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Improvement of surface quality of aluminum product in cold extrusion by using reuse tool with groove array formed on tool surface

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Abstract

Surface smoothness of aluminum product was investigated with regard to viscosity range of naphthenic mineral oil N1 (VG10), N2 (VG22) and N3 (VG460) by carrying out cold extrusion tests using the plane strain extrusion apparatus constructed with the taper die, plane plate tool and container. The plane plate tools without or with the fine groove arrays scraped on the tool surface were prepared for the present investigation. Fine smooth surface of the products could not be obtained in case of N1 and N3 in extrusion tests. While, surface roughness of the product was fine in 0.04μmRa in case of N2 and tool surface roughness 0.05μmRa. Cross sectional profile of the groove of groove array was self-reformed at the first time extrusion process using different lubricants. Then, extrusion tests for achieving smoother surface of the product were carried out by using reuse tool with the selected groove array and lubricants, N1 and N3. Surface smoothness of the product could be improved by using the reuse tool with the self-reformed groove array having selected cross sectional groove profile and at lubrication condition using N1 or N3. It was found that combination of the cross sectional profile of the groove of groove array and viscosity of lubricant could control the thickness of oil film and contribute to achieve smoother surface of the extruded products.

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Keywords: Aluminum; Cold extrusion; Lubrication; Surface roughness; Product surface smoothing process

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1. Introduction

Smoothness of surface of the aluminum products improves the appearance of the products, functional properties and strength, but requires multiple machining processes and additional forming cost. The metal forming processes hold advantages such as short process time and net shape forming with little waste material in mass production. Then, mirror-like surface products produced by metal forming process should be beneficial for saving of energy and resources. Achievement of smooth surface of the product in metal forming requires to select both the appropriate surface condition [1] and material of the forming tool and the optimum forming lubricant. Furthermore, thin oil film should be exists between the contact surfaces of workpiece and tool to prevent adhesion and seizure between tool and workpiece. Therefore, low viscosity lubricants are often used and oil film thickness is controlled in the prevalent cold forming processes.

The pits are formed on the workpiece surface as utility of desirable surface texture for lubrication in metal forming. Those pits are deformed in the forming process and supply lubricant trapped in the pits to contact surface area of the workpiece [2]. In ironing process, an example of mirror surface product by using trapped oil in the pocket of workpiece surface was reported [3]. Some examples of use of the surface texture of tool surface in metal forming process could be found in the reports on tool life extension in the backward extrusion [4] and on control of friction and wear in rolling [5].

We have proposed the surface finishing of aluminum in a cold extrusion process by using the tool with groove array on its surface [6-9]. That investigation was aimed to find effective use of the tool surface texture for achieving the smoother surface products in metal forming. The groove array scraped on the tool surface are considered to have functions of oil holding and feeding by hydrodynamic effect depending on configuration of the groove array, thickness adjustment of thin oil film on the tool surface and the type of lubricant [8, 9].

In the present work, surface smoothness of aluminum product was investigated with regard to viscosity range of naphthenic mineral oil by carrying out cold extrusion tests using plane plate tool with or without groove array scraped on the tool surface.

2. Experiments

2.1. Experimental apparatus

Figure 1 (a) shows the plane strain extrusion apparatus. The apparatus consists of the plane plate tool, taper die with 45 degrees die half angle, container walls and billet. Extrusion ratio was two. For experiments, plane plate tools with or without groove array on its surface were used. Figure 1 (b) shows location and dimension of groove array scraped on the surface of plane plate tool by using the NC milling machine.

The tools, dies and container were made of the tool alloy steel SKD11 (JIS) corresponding to D2 (AISI) and BD2 (BS). Those were hardened and tempered by heat treatment. Hardness of the dies was 760HV and surface roughness of the test surface of plane plate tool is finished in 0.05μmRa.

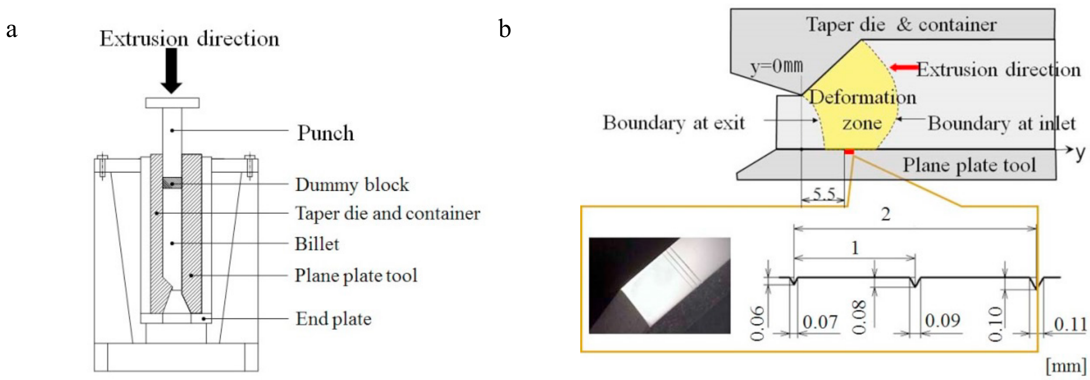

Fig. 1. Experimental apparatus; (a) plane strain extrusion apparatus and workpiece (billet); (b) location and dimension of groove array.