Effect of Small Corner Radius in Cold Punching of 22MnB5 Die-Quenched Boron Steel Sheets

Hasnulhadi Jaafar[1*], Liyana Tajul[1], Mohd Zamzuri[1], Zailani Zainal Abidin[1], Muhamad Nasir Murad[1], Zamzuri Hamedon[2]

[1] Universiti Malaysia Perlis, Arau, 02600, Perlis
[2] Universiti Malaysia Pahang, Pekan, 26600 Pahang
[*]hasnulhadi@unimap.edu.my

Abstract: The effect of small corner radius in punching process of ultra-high strength category of steel i.e. 22MnB5 die-quenched boron steel was investigated. Although the die-quenched steel sheet can reach superior strength of above 1500 MPa, the ductility of the steel sheet is low, making punching process totally challenging. Punching of hole at 22MnB5 boron steel commonly carried out in hot condition prior to die-quenching and usually needed for complex tools for preheating, punching, transferring, and cooling the part. Inaccurate of hole dimension after quenching is inevitable due to the change of grain structure during cooling. In this study, a pre-hardened 22MnB5 boron steel sheet is punched under a small clearance in a normal cold condition. The small corner radius disperses the stress concentration at the punch edge and thus increases the material flow during initial stage of the punch penetration. The action of small clearance between punch and die reduce the tensile stress and therefore, the initiation of crack is delayed. The quality of the sheared edge surface was improved with the high percentage of area cover with the burnished surface.

1. Introduction

Application of the light in weight but high in strength materials for the body-in-white (BIW) parts become popular in this new era of car manufacturing process [1]. In car manufacturing process, to make the car to be a successful product, apart from optimizing shop floor arrangement and layout, assuring the high quality of the car part and minimizing defect is a must [2-3]. For the case of the BIW parts, high strength steel sheets, titanium and high grade aluminum alloys are among the most common selected metals used to make the car chassis for its superiority in strength which give higher safety standard and low in density to weight ratio which improve the fuel consumption [4]. Die-quenched steel is one level above in high strength low weight metal category as the strength of the quenched part can reach above 1500 MPa, which are far superior to the rest. As the A, B, and C-pillars of the BIW of a car are the most critical parts when subjected to the strength requirement, making the parts form the die-quenched steel will give a huge advantage in the car safety prospect [5].

The die-quenched steel parts are usually formed in hot condition. The steel blank is moved into a dedicated furnace station at the production line and heated up to 900 °C into the austenization phase prior to stamping process. As the flow stress decrease and ductility increase, stamping the heated blank into pillar shape becomes easy [6]. When stamping at elevated temperature, large reduction of the forming load and springback can be achieved as the formability is greatly improved. By holding at the bottom dead center of the die during stamping, the steel sheet permanently turned into martensite part [7].

Part joining and body attachment are the main reason needed for holes punching at the automobile panels. However, for panel or body part made of die-quenched steel, it is not easy to punch or making hole. Because of high strength and hardness, the most common method used for cutting and making holes out of the stamped die-quenched parts is by using laser. In spite of high reliability, cutting or making hole using laser is an expensive approach for its high setup cost [8]. Another approach is the conventional punching process for making hole using mechanical servo press. However, the small ductility of the die-quenched part make the conventional punching process using flat punch to reach another level of challenge as the fracture surface are commonly large and thus create higher possibility for delayed fracture [9]. The large punching load increase the tool wear rate and thus shorten the tool life [10-11]. The use of coating and lubricant minimize the wear of the punch and improve tool life [12-13].

In this study, the effect of small corner radius in punching of 22MnB5 boron steel sheets having high in strength but low in ductility was investigated. A small clearance was set in this punching process.

2. Experimental Procedure

The punching die set used for punching hole at 22MnB5 die-quenched boron steel sheets is given in Fig. 1. The punch used is 10 mm in diameter; having round edge corner shape and side relief. The die was tightly held by the die holder and the inner dimension of the die hole is 10.20 mm. During punching process, manual feeding of the steel sheet is done for every hole punched. The length, width, and thickness of the workpiece are 60 x 40 x 1.2 mm, respectively. Three different round edge punch were used for the experiment with corner radius of 0.15, 0.3, and 0.5 mm, respectively. The side relief is set to 0.1 mm of the based 10 mm of punch diameter. Table 1 shows the mechanical properties of the die-quenched steel sheet. The tensile strength of the workpiece after pre-hardened was measured at 1504 MPa under tensile test and the measured Vickers