DEVELOPMENT OF HYDRO MECHANICAL FORMING TECHNOLOGY USING ALUMINUM DAMPING SHEET FOR DEEP DRAWING AUTOMOTIVE PART.

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ABSTRACT

Hydro mechanical forming method was studied on forming of deep drawing automotive part using aluminum damping sheet. Concretely speaking, effect of mechanical properties, lubricating conditions, hydro pressure patterns, tool dimensions and forming processes were investigated on formability for deep drawing automotive part, and the appropriate forming condition was made clear. Consequently deep drawing automotive part using aluminum damping sheet was formed without fracture.

Keywords: *hydro mechanical forming, hydro pressure pattern, aluminum damping sheet, deep drawing, automotive part*

1. INTRODUCTION

Applying aluminum sheet to automotive part is effective to decrease the weight of car body and lead to enhance the fuel efficiency. But formability of aluminum sheet is inferior to that of steel sheet for automotive parts. Then hydro mechanical forming method has become of major interest lately[1,2,3,4]. The hydro mechanical forming method is efficient forming method to increase the formability of aluminum sheet[5,6]. This forming method is also applied to the forming of steel sheet for difficult shape parts[7].

2. EXPERIMENTAL

2-1 Specimens

Mechanical properties of specimens are shown in table 1. 1100-O, 5000 series aluminum alloy and aluminum damping sheet were used. 1100-O has high elongation, and 5000 series aluminum alloy has high strength. Aluminum damping sheet is produced by sandwich structure method consisting of pure aluminum sheet and damping resin.

Table 1 Mechanical properties of specimens

No	Alloy	Thickness mm	σ_B N/mm²	$\sigma_{0.2}$ N/mm²	δ %
1	1100-O	2.0	88	40	42
2	5000 series alloy	2.0	290	144	35
3	1100-O	2.5	95	52	39
4	Aluminum damping sheet	2.0	102	41	38

2-2 Forming test conditions

Press specification and forming test conditions are shown in table 2 and 3. Product shape and forming processes are shown in figure 1. Forming tools used in this trial are applied to steel damping sheet (1st drawing:185mm, 2nd drawing:266mm).

Table 2 Press specification

Type	Oil hydraulic press (Double action)
Capacity	Inner: max.1000ton Outer:max. 400ton
Table size	max.3000 × 1700mm
Stroke	Inner:1650mm Outer:1300mm
Speed	Inner: max.40mm/sec Outer:max.40mm/sec
Hydro pressure	max.240kg/cm^2

Table 3 Forming test conditions

Tools	For steel damping sheet → modifying for Al damping sheet 1st drawing (185mm) → 2nd drawing (266mm)
Processes	① 1-step (→ 266mm) ② 2-steps (→ 185mm → 266mm) ③ 3-steps (→ 145mm → 185mm → 266mm)
Blank shape	Square shape (810W × 1410L) Pre-drawing → Flange cutting (Refer to Fig.6)
Lubricating conditions	① Conventional oil (80cSt/40 ℃) ② High viscosity oil (430cSt/40 ℃) ③ Vinyl sheet + High viscosity oil
BHF	① 30 ~ 60ton (Constant pattern)
Hydro pressure patterns	① 10 → 40 ~ 80kg/cm^2 (35 ~ 75mmUP) (Increasing pattern)

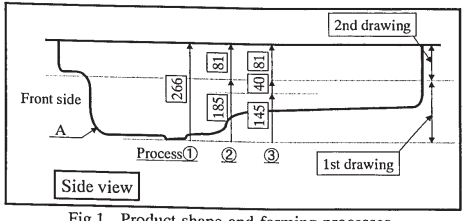

Fig.1 Product shape and forming processes.

3. RESULT AND DISCUSSION

3-1 Material properties and formability

Effect of material properties on formability is shown in Fig.2. The formability of 5000 series aluminum alloy is inferior to those of 1100-O and aluminum damping sheet in the 1st drawing tool test, because large wrinkles occur at the flange part and the step shape in the forming of 5000 series aluminum alloy. And aluminum damping sheet shows the same formability as 1100-O.

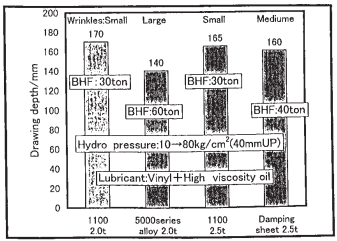

Fig.2 Effect of material properties on formability.

3-2 Lubricating conditions and formability

Effect of lubricating conditions on formability is shown in Fig.3. The 1st drawing height of aluminum damping sheet is max.160mm using the vinyl sheet and high viscosity oil. The height is not enough to get final product shape by conventional method. (2-step drawing).

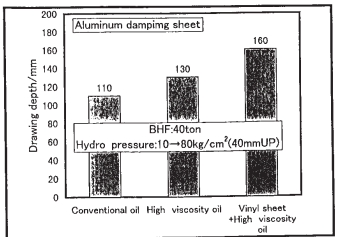

Fig.3 Effect of lubricating conditions on formability

3-3 Hydro pressure patterns and formability

Effect of hydro pressure patterns on formability is shown in Fig.4. Hydro pressure patterns of ③,④ and ⑤ give good formability in case of 160mm in drawing depth. The appropriate hydro pressure pattern area is recognized [5].

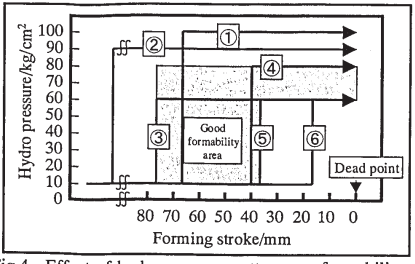

Fig.4 Effect of hydro pressure patterns on formability.

3-4 Tool shapes and formability.

Forming tools were modified because the wrinkles and fractures were occurred in the tool shape for steel damping sheet. Modified tool dimensions are shown in Fig.5. The wrinkles and fractures were prevented by these modifications in each drawing steps.

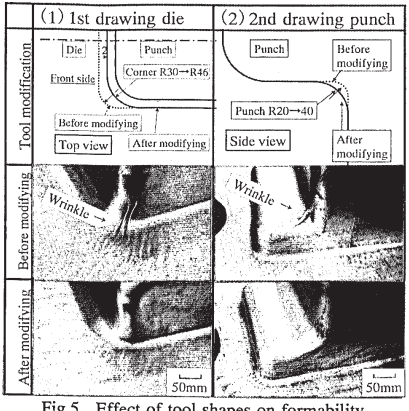

Fig.5 Effect of tool shapes on formability.

3-5 Forming processes and formability.

Effect of forming processes on formability is shown in table 4. The fracture was prevented until 266mm drawing depth by cutting side flange after pre-drawing (→ 145mm) and applying the 3-steps process. The appropriate forming technology of deep drawing automotive part was established by investigating forming conditions (mechanical properties, lubricating conditions, hydro pressure patterns, tool shapes and forming processes). The cutting position

of side flange is shown in fig.6 and the forming samples of automotive part in each processes are shown in fig.7.

Table 4 Effect of forming processes on formability.

Processes	Results of forming trials
① 1-step	Wrinkles occurred in the part of step shape → Fracture occurred in the part of "A".
② 2-steps	Fracture occurred in the 1st forming step. (→ 185mm) (Forming condition for steel damping sheet)
③ 3-steps	No fracture in the each processes [(1) Pre-drawing (2) 1st drawing (3) 2nd drawing]. After pre-drawing (→ 145mm), flange cutting was conducted. (Refer to Fig.6)

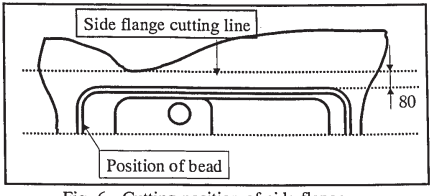

Fig. 6 Cutting position of side flange .

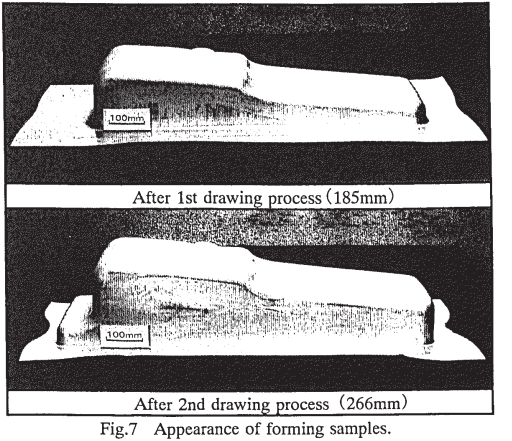

Fig.7 Appearance of forming samples.

4. CONCLUSION

(1) The formability of 1100-O and aluminum dampimg sheet were superior to that of 5000 series aluminum alloy in this automotive part forming. Low deformation stress prevented the occurring wrinkles and fractures in the forming of 1100-O and aluminum damping sheet. And aluminum damping sheet had the same formability as 1100-O.

(2) Hydro forming technology of deep drawing automotive part (266mm in depth) using aluminum dampimg sheet was established by optimizing forming conditions.

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