別紙４（課程博士）

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Abstract
論文内容の要旨　（博士）

Title of Thesis 博士学位論文名	Successive Forging of Quenchable Steel, Aluminium and Stainless Steel Sheets Having Thickness Distribution and Inclined Cross-Section (肉厚分布と傾斜断面を持つ焼入れ鋼,アルミニウム，ステンレス鋼板の逐次鍛造)

(Approx. 800 words)

(要旨　1,200 字程度)

The use of tailored blanks having a thickness distribution increases in automobile body parts, because the tailored blanks offer substantial weight reduction, crash resistance and protection. The tailored blanks allow the use of an optimum thickness distribution in parts, and thus material utilization is optimized and weight is reduced. Although the tailored blanks are generally produced by welding, joining of multiple sheets by welding is costly and the sharp change in thickness induces stress concentration. Although stress concentration is reduced by gradual change of the thickness in the transient region for tailor-rolled blanks, these blanks are expensive.

A successive forging process of tailored blanks having a thickness distribution supplied for hot stamping was developed to overcome these problems. In this study, a blank having a uniform thickness was successively compressed with upper and lower punches. Since local deformation was repeated in successive forging, the forging load is comparatively small, and tailored blanks without joining are produced as well as to the tailor rolling process. The thickness was controlled only by the feed under a fixed stroke of the punch. As the feed decreases, the forging load decreases due to small contact area, and thus, the reduction in thickness of the blank becomes large for small elastic deformation of the press and tools.

During compression, the press ram is inclined by deflection of the press frame, and then tool marks were observed on the surface of the tailored blank. Finite element simulation was performed to obtain the shape of the punch to prevent the tool marks on the surface of the tailored blank. A die for correcting the upper punch inclination was proposed to reduce the tool marks. By inserting concave and convex plates into a C-frame of a press, the inclination of the upper punch was reduced and the misalignment between the upper and lower punches was decreased. Uneven surface of the tailor blank was minimized by using corner radius punch and also concave and convex plates.

Although aluminium alloys are attractive to reduce the weight of a car, car parts produced from steel are effective due to high strength and lower cost. High strength steel sheets however, are difficult to form. Hot stamping reduces the flow stress, forming load and produces parts strengthened by martensitic transformation. A tailored blank having two thicknesses was successively forged, and then hot-stamped into a roof rail miniature. The large curvature of the

tailor-forged blank by successive forging was eliminated after the hot stamping process. The strength of the hot-stamped roof rail miniature increase significantly. A reduction of weight by 20% for the tailor-forged roof rail miniature was measured.

For tailor-rolled blanks, the thickness of the sheet is reduced and this portion is work-hardened. However, the strength required for the thin portion is small, whereas the strength is increased by work-hardening. Sheet forging having local thickening by beading and compression was developed to produce sheet having a strength distribution. A uniform thickness sheet was beaded and the sheet was then compressed to form thickening. As the beading die height increases, the degree of thickening increases. The effect of beading die shape was analysed to prevent folding for a large beading height. The produced tailored blank has high and low strengths for the thick and thin portions, respectively.

Sheet forging is widely used in metal forming industries to form sheets having a thin cross-section into various shapes and thicknesses. In this process, the forming load becomes high due to the large frictional restraint. For long parts, the forming load increases for large deforming area. Long sheets having a uniform cross-section are generally produced by rolling, whereas it is not easy to change tools and formed cross-sectional shapes are limited due to curvature and wrinkling. Long sheets are also produced by cutting, however this process results in a large amount of scrap. The use of long parts having an inclined cross-section is important in the printing industry to ensure smooth and high quality printing. These blades are used for cleaning and regulating toners in printers. In order to produce a long sheet having an inclined cross-section, a successive forging process was employed. Since only a small portion of the sheet was deformed at a time, a small load is required. The used of a taper bottom inclined punch minimized the formation of waving and depression of the forged sheet. A side guide was introduced to reduce the curvature of the sheet. However for a very small feeding, burr was formed on the side of the sheet due to a large curvature. The introduction of a grooved die eliminates the curvature of the forged sheet having an inclined cross-section.