakej značky ocele, v porovnaní so spojovaním prístrihov majúcich rôznu hrúbku a rôznu akosť ocele. Trhanie laserovo zvarovaných ″ lailored blanks ″, ktoré sa vyrobili ako prístrihy rôznej hrúbky a rôznej akosti materiálu, sa vyskytuje na mieste tenšieho prístrihu (pevnosť prístrihu menšia), v blízkosti tepelne ovplyvnenej zóny. Plastické vlastnosti blízko tepelne ovplyvnenej zóny sa slabo zhoršujú vplyvom zmien v štruktúre materiálu v porovnaní s vlastnosťami prístrihov pred procesom zvárania. Prezentované výsledky môžu slúžiť pre vypracovanie podkladov laserového zvárania ″ tailored blanks ″ aplikovaných v hydroformingu.

Abstract

The article presents examination results of the process of bulging of laser welded tailored blanks with the use of rigid punch or liquid. Local strain distribution in bulged coatings have been determined applying the method of measuring the co-ordination nets. The determined local strain allowed to define the differences in the flow of welded tailored blanks according to the mechanical properties of the blanks, their thickness and the position of the laser weld. The obtained results were the proof of the fact that the laser weld, despite its width, significantly changes mechanical properties of the zone of joining of the blanks. The shape of cups obtained in the process of bulging where liquid bas been used is significantly different for the joining of blanks of the same thickness and the same grade compared to the joining of the blanks of different thickness and different grade. Cracking of laser welded tailored blanks which have been made of blanks of different thickness or different grade appears on the side where the thinner blank is (i.e. where the strength of the blank is lower) near the heat effect zone. Plastic properties near the heat effect zone have been slightly deteriorated as a result of changes in the

structure of the material as compared to properties of the blanks before the process of welding. The presented examination results made it possible to elaborate some guidelines for processing laser welded tailored blanks applying the method of hydroforming.

Key words: hydroforming, bulge test, tailored blanks, drawability, stress and stain analysis

1. Introduction

Laser welded tailored blanks and tubular blanks produced by hydroforming method are used for producing car body elements [1, 2]. Fig. 1 presents exemplary elements of car body construction made from tubular blanks by hydroforming method [3].

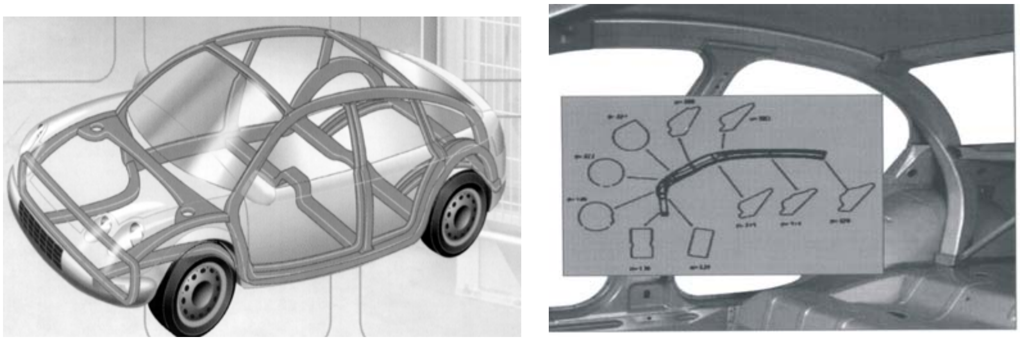

Fig. 1 a)Elements reinforcing car body construction made by the method of hydroforming; b). Elements made from Ø 96 x 1 mm tubular blank [3].

Introducing laser welded tailored blanks for forming car body elements (including the use of hydroforming method) is quite advantageous in terms of technology and economy. However forming tailored blanks of complex heterogeneous mechanical properties and diversified thickness requires thorough identification of formability of that type of materials. This is closely related to diversified flow of material and the distribution of local strain as compared to conventional blanks. The above mentioned problems regarding the process of forming the blanks with the use of rigid tools have already been solved [4,5], whereas in the case of hydroforming these problems call for further examinations.

2. The process of forming laser welded tailored blanks by a punch or liquid

Characteristic feature of the flow of welded tailored blanks in the process of forming is the non-uniformity of strain caused by the weld and diversified properties as well as by different thickness of tailored blanks. While forming a drawpiece by a punch both the size and the local distribution of strain depend on friction and the shape of the element to be formed. In the case of hydroforming the distribution and the position of strain at the initial stage of the process, when the coating is formed without the action of a die, depend only on the local value of the product of thickness of the blank and yield stress. There is no friction at that stage of forming. Diversification of the value of local strain in tailored blanks or tubular blanks has significant influence upon the second stage of the process when the use of die causes friction during the process of material flow and differentiates the local flow according to the geometry of a drawpiece and the shape of the die. This is a result of different strain hardening. It is important to keep in mind that tailored blanks are composed of blanks of different grade so in the second stage of the forming process they form a material featuring different local strain hardening and additionally the weld is a zone of different properties where the material also features different strain hardening.

2.1 Examinations

In order to define the above discussed differences in the position of the strain during the process of forming laser welded tailored blanks by a rigid punch or liquid, some forming tests have been carried out using the same round Ø100 mm die. The examinations were performed for blanks of S355 grade (in accordance with EN 10149 norm) and symbols A have been chosen whereas for blanks of H180BD+Z grade (in accordance with PN-EN 10292:2000) symbols B have been used. Table 1 presents basic mechanical properties of the examined blanks determined in tensile tests such as: Rm - tensile strength, R_{02} - yield point, A_{80}, A_r - percentage elongation and uniform elongation, n, C - parameters of the function of strain, r, Δr - regular and flat anisotropy and Erichsen test - IE. The welding process of A+D blanks has been carried out in the Institute of Welding in Gliwice.

Table 1 Characteristics of mechanical properties of the examined blanks.

Blank A, grade S355 (in accordance with EN 10149 norm)											
Thickness of the blank [mm]	Direction of the sample	Rm [MPa]	$R_{0,2}$ [MPa]	n [-]	C [MPa]	r [-]	Δr [-]	$r_{śr}$ [-]	A_{80} [%]	A_r [%]	IE [mm]
1,50	0°	444	350	0,118	311,0	0,76	-0,26	1,32	30,1	20,0	10,8 płytko tłoczna
	45°	429	356	0,099	317,0	1,45			32,3	21,0	
	90°	457	383	0,096	344,6	1,61			28,8	19,9	
Blank D, grade k H180BD+Z (in accordance with PN-EN 10292: 2000 norm)											
Thickness of the blank [mm]	Direction of the sample	Rm [MPa]	$R_{0,2}$ [MPa]	n [-]	C [MPa]	r [-]	Δr [-]	$r_{śr}$ [-]	A_{80} [%]	A_r [%]	IE [mm]
1,20	0°	326	224	0,161	194,9	1,63	0,60	1,32	38,2	25,0	10,7 głęboko tłoczna
	45°	326	230	0,151	202,6	1,03			38,2	23,8	
	90°	343	243	0,149	215,2	1,63			34,9	23,9	

Fig.2 presents the photographs of drawpieces obtained in bulging tests of welded tailored blanks made of A+D blanks by a punch and liquid in Ø 100 mm die. Measurements of local strain ε_1, ε_2 in the plane of a blank have been carried out in order to determine the effect of diversified flow of the blanks for drawpieces presented in Fig. 2. Co-ordination net (the initial diameter of a mesh was Ø 2 mm) was marked before the process of forming which enabled to determine the strain of meshes located along the weld on the line perpendicular to the weld running across the top of the bulge. The results have been shown in Fig.3 and 4. The principle of constant volume has been used to determine the strain in the direction of ε_3 thickness of the blank.

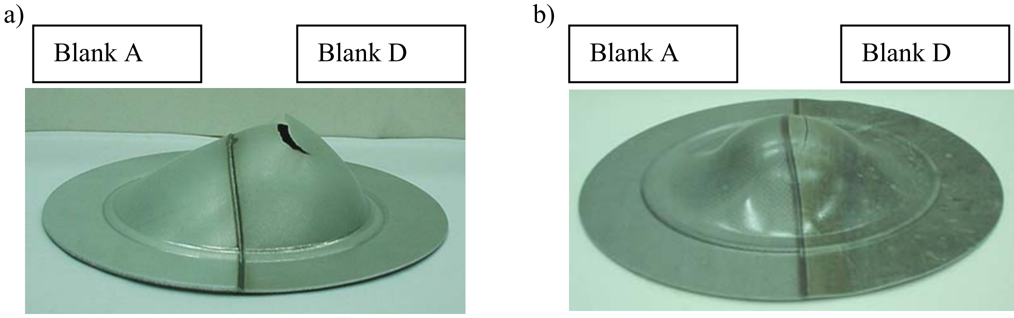

Fig.2 Drawpieces made of laser welded tailored blanks, bulging made by: a) liquid, b) punch. Laser welded tailored blanks made of blanks A and D according to the symbols shown in Table 1.

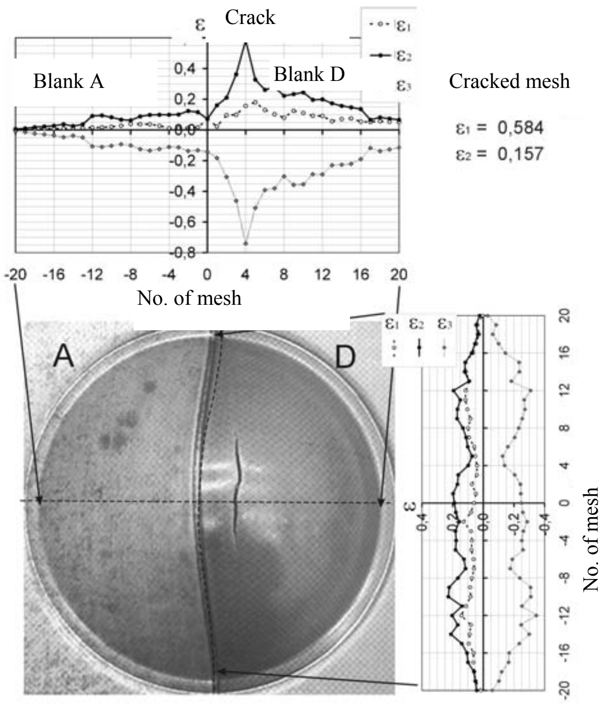

Fig.3 Analysis of local strain in a drawpiece obtained during the process of bulging by liquid.

3. Summary and conclusions

The shape of bulging in a drawpiece formed by a punch is the same as the ball-shaped end of a punch and it is a result of the acting friction forces. During the process of forming by liquid, the bulging results from the acting pressure which is evenly distributed upon the entire surface of the formed blank. In both these cases the quality of bulging depends on the properties of a weld as well as on the local differences in hardening caused by the above discussed conditions.

1) The distribution and the position of strain in tailored blanks bulged by a punch depend on the shape of the punch, the conditions of friction and the interrelations between the levels of properties of the blanks and the weld itself.
2) In the process of bulging the tailored blanks by liquid the distribution and the position of strain depend only on geometry of the sample and on the interrelation between the level of properties of tailored blanks and the laser weld.
3) The process of bulging by liquid occurs in those areas where for a given blank the product of thickness and the size of local yield stress is smaller, which in turn results in producing a few overlaying bulges of different level of strain of the blank.
4) The process of cracking in tailored blanks bulged by liquid proceeds at constant value of strain measured along the groove and it is the same as the strain obtained at the stage of uniform strain.

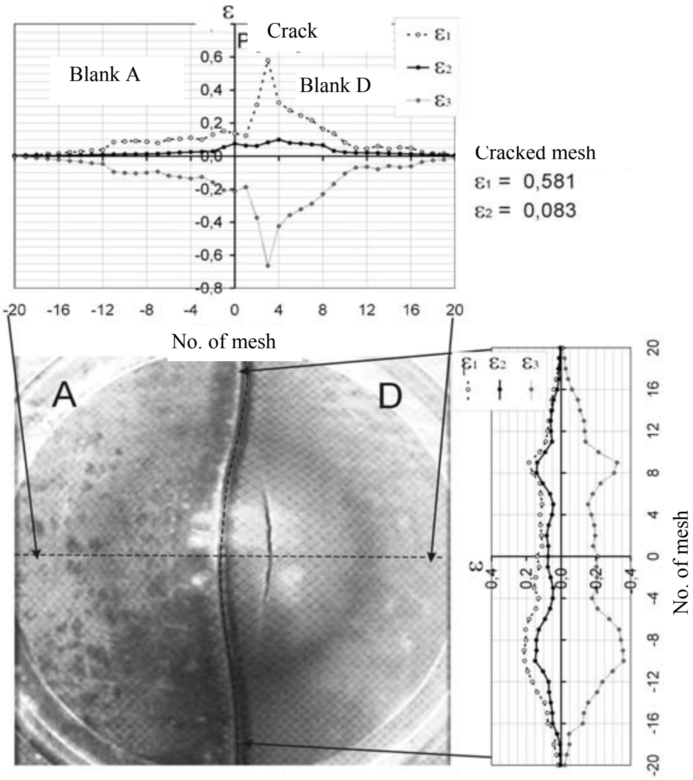

Fig.4 Analysis of local strain in a drawpiece obtained during the process of bulging by a punch.

Acknowledgment

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