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LOADING CAPACITY OF CROSS JOINT COMPONENT MADE OF ALU-SCRAP

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Abstract: In this paper loading capacity of cross joint, made of Al-scrap has been investigated. Al billets were prepared in a specific recycling process. As the mechanical compacting did not ensure acceptable billets, special procedure ("squeeze casting") was applied to produce billets. Cross joint was then made by classical hot forging. In experimental investigation limiting transmission force and bending moment were determined. Appropriate force – stroke diagrams were also presented.
Keywords: cross joint, recycling, hot forging, transmission force and moment

1. INTRODUCTION

Universal cross joint (Figure 1) is a typical mechanical engineering component which is used in different engineering assemblies for transferring movement and power within the various units of transmission system. Main applications of cross joint are automotive industry, heavy vehicles, different transportation units, conveyor belts, machine tools etc.

During exploitation this component is subjected to the high mechanical loading, mainly bending and shearing. It is produced mostly by forging, as this technology quarantines high mechanical properties which are required from the component. In most cases, classical hot forging is applied but in some specific cases other variants of forging could also be employed in manufacturing of cross joint.

Figure 1. Cross joint component after final machining [1]

Most commonly cross joints are made of steel. But, in some cases, when the load and moments to be transmitted are not high and low weight of the component is required, other materials for production of cross joint can be used. One attempt to manufacture cross joint from aluminium scrap is described in this paper.

Aluminium is second metal most used in the world, after steel [2]. This metal is characterized by low weight and low density, good corrosion resistance, relatively good mechanical properties and high recyclability potential. Due to its comparative advantages aluminium and its alloys are applied in many branches of mechanical, civil and electrical engineering, mainly in automobile and aerospace industry, general transportation, building and construction, packaging, electrical devices and apparatus, machine tools etc. As recycling of Al and its alloy is concerned, there exist two ways of performing it. Classical recycling includes melting of collected scrap and, after cooling, billets for further processing are produced. The main disadvantage of this recycling variant is high energy consumption in melting process [3]. Second possibility excludes melting sequence. Scrap is exposed to the high mechanical pressure in closed dies in order to realize good bonding between scrap particles. As a result, useable billets, consisting of pressed scrap particles, are made. This kind of recycling is called "solid state recycling".

In current paper one industrial trial is described in which Al-billets are made by recycling. Such billets are then used for manufacturing of cross joint component by hot forging. Finally, produced cross joint is subjected to the bending load in order to observe elastic and plastic behaviour of the component.

2. BILLET MANUFACTORING AND FORGING OF CROSS JOINT COMPONENT

Initially, billets for hot forging of cross joint were made by pressing (compacting) of Al scrap. It was carried out on the hydraulic press of 2,5 MN in the die with the inner diameter of 32 mm. Schematic presentation of compacting process is given in Figure 2. In the experiment four different chip-types and three different compacting forces are varied in order to investigate the process and to obtain optimal billet (higher density).

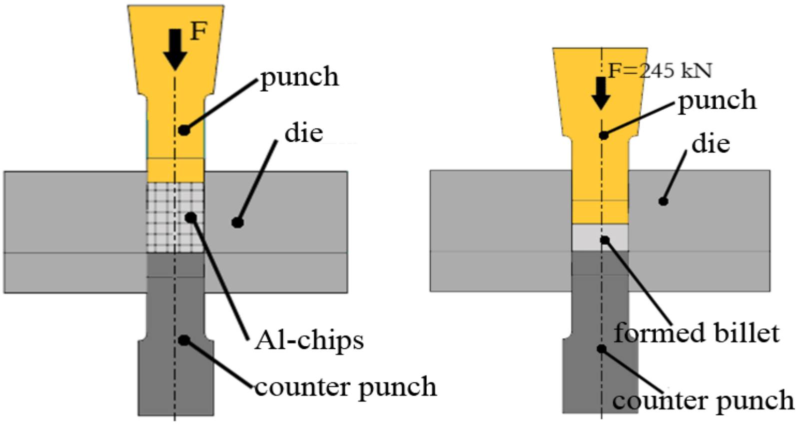

Figure 2. Compacting of Al-chips [2]

Different Al - chip – types are produced by milling, applying adequate milling parameters (Figure 3).

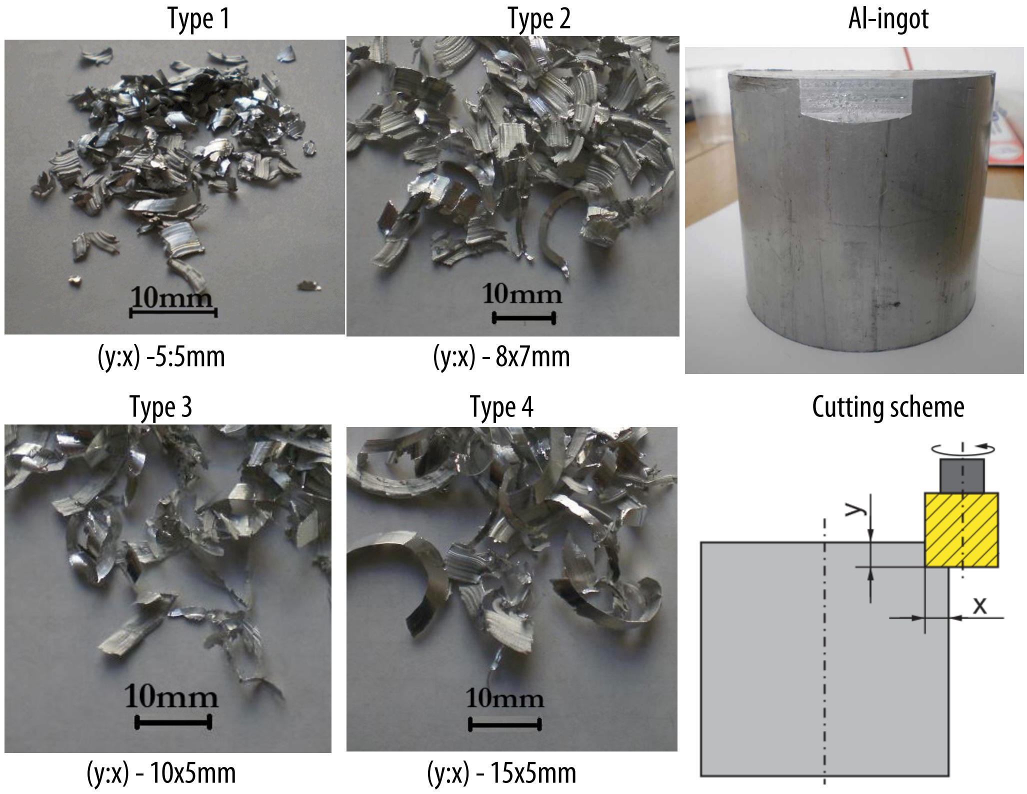

Figure 3. Different chip-types [2]

Influence of chip-type on billet density is illustrated in Figure 4. In the same figure density of compact Al is given. As it is seen, the smaller chip results in the higher billet density. Influence of applied compacting force on billet density is shown in Figure 5.

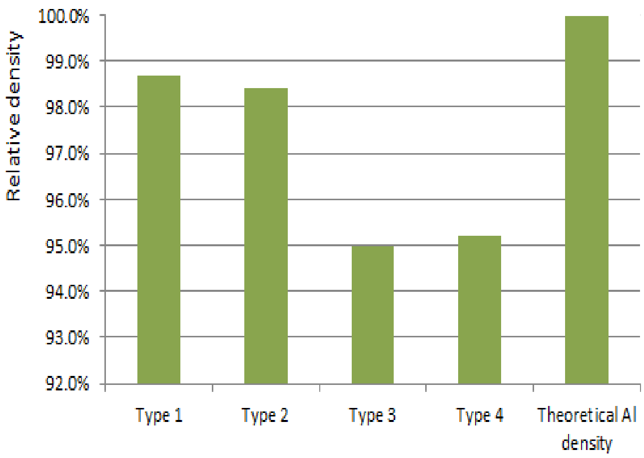

Figure 4. Influence of chip type on billet density [2]

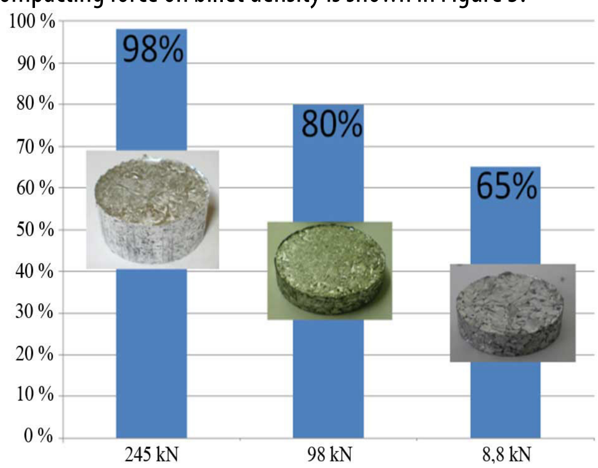

Figure 5. Influence of compact force on billet density [2]

As expected, the higher load gives higher billet density.In further investigation billets compressed by highest load (245kN) and produced from smallest chips are subjected to different metal forming processes (upsetting, backward extrusion) in order to examine their suitability for industrial metal forming application. This part of investigation revealed that billets produced by compacting of Al chips show pretty high deterioration of outer surfaces and quite low integrity and compactness during deformation. Therefore, it was concluded that billet produced by solid state recycling are not suitable for further metal forming processing.

In the next step, alternative method to make billets from Al-scrap, consisting of following phases, was employed:

- Heating of Al-scrap over the melting temperature
- Pouring of melted Al into the mould and imposing a pressure to the solidifying molten aluminium ("squeeze casting")
- Cooling in air to the temperature of 510 C
- Upsetting with flat dies
- Cooling to the room temperature

Billets prepared in described way were immediately subjected to the classical hot forging in the following steps:

- Heating to the temperature of app.500 C
- Hot forging in the pre-form die cavity (intermediate shape)
- Hot forging in the final die cavity (finale shape)
- Trimming

Figure 6.Squeeze casted billet after cooling to the room temperature

In Figure 6, a squeeze casted billet after cooling to the room temperature is given.

3. BENDING OF CROSS JOINT COMPONENT

Forged cross joints were subjected to the bending on the hydraulic press Sack-Kiessebach, Figure 7.Disposition of the die and workpiece (cross joint) within the working area of the press is shown in Figure8. From the lower side two arms of cross joint were supported by two cylinders. Bending force was exerted by upper flat die. Force and stroke measuring was done by Spider 8 device.

Figure 7.Sack-Kiesselbach press

Figure 8.Free bending of cross joint

Load – stroke diagram exhibits three different zones: elastic deformation, plastic deformation and cracking (fracturing) zone. Elastic zone ends at the load of 12,9kN (6,45kN pro arm, bending moment in the critical cross section area is app. 174 Nm)

From that load on plastic deformation without fracture develops, Figure 9.

Initial cracks occurs at the load of 89 kN (44,5kN pro arm, bending moment in the critical cross section area is app. 1200 Nm), Figure 10.

From that point on sharp load decrease takes place with the emerging of intensive fractures over the entire cross section.

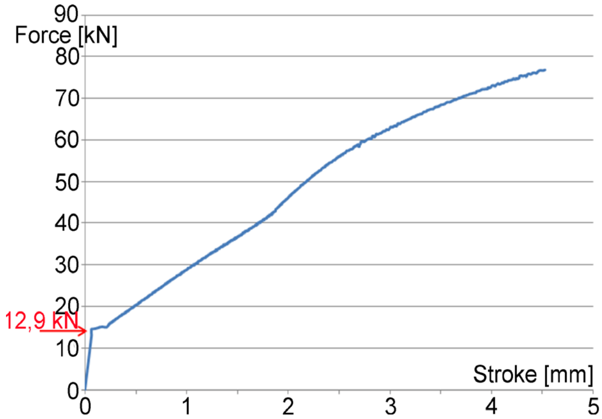

Figure 9. Load-stroke characteristic

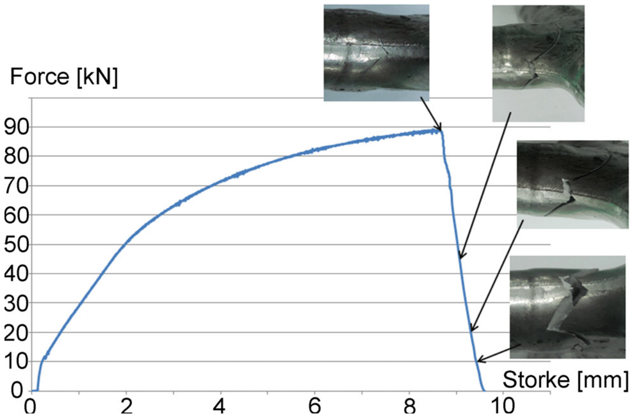

Figure 10. Cracking phase

4. DISCUSSION WITH THE CONCLUDED REMARKS

Cross joint component is a typical component in the field of mechanical engineering. It is made mainly from high quality steel but in some specific cases, for specific tasks, it can be manufactured from aluminium. Current paper investigates mechanical behaviour (in terms of bending loading) of the Al-cross joint component which is made out of Al-scrap. It has been determined that, in concrete case, three different zones in the loading of cross joint occur: elastic bending, plastic deformation and cracking (ductile fracture). Maximal load which can be safely transferred by cross joint is 6,6kN pro arm and maximal bending moment is 174 Nm.

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