Investigation of a partial, inductive short-time heat treatment of thin metal sheets integrated into the forming process

EUROPÄISCHE UNION
Europäischer Fonds für regionale Entwicklung

Mecklenburg Vorpommern
MV tut gut.

HOST Hochschule Stralsund
University of Applied Sciences

HAFF-Dichtungen GmbH
Flachdichtungen aller Art

Benjamin Clausius and *Petra* Maier

University of Applied Sciences Stralsund, D-18435 Stralsund, Germany

School of Mechanical Engineering – Materials Science

Introduction

Flanging is a widespread method in the sheet metal working industry. Especially the sealing technology makes high demands on the flanging process: a low sheet thickness of the inner eyelet is necessary for proper sealing. Quality of pre-punched holes which are expanded during the stretch-flanging process, sheet thickness and material are influencing factors for the process limits.

Our goals:

· Evaluation of the pre-punched hole quality by investigating strain hardening and notch effect.
· Determination of achievable hole expansion ratios (HER).
· Increase of the process limits by inductive short-time heat treatment (ISH).

Experimental

The material used for the investigation is 1.4571 (AISI 316Ti) with a thickness of 0.1 mm. Regarding the quality of pre-punched holes, the averaged notch depth was optical measured and strain hardening was investigated by Vickers HV0.2 hardness measurements in the area of the cutting edge for different cutting methods.

To evaluate the risk of cracking, a hole expanding test (HET) following the standard ISO 16630 was used. To investigate the influence of strain hardening and notch effect, samples with deburred cutting edges, solution annealed samples at 1020 °C for 10 min and solution annealed samples with deburred cutting edges were compared with untreated samples.

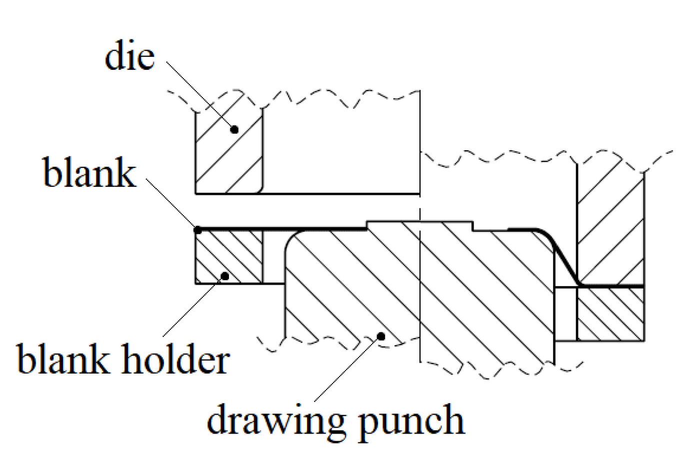

Fig. 1. Schematic drawing of HET

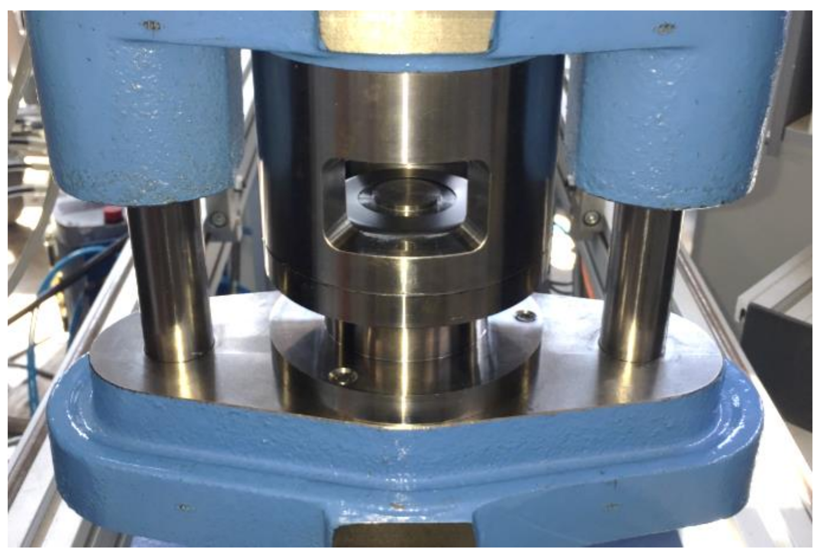

Fig. 2. Experimental setup of HET conducted with mechanical testing machine TIRAtest 28100

In the context of ISH, an inductive heating system with a flat, 50 mm spiral inductor was used to apply a partial annealing limited to the area of the cutting edge. To compare the results of the ISH with the solution annealing, hardness measurements and hole expanding tests were repeated.

Fig. 3. Inductive heating system iew TTH2t with 50 mm spiral inductor

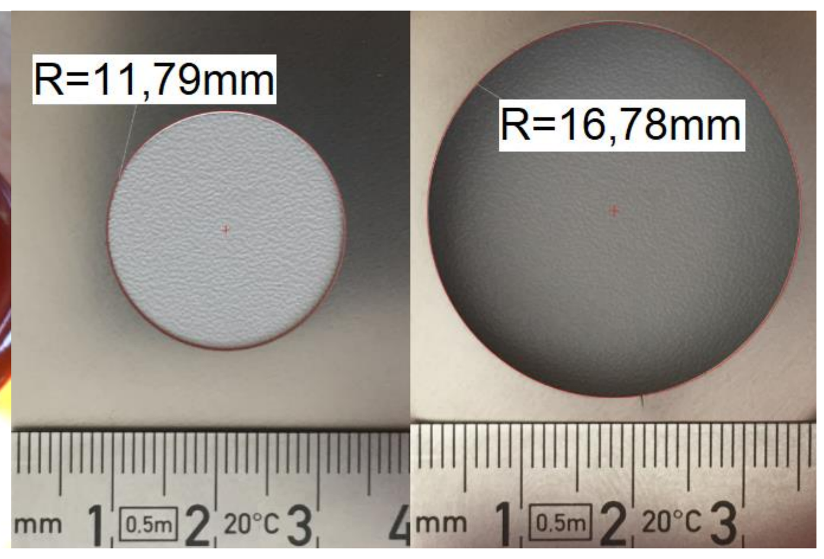

Fig. 4. a.) Pre-punched hole b.) HER of 1.42 after ISH

Results

Shear cut pre-punched holes provide the highest quality regarding strain hardening and notch depth for the considered methods.

The measurement results of the hardness after solution annealing show a complete degradation of the strain hardening which is the reference for the ISH.

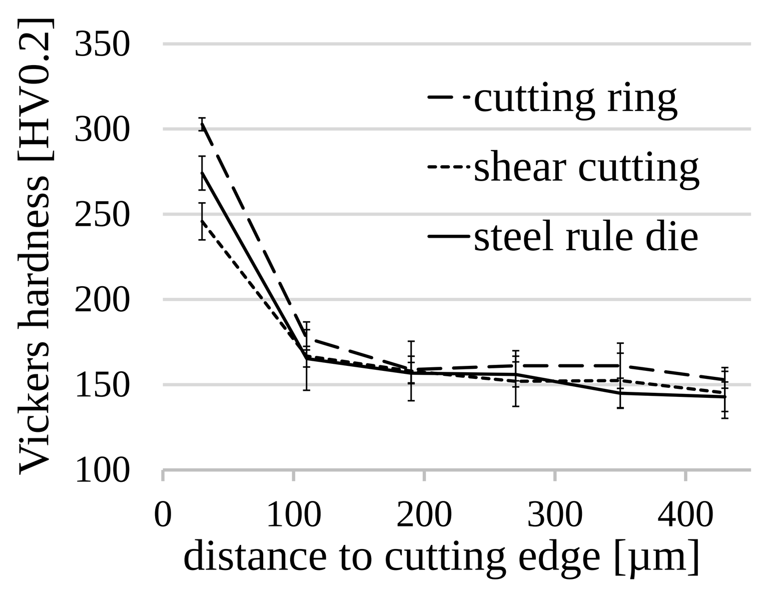

Fig. 5. Hardness profile of investigated cutting methods on distance to cutting edge

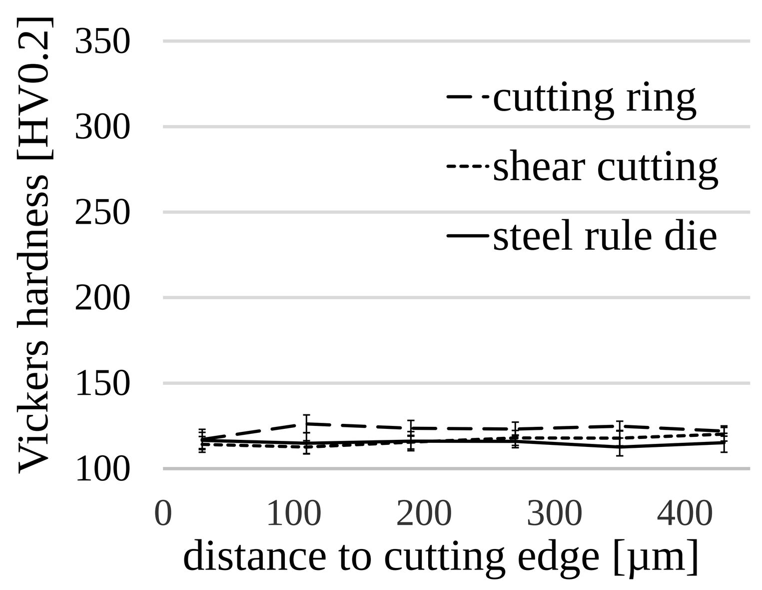

Fig. 6. Hardness profile of investigated cutting methods on distance to cutting edge after solution annealing

The HET results for the solution annealed and deburred condition show the process limits with a maximum HER of 1.52. To ensure that the strain hardening is unaffected by the deburring, hardness measurements are conducted which show values inside the standard deviation of the untreated shear cut samples. Consequently, the strain hardening has a higher influence on the risk of cracking than the notch effect.

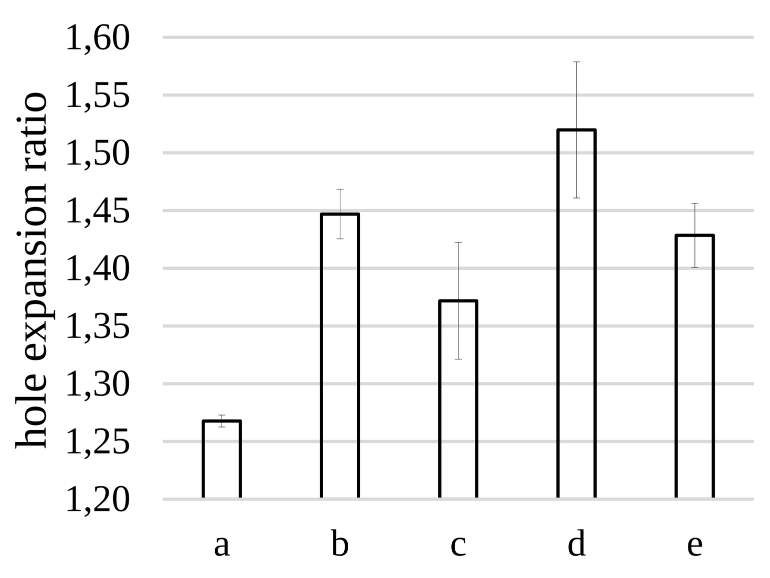

Fig. 7. HER – a.) untreated b.) solution annealed c.) deburred d.) solution annealed, deburred e.) inductive annealed

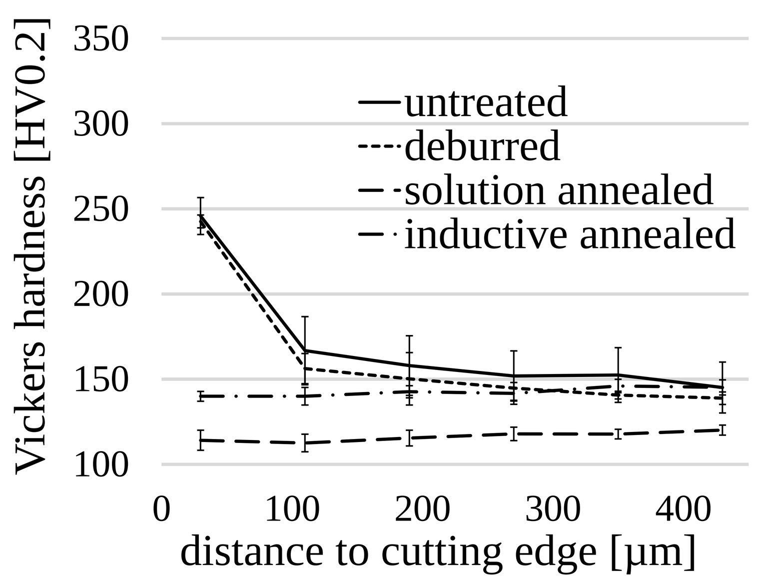

Fig. 8. Hardness profile of different conditions on distance to cutting edge

The optimized ISH process for the investigated material and pre-punched hole size was determined with a hold time of 0.5 s after reaching 1020 °C in 1.8 s.

Conclusion

The manufacturing of the pre-punched hole is an important part for the further flanging process. HET were conducted which showed that the solution annealed samples have higher HER of 1.45 compared to the deburred samples with 1.37. The ISH was adapted to reduce the strain hardened area with an annealing for 0.5 s at 1020 °C. This condition reached a HER of 1.43. Impermissible heat input to the forming tools has to be considered in further investigations.