

INVESTIGATION OF THE FORMABILITY OF EN AW 5754 ALUMINIUM ALLOY SHEETS WITH DIFFERENT THICKNESS

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1. INTRODUCTION

Nowadays, developments in the automotive industry are progressing in two different ways: one of the main trends is to increase the safety of a car (active and passive safety systems, driverless cars, etc.) while the other is to reduce the consumption (engine developments, weight reduction). The demand for low consumption is endless in the automotive industry, and it is not only important in case of oil crisis, or severity of emission rules. The European Union forced the car manufacturers to develop their cars to pass the emission rules, which development is not about the competition anymore. In 2015 there were some emission scandals which showed the problems with the present emission rules, especially with the test method to the publicity. The present test cycle is evadable and at the same time it is outdated. The previous developments (DPF, hybrid drive connected to a 5 or 6 litre petrol engine, ECO and other engine modes, downsizing) were created by the fact that the car has to pass the test only on the dynamometers. Most of the car manufacturers wanted to pass the emission rules with some engine modifications, because of their low price. To integrate a filter or modify the engine control unit does not need large investment opposite to redesign the whole car to reduce its weight.

Analysing the data of the new cars we can see that the weight is increasing, though car manufacturers are using high amount of HSS, UHSS, and aluminium alloys [1]. The weight of the Volkswagen Golf from the first series to the present model is shown in Figure 1.

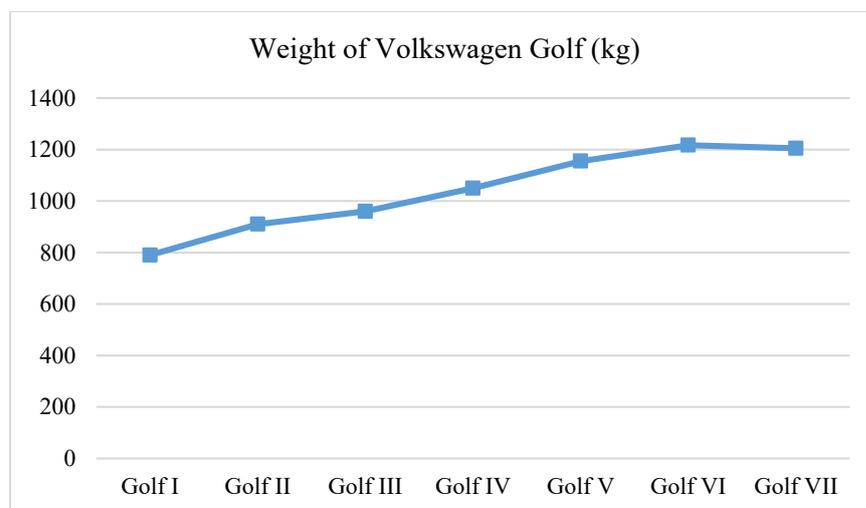


Figure 1.
Weight of Volkswagen Golf models [2]

The increase of the weight is closely continuous, but from these data we could make wrong conclusion. To answer the question that what is going on in the automotive industry, we must analyse the overall dimensions of cars. Obviously, the product of the length, height and width is a cubic, which includes the air too, but this could be a sufficient approximation of the car's volume.

Then, we can create a ratio with the weight and the volume (Figure 2.). It shows that how much volume belongs to a unit weight during the evolution of the model. What does it mean for us? It's a fact that the car's weight are increasing but their relative weight is decreasing. Nowadays, the automotive industry can produce larger car from unit weight than before. On the other side, unit size car has lower weight than in the past, however they include for example double clutch system, climatic compressor, turbocharger, on-board computers, full leather interior, etc.

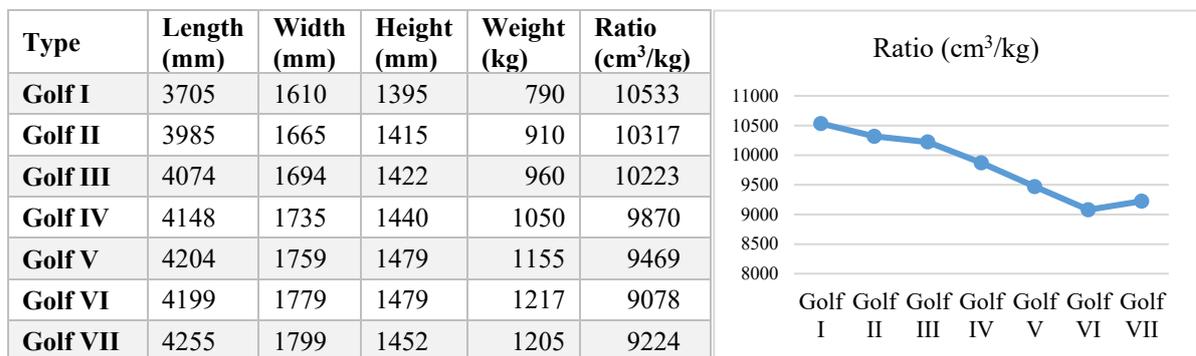


Figure 2.
Relative weight of Volkswagen Golf models [2]

The weight reduction would be an overall solution to reduce the consumption, but to achieve this, it is not enough to change the base material to a lighter one. In our researches, we are interested in automotive aluminium alloys which are used in the industry. The EN AW 5XXX, 6XXX and sometimes the 7XXX has common use in due to their lower formability. Sometimes, the part also needs geometry changes, since the designed geometry can be hardly manufactured from aluminium. In our researches we would like to analyse the possibilities to increase the formability of aluminium alloys. To achieve this, there are two possibilities. The first is to reduce the strain rate of the forming, and the second is to increase the forming temperature. In some cases, the product permits the change of the sheet thickness which are in connection with the formability. In this paper, the effect of the sheet thickness on formability will be investigated [1].

2. EXPERIMENTAL INVESTIGATIONS

During our tests, the specimens with different thickness were formed at room temperature to obtain the FLC curves (Figure 3.). The applied material was the EN AW 5754 H22. In our investigations the tool speed was constantly 1 mm/s. The EN AW 5754 (AlMg3) alloy is used in sports cars like the Jaguar XK, Lotus Evora and Chevrolet Corvette. This alloy has medium strength among the aluminium alloys.

Composition: 95,8% Al, 2,78% Mg, 0,29% Si, 0,36% Fe, 0,37% Mn. Temper: H22.
Mechanical properties: $R_{p0,2}=180$ MPa; $R_m=243$ MPa; $A_{50}=17\%$ (Alcoa).

The specimens had different geometries. These different pieces are connected to the FLC's special strain paths. The investigated sheet thicknesses were 1.0, 1.2 and 2.0 mm.

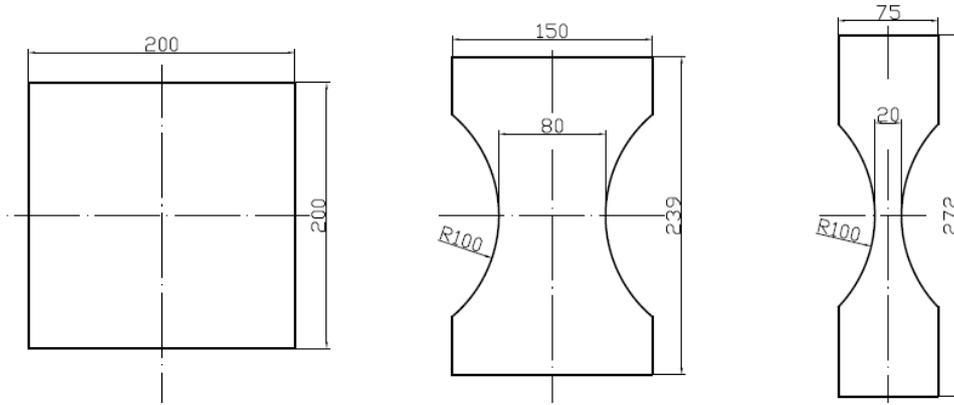


Figure 3.
Test specimens

In our tests, a computer controlled universal sheet formability testing machine was used (Figure 4.). This is able to perform various formability tests, e.g. Erichsen, Nakazima, Bulge, FLD, FLC tests. The equipment has electrohydraulic powertrain and it is suitable to test 3 mm maximum sheet thickness of steel, or 6 mm maximum thickness of aluminium. The forming tool geometry is a hemisphere with a diameter of 100 mm (Figure 5.). The maximum load is $F_{max}=600$ kN, the speed interval of the tool is between $v=0$ mm/s and $v=5$ mm/s. The equipment includes an optical strain measurement system, which records the distortion of the grid which is painted on the sheet before the tests. The system has 4 CCD cameras to obtain the 3D point cloud from the mesh. From the measurements, the Vialux-AutoGrid software determines the deformation and strain distribution along the curved surface. With these data, the FLC and FLD can be determined [3].

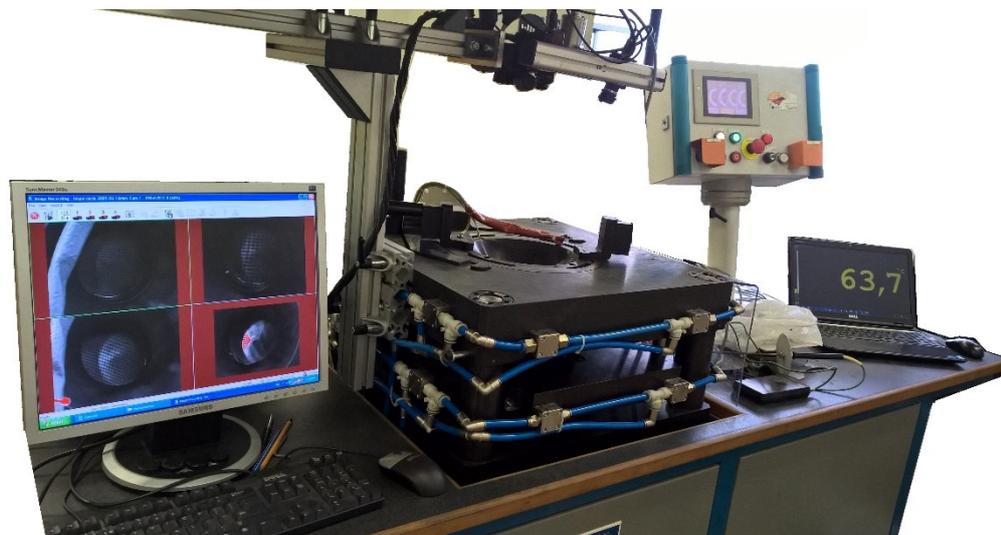


Figure 4.
Universal sheet formability tester

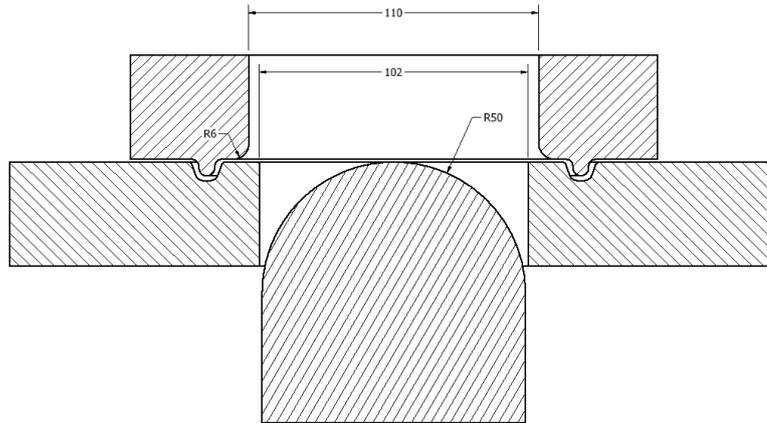


Figure 5.
Geometry of the forming tool

3. RESULTS

During the experiments, we measured the tool displacement and the forming force. With the mesh and the optical system we determined the maximum elongation before the failure of the sheets. We obtained the FLC curves of the different sheet thicknesses (Figure 6.). The formability of the EN AW 5754 continuously increased when we increased the thickness. The sheet with 2.0 mm thickness was the best and the sheet with thickness of 1.0 mm was the worst regarding formability. The sheet with 1.2 mm thickness was in the middle between them. After these investigations we can declare that the sheet thickness may significantly affect the formability, and if we increase the thickness of a sheet, the formability will increase with it. The reason is probably the difference of the material amount. More amount of material has more slipping planes which results in higher formability. Furthermore, the more amount of material has more capacity of formability that decreases during the forming because of the strain hardening effect.

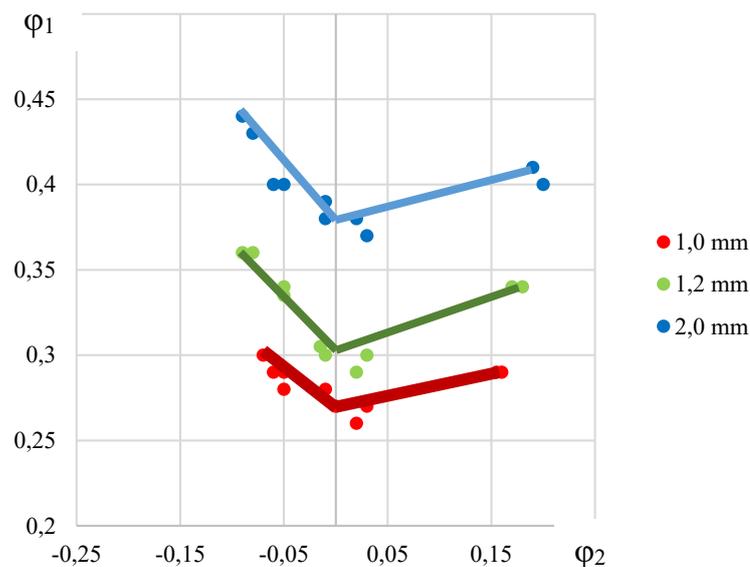


Figure 6.

FLC curves for different sheet thicknesses of the same materials grade

4. CONCLUSION

The investigations of the selected EN AW 5754 aluminium alloy were completed successfully: the formability increased when the sheet thickness was increased. When we talk about how to increase the formability, we usually talk about the so-called external state factors (temperature, stress state, strain rate): however, the sheet thickness is not changed in those cases. In our investigations we showed how the sheet thickness affects the formability. If an engineer has an issue in forming, there is another way to solve the problems with sheet failures. Sometimes it could be more economic to increase a bit the sheet thickness, than heating the sheet or reducing the strain rate.

5. REFERENCES

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