Review on Aluminum Alloy Sheets by Cryorolling and Warm Formability

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A B S T R A C T

As in the present study, Aluminium alloys are extensively used in automobile industry due to their high strength to weight ratio, tremendous corrosion resistance with easy machinability making aluminium an alternative material to low carbon steel. However, one of the major drawback of aluminum alloy sheets is their low-grade strength and formability at room temperature when compared to low carbon deep drawing grade steels. presently, various types of methods are included in the examins of application of warm forming of aluminum alloys or different materials for various applications of manufacturing automotive panels. Cryorolling is a severe plastic deformation technique which is used to obtain ultra-fine grain structure in aluminium alloys along with high strength. on the other hand, it results in poor ductility and formability. Formability can be improved by warm forming, in which sheets metals are formed into desired shape at elevated temperatures but below the recrystallization temperature it combine the advantages of both cold working and hot working.Warm forming not only improved the deep-drawing formability of aluminum alloys but also their springback in hat-shaped bending with the shape improved further and was comparable to that of steel. even though Molybdenum disulfide have been used in warm forming so far. Formability of the cryorolled sheets has been improved by forming in the warm working temperature range. Limit strain and height have been found to be higher than in the case of conventional processing route (cold rolled, annealed and formed at room temperature)which makes the process accomplished of producing sheet metal parts of aluminium alloys with high strength and better formability.

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Introduction

Aluminium alloy are alloys in which aluminiuming (Al) is the predominant metal. The typical alloying element are copper, magnesium, manganese, tin and zinc. About 85% of aluminium is used for wrought products, For example rolled plates, foils and extrusions. In past time, automotive panels is made from aluminum alloys in place of steel. In response to the need to reduce the weight of car bodies for better perfomance and efficiency, the aluminum alloys has been used mostly. The properties which is required mainly of materials for automotive panels are formability and strength.When producing an aluminium product the grade selection must be made with the consideration given to not only the durability of the alloy when in service, but also if the product can be readily fabricated from the material. To improve the formability of aluminum alloys and to expand their application, several new forming methods that may be used in place of the old cold forming process have been studied. One of them is hot blow forming, which was developed to achieve higher ductility in aluminum alloys than that conventional cold forming does not have. Another forming method that utilizes heat is the warm forming method. Instead of heating the aluminum alloy as in the previous method, this method uses a previously heated tool to deep draw the material. Unlike hot blow forming, warm forming does not impart high ductility (stretch formability) to the material. However, for a general-purpose aluminum alloy, warm forming offers better deep drawability than cold forming[1]. In addition, hot blow forming offers good stretch formability for aluminum alloys whose Mn and Cr contents are appropriately adjusted. Another forming method that utilizes heat is the warm forming method. Instead of heating the aluminum alloy as in the previous method, this method uses a previously heated tool to deep-draw the material. Unlike hot blow forming,warm forming does not impart high ductility (stretch formability) to the material. However, for a general-purpose aluminum alloy, warm forming offers better deep drawability than cold forming[2-5] .Warm Forming is not yet been used in automotive parts production. However, form when it can be carried out by using a standard cold press, the investment to implement is not very large. It is possible, therefore, that this specific forming method will be ready to put into practical use to manufacture automotive parts in the future. The main characteristics of warm forming technology applicable to aluminum alloy sheets and discusses the major problems or issues involved in putting this technology into practical use. The warm forming process is outlined and the enhancement of shape fixability and deep drawability attainable by warm forming is explained. Regarding the problems associated with the warm forming technology, this report lights on three issues that are rising: a lubricant created specifically for warm forming, clarifying the influence of the forming speed, and developing technology for simulating the warm forming process.But in the other hand the other technique introduced in industry for improving the strength and hardness of the materilas i.e Cryo-rolling, cryorolling is a potential technique to improve a strength and hardness of the material.it is a very effective and reliable process to get desired mechanical properties. By using cryorolling we can achieve a ultra-fine grain structure which improves a strength and ductility compared to cold rolling process, handling of the material is easy in cryo-rolling compared to hot rolling precess, If subsequently we are doing a annealing process after cryo-rolling then we can get a desirable ductility and cryo-rolling require a less plastic deformation compared to sever plastic deformation process.From Sever plastic deformation process ,we can also achieve a ultra fine grain structure,but it require a large plastic deformation but this process also having disadvantage that, by doing Only cryo-rolling,we can not get a proper ductility.Subsequent annealing process is require,but it is a preferable for cryo-rolling process mostly we will use a Al & Cu material as it is a very soft and ductile material and it is not achieve easily a brittle structure at cryogenics temperature. Resources/items needed for Cryo-rolling Liquid nitrogen plant, Tensometer for tensile test., Hardness tester for hardness test, Hand gloves for safety purpose, Scanning electrons microscopy (SEM)or other microscope for analysis of micro structure.

Nomenclature

Al Aluminium
Cu Copper
SEM Scanning electrones microscopy
LDR Limiting Drawing Ratio

1.Method of Warm Forming and Cryorolling

Warm forming is a deep-drawing method which uses die and blank holder, which heated upto a certain temperature with the help of heater or other means, and a punch, which is kept at room temperature. The blank is not heated beforehand, it is clamped by the die and blank holder, and subjected to deep drawing. In a deep-drawing test of A5182 alloy with the help of cylindrical die, the limiting drawing ratio (LDR) at room temperature was about 2.1. And the rise in temperature of the die and blank holder, LDR increased continuously, upto 2.8 at 250℃[6]. while in the case of A5083 alloy, the LDR at room temperature is also about 2.1, but it rises almost 2.8 at 200℃[7]. Thus, the deep drawability of aluminum alloys improves when we use a heated die. The change in the temperature of the blank relative to the die/blank holder while the blank was clamped in between the die and the blank holder (punch was kept in contact with the blank). On the other hand, the temperature of the blank which is in contact with the punch was not constant: It rose with increase in die/blank holder temperature as result of the heat transfer from die and blank holder. Because of the heat removal due to punch, the rise in the blank temperature was not that high as that the flange temperature. Thus, the difference in temperature inside the blank widened with rise in die temperature. It seen that widening of the temperature difference caused the difference in the material properties of blank to increase, which in turn help to enhance the deep drawability of blank. In warm forming, the material strength of the flange and blank decreases as it was heated to a high temperature. As a result, the inflow resistance during deep drawing decreases. In either interpretation, the enhancement of the deep drawability attributed to reject the deformation resistance of flange and the difference in stress and punch shoulder or vertical wall. Cryorolling is a process which is generally carried out using a cryogenic temperature(- 190℃) using liquid nitrogen at a laboratory scale using 4-high rolling mill. In this process the samples are in first phase dipped in a liquid nitrogen for haf an hour and after after that 10-15min for the consequent passes.During in each pass, the thickness of the sheet reduced in each pass by 5-10% by the adjusting roll gap. It has been evidently established by different researchers that cyrorolling of aluminium (AA6061) sheets with reduction of thickness by 70-90% develops the ultrafine grain structure in the material.

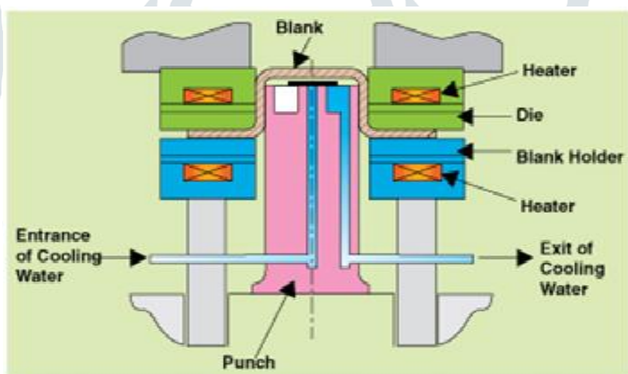


Fig.1- Schematic illustration of warm forming

2.Shape fixability

Shape fixability of a sheet metal refers to degree of maintaing formed shape close to the shape of a die during sheet metal forming process. In all the sheet metal forming processes the shape change is a phenomenon that cannot be avoided. Recently, inadequate shape fixability has become a problem with high strenght steel sheets that are being increasingly used in car bodies.for example, by adopting a variable uplifted bead whereby In the forming process the vertical wall tension is varied, it is possible even for a high-strength steel of 690 MPa class to secure better shape fixability than that of a high-strength steel of 390 MPa class[8]. The shape fixability of the blank in warm forming has also been studied. For a 590 MPa high-tensile steel sheet, At a temperature of 400℃ the tensile strength decreased, whereas the shape fixability measured in a hat-shaped bending test at the same temperature improved to the level of a 440 MPa steel sheet. In its warm forming temperature region (100℃ and above), the tensile strength of the aluminum alloy also decreased as compared with its tensile strength at room temperature.Therefore, it is expected that in warm forming of aluminum alloys, a similar improvement in shape fixability will be achieved. Hence, we carried out a warm hat-shaped bending test to study the improvement in shape fixability and the influence of the vertical wall tension due to the blank holding force (BHF).

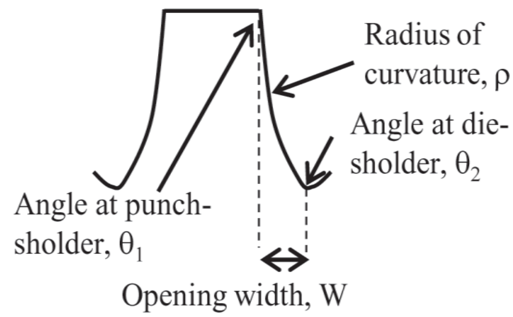


Fig. 2- Spring-back in hat-shaped bending

3.Methodology

3.1 Chemical composition

Automotive and aircraft industries uses Al-Mg alloys widely.The sheets of AA5083 alloy of 5mm thickness were selected for this study**.** In Table I the chemical composition of this alloys analyzed using spectroscopy and were given.

Table 1- CHEMICAL COMPOSITION OF AA5083 ALLOY

Composition	Value
Mg	4.365
Mn	0.624
Fe	0.122
Si	0.386
Cu	0.074
Cr	0.068
Zn	0.040
Al	Balance

3.2 Microstruture

Microstructural studies are conducted using Keller'sreagent by optical microscope. Fig. 1 (a) & (b) shows microstructure of cryorolled sheets with 70% thickness reduction and cold rolled annealed sheets respectively. The microstructure revealed for cryorolled sheets shows fragmentation of grains and ill-defined grain boundaries.Whereas the optical micrograph of sheets produced by cold rolling at annealed condition revealed coarse grains[9].

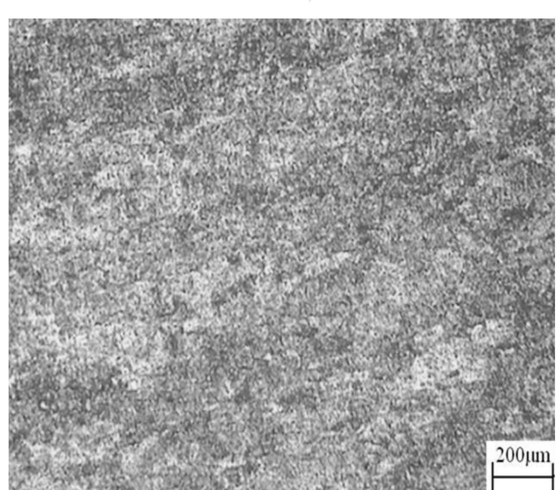
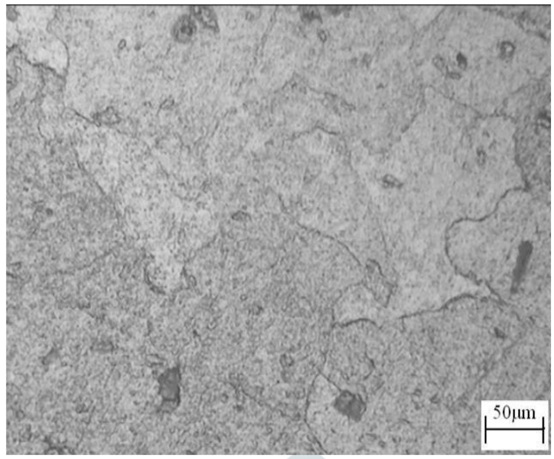


Fig. 3- (a) As cryorolled sheet with 70% thickness reduction



(b) coldrolled and annealed sheet with 80% thickness reduction.

3.3 Mechanical Properties

Cryorolled and conventional sheets were prepared as per ASTM-E8 standard for conducting tensile tests. Uniaxial tensile tests were carried out on INSTRON 5582 with cross head speed of 2.5mm/min. Engineering stress-strain curves were plotted using load-displacement data. Mechanical properties like yield strength (YS), ultimate tensile strength (UTS) and ductility (%elongation) were measured. Hardness is measured using Vickers hardness tester with test load and dwell time[10].

Fig.4- Experimental setup for cryorolling.

Fig.5- Experimental set up for warm forming.

4.CONCLUSIONS

Warm forming of cryorolled sheets without any post heat treatment technique has been found to improve both strength and formability of alloy sheets. In as-rolled condition, the cryorolled sheets shows poor formability.By combining the advantages of higher strength due to cryorolling and increase in formability by warm working when compared to conventional cold rolled and annealed sheets, forming at 250℃ temperature has been found to be suitable for Aluminium alloy . Cryorolling followed by warm forming can be used as a potential method to obtain parts with high strength and enhanced formability. Aluminium alloy sheets offers the possibility for deep drawing of complex sheet products, which cannot be made at room temperature without applying pre-forming and post- forming heat treatment process. These results need to be supplemented with further investigations to permit their reliable implementation in production for automotive applications.

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