別紙４（課程博士）

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Department 機械工学専攻	Student ID Number 学籍番号	第 139107 号
Applicant's name 氏名	Muhammad Hasnulhadi Bin Mohammad Jaafar	

Supervisors 指導教員	Ken-ichiro Mori Yohei Abe

Abstract

論文内容の要旨　(博士)

Title of Thesis 博士学位論文名	Punching and Trimming of Die-Quenched Steel and Ultra-High Strength Steel Sheets (ダイクエンチ鋼板と超高張力鋼板のトリミングおよび穴抜き加工)

(Approx. 800 words)

(要旨　1,200 字程度)

In the introduction, an overview of reduction in weight of automobiles for a less CO2 emission is presented. The use of lightweight materials such as aluminium, magnesium and titanium alloys is attractive for the reduction. However the high cost of the alloys is disadvantageous, and thus the steel is preferable. Hot stamping processes of ultra-high strength steel sheets are attractive as a key technique for the reduction in weight of automobiles parts having a tensile strength of 1.5 GPa can be formed by die-quenching. However, finishing operations such as hole-making become difficult, and the application of laser cutting having high investment cost and low productivity is a bottleneck. The conventional punching process is desirable for mass production.

In Chapter 2, a cold small clearance punching process of die-quenched steel sheets by punch having a small round edge was developed to improve the quality of the sheared edge. The sharp edge of the punch leads to the concentration of stress at the punch edge, and thus initiates the early onset of cracks. Therefore the rough fracture surface on the sheared edge becomes large. For a small clearance and small round edge of the punch, the concentration of deformation around the edge of the punch was relieved, and thus the onset of a crack from the edge of the punch was prevented. The burnished surfaces became considerably large.

In Chapter 3, an automatic centring process using a moving die was developed to correct the eccentricity between the punch and die in the small clearance punching process.Although small clearance was effective for a high quality sheared edge in punching of die-quenched steel sheets, setting of tool becomes difficult due to the less space and complex structure of the die. For a small clearance the punch and die tend to be eccentric. By setting a gap between the moving die and holder, the die is shifted by imbalanced force, and the punch and die become concentric after several strikes.

In Chapter 4, since the small clearance punching is effective, a repeated small clearance punching process of die-quenched steel and ultra-high strength steel sheet were carried out. In the real industry application, car parts usually consist of multiple holes for joining, attaching, painting, etc. For repeated small clearance punching with fixed die, the punch was broken by an eccentricity between the punch and die after several strikes. The combination of small clearance and automatic centring using a moving die is effective for a high number of strikes in repeated punching of die-quenched steel and ultra-high strength

steel sheets. However the high strength of the sheet deteriorates the punch life. By lubricating the surface of the punch, galling is reduced and tool life is increased.

In chapter 5, an attempt to reduce the fall velocity of the scrap and noise level during trimming of ultra-high strength steel parts using an inclined punch was developed. Since the use of the ultra-high strength steel sheets for automobile body-in-white parts is increased, trimming is required to remove the scrap portions. In trimming of ultra-high strength steel sheets, the flying speed is large due to the high strength, and thus the scraps jump out from a disposal box. The trimming operation also becomes noisy due to high trimming load. The deformation and shearing behaviours of the sheet during trimming with the straight punch were investigated and the level of noise during trimming was measured. By the inclined punch, only a local zone of the sheet is in contact with the punch during trimming, and thus the trimming load and the flying speed of the scrap are reduced.

In chapter 6, an approach to prevent chipping and fracture on the trimmed edge of the ultra-high strength steel parts having curved shape was developed. Trimming of ultra-high strength steel parts having curved shapes with the straight punch has possibilities of defect such as chipping, edge fracture, and bent which deteriorates the surface quality and dimensional accuracy of the part. In trimming of an L-shape ultra-high strength steel sheet having curved shapes, the scrap at the curved zone is bent and results in chipping and fracture of the sheet edge. The L-shaped punch having an inclined angle was introduced to prevent chipping and fracture at the trimmed edge, and at the same time reduces trimming load and energy.

The conclusion emphasises the importance of small clearance punching by punch having small round edge to produce high quality of the sheared edge surface and prevent the delayed fracture. The application of automatic centring eases the small clearance punching process especially for repeated punching. By gradually trimming ultra-high strength steel sheets with the inclined punch, the flying speed of scraps and noise level are reduced. Moreover the problem of chipping and edge fracture was prevented.