Investigation of the hardening behavior of sheet metals at intermediate strain rates considering the pre-strain

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This paper is concerned with the hardening behavior of sheet metals at intermediate strain rates ranging from 0.001 s^{-1} to 100 s^{-1} with respect to the pre-strain in order to propose a new flow stress model for a pre-strained material. Most members of an auto-body are made of mild steels or advanced high strength steels(AHSS) fabricated by the sheet metal forming process. During the process, the flow stress of the sheet metals are changed with the plastic strain as well as residual stress and consequently the tensile properties of the sheet metals are also changed. A new design of a device to impose the pre-strain was developed to investigate the hardening behavior of the sheet metals considering the pre-strain and the specimens were obtained from the sheet metals with SPCC(CQ) and DP590(DP) for outer and inner members of an auto-body. The specimens were prepared with the pre-strain of 5 % and 10 % using tensile testing machines and the pre-straining device. The Instron 5583 and a high speed material testing machine (HSMTM) were utilized at the quasi-static state of 0.001 s^{-1} and the intermediate strain rates ranging from 1 s^{-1} to 100 s^{-1} respectively. The experimental results demonstrate that the stress–strain curves at the strain rate of 0.001 s^{-1} for SPCC and DP590 pre-strained by 5 % and 10 % traced the original stress–strain curve without the pre-strain, following a classical conjecture that the flow stress of a material follows the unique stress–strain curve. The results also reveal that the hardening behavior of SPCC and DP590 were noticeably influenced by the pre-strain with stress overshooting when the strain rate is over 1 s^{-1} and the flow stress as well as the ultimate tensile strength increased due to the pre-strains consequently. For an accurate crash analysis of an auto-body, the correct material properties should be utilized for the numerical simulation with the stress–strain relation depending on the strain rate and the amount of pre-strain.

Keywords: *pre-strain effect, stress–strain curve, intermediate strain rate, sheet metal*