The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering and Mathematics (EPSTEM), 2025

Volume 38, Pages 559-566

IConTES 2025: International Conference on Technology, Engineering and Science

Punch Geometry and Burr Height on Blanking Process for Garbage Container Wheel Parts

Ilyas Uygur
Duzce University

Halit Kocasungur
Kocaeli University

Sitki Akincioglu
Düzce University

Hasan Oktem
Kocaeli University

Abstract: Sheet metal punching process is a manufacturing method frequently used in many industries such as packaging, construction, aerospace, machinery, chemistry and electronics. Today, a large number of parts are produced from hair materials in almost all areas of industry. The fact that the parts produced are generally in the millions and that delivery times are limited increases the importance of molds day by day. During production, it is desirable that the wear rate of the mold be kept to a minimum, that it does not cause problems during operation, that it be suitable for mass production of parts, and that the dimensional tolerances of the produced parts remain within the specified limits. In this study, holes were obtained with punches with different geometric surfaces and punch performances were evaluated by comparing average burr heights. As a result of the study, burr height increased with increasing stroke. Plain punch showed the best performance, while the worst performance and burr height were obtained with channel punch. TiN coated channel punch was among these two punches. The performance difference between plain punch and channel punch was around 10%.

Keywords: Punch geometry, Burr height, Wear, Punching

Introduction

Today, punches are used in many industrial applications to create cuts, slits, gaps and holes in sheet metal parts. The punching (metal blanking) process is performed by applying very high cutting force and removing a certain part of the material with the help of male and female die parts. It is widely used especially in electronics, automotive, packaging, aviation and space industries due to its suitability for automation, high speed manufacturing and being quite economical. Many scientific studies have been conducted to reduce tool wear, obtain higher quality products and determine the optimum operating parameters in the punching process (Arslan et al., 2015, Uygur et al., 2015, Arslan, 2020). The fundamental principles of metal forming and the relationship of its mechanics to material properties should be well understood by manufacturing engineers. The main bulk forming processes are drawing, extrusion, rolling; and sheet forming processes. The punching process typically consists of four stages: Contact engaging (elastic deformation), Penetration (plastic deformation), Fracturing (crack initiation), and Full material separation (crack propagation). Typical stages of punching process are displayed in Figure 1.

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

The clearance, mechanical properties, contact friction conditions, sheet thickness, and punch speed play a critical role in the blanking process; significantly influencing die life, blanking force, surface quality, and measurement accuracy. The most important factor affecting product quality and blanking process in blanking operations of sheet metal materials is the clearance value between a punch and die (Cavusoglu & Gurun, 2016, Samuel, 1998). Tool design, including punch and die clearance, significantly affects the quality of the punched product and tool longevity. Reducing clearance often results in cleaner cuts but increases tool wear, while larger clearances can lead to burr formation. Tool wear, particularly in high-volume operations, has been addressed through the use of wear-resistant coatings such as TiN, Al_2O_3 and cryogenic treatments (Akincioglu et al., 2015, Akgun et al., 2023).

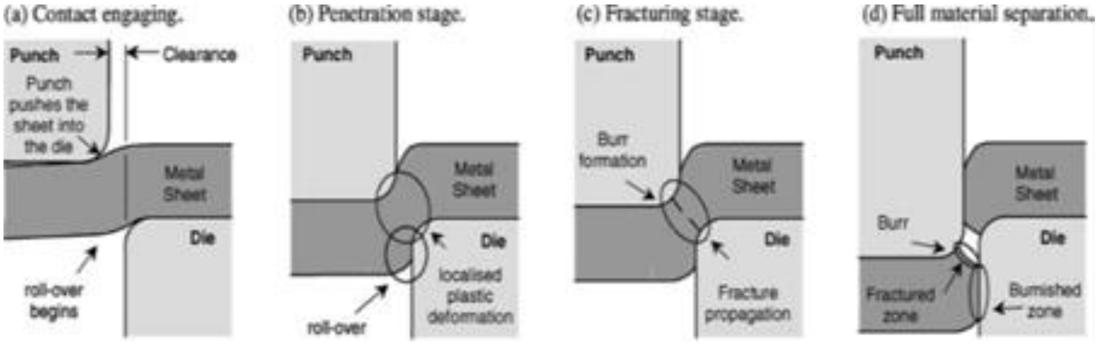


Figure 1. The stages of sheet metal blanking process (Miguel & Bressan, 2002)

Burr formation is a major quality concern in punching. Ghosh & Mallik, 1984, developed early models correlating burr height with tool wear and clearance. Recently Jin et al. 2020 published the extensive review paper for burr formation and its treatments. The study explores the mechanisms, impacts, and variations of burr formation in common machining processes such as drilling, milling, turning, blanking, and grinding, based on existing literature. Burr formation can be minimized through the appropriate selection of tool geometry, tool materials, coolant, machining parameters, work piece material, process planning, and tool path design. Innovations such as fine blanking aim to minimize burrs by using enhanced tooling and controlled blank holding forces. Also, the effect of punch materials, blanking material, and punching locations on the burr height formation are studied before in detail (Uygur et al., 2025, Uygur et al., 2025).

Method

In this study, ASTM A1011 sheets for garbage container wheel parts, produced through the cold rolling process with a low carbon content ranging between 0.15% and 0.2% and a thickness of 1 mm, were used as shown in Figure 2. Typical microstructure of the steel sheets is shown in Figure 3. The experiments were conducted using a 500-ton conventional hydraulic press with a punch gap of 10% (0.1 mm), a die cutting force of 610 kg, a stroke rate of 8 strokes per minute, a stroke length of 60 mm, and a punch speed of 900 mm/min (Fig. 4). The punch material is made of AISI D2 (see further details in Uygur et al., 2025, Uygur et al., 2025). Three different punches (plain and groove less punch, grooved punch, and TiN coated grooved punch) were used to produce the wheel parts. The measurement of the burr height geometry of the cut surface of the blanks, contour measuring machine with a sensitivity of 1×10-3 mm was used. Thus, no damage was done to the control arm parts for measurements.

Figure 2. Studied products of ASTM A1011 sheets for garbage container wheel parts

Figure 3. Typical Microstructure of the ASTM A1011 steel sheets (X50)

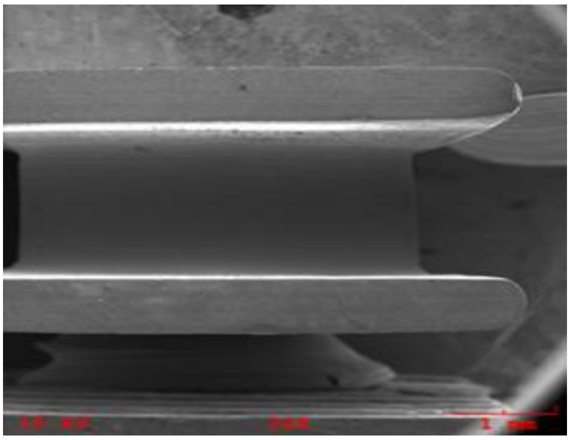
Figure 4. Punch press and sheet metal blanking process

For the measurements, after 5000 strokes manufactured parts were taken each of 5000 strokes intervals and measured by the means of maximum burr height. The burr height on each blanked samples had been measured by taking specified 5 points at the perimeters and then "the average burr height" has been measured in Fig. 5.

Figure 5. The measurement of the burr height

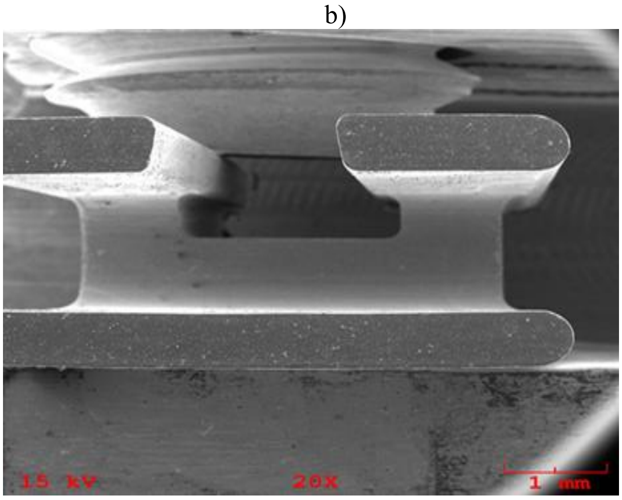
Results and Discussions

As seen in Figure 3, the microstructure of mild steel consists of ferrite grains of pure iron and lamellar cementite with in a pearlite phase. The grains are partially equiaxed and, depending on the pressure in the rolling direction, they are partially elongated and tend to fibrose. Three different type of punches and their worn edges can be seen in Figure 6. The least wear occurred in the flat punch, while partial wear was observed in the TiN coated and channeled punch and the most intense corner surface wear was observed in the channeled punch. The primary mechanisms responsible for tool wear and reduced tool life at the tool-chip and tool-part interfaces in machining and punching operations include scraping, adhesion, diffusion, abrasion, chemical reactions, and excessive plastic deformation. Most instances of tool wear involve one or more of these processes. In Fig. 6, it can be seen clearly that the wear is more severe on uncoated punch after 55.000 strokes. When the high magnification SEM images were examined, abrasive wear was observed in the channeled punch due to intense plastic deformation (Figure 7). Some edge rounding had also occurred plain and channeled punches. Excessive abrasive wear was also observed on the flank surface of the punch. The micro particles that broke off from both the product surface and the punch edges further disrupted the flank surface geometry and created intense burr height formation on the product surface (Figure 8). The D2 tool steel particle on the flank surface scratched the lateral surface and created a deep surface in the form of a channel (Figure 9). As can be seen in Fig 8, the flank surfaces of uncoated and channeled punches show adhesive and abrasive wear. The flank surface close to the cutting edge presents some wear tracks due to abrasion. A small amount of corner and flank wear was observed in the flat punch without a channel (Figure 10). As seen in Figure 11, relatively little surface and corner wear was observed in the TiN coated and channeled punches. It can further be seen that adhesive wear and plastic deformation of punch cause the cutting edges to be rounded. More severe adhesive wear was observed at flank surface and cutting edge of uncoated plain and channeled punches (Figure 6). Typical microstructure of AISI D3 tool steel is given in Figure 5. The microstructure of the tool steel contains martensitic structure with presence of carbides and ferrites. The equaled fine grain can be seen and distributed uniformly in same macrograph.



a)

b)



c)

Figure 6. a) Channeled plain punch, b) Channeled punch general appearance and flank wear c) Channeled TiN coated punch

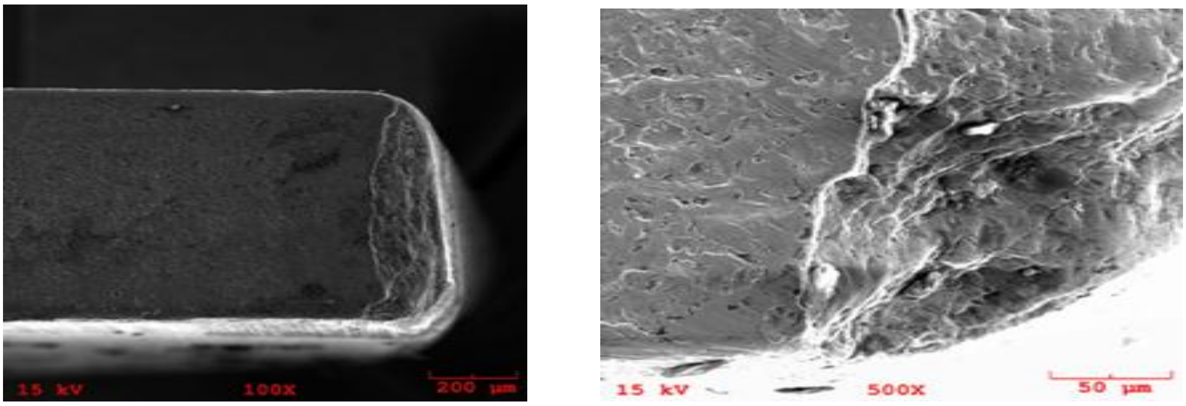


Figure 7. High magnification SEM Pictures of channeled punch surface edges

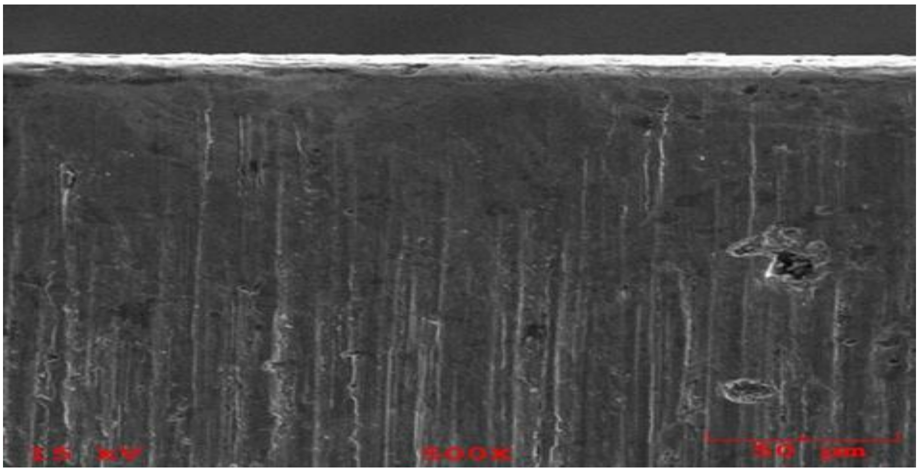


Figure 8. Flank (Lateral) surface wear on the channel punch

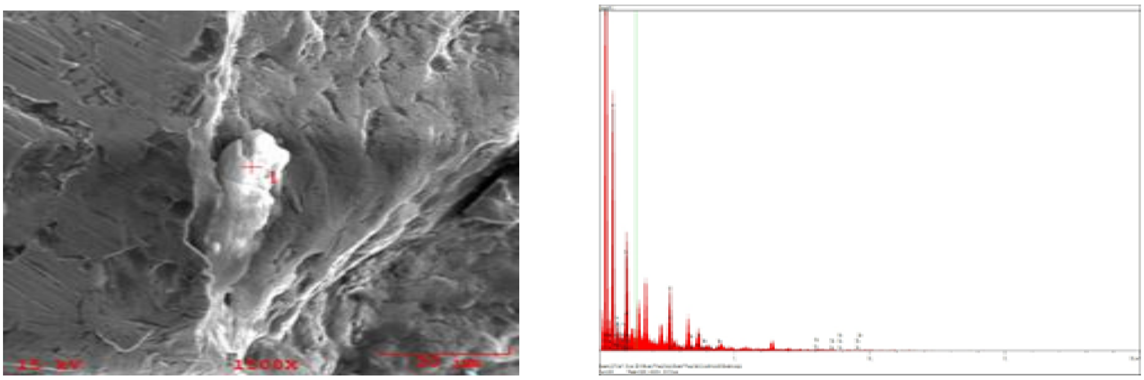


Figure 9. High magnification worn flank surface SEM pictures with EDX analysis of the D2 tool steel punch

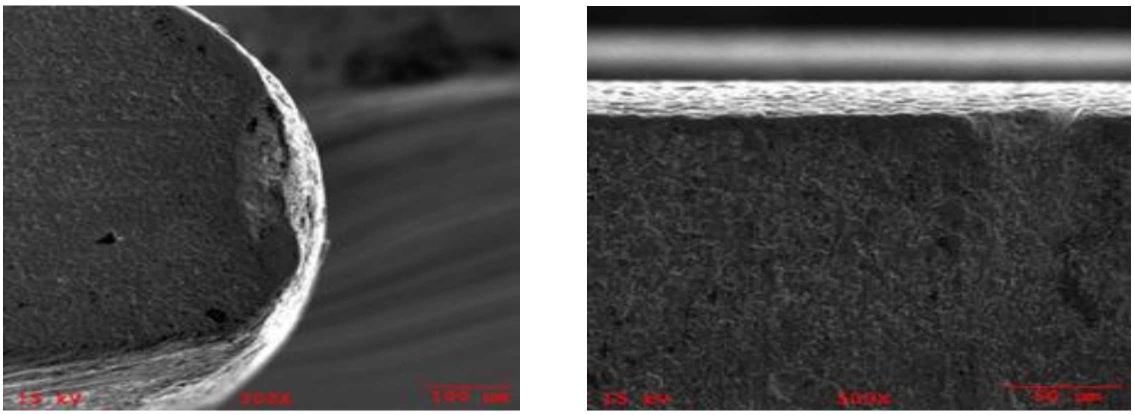
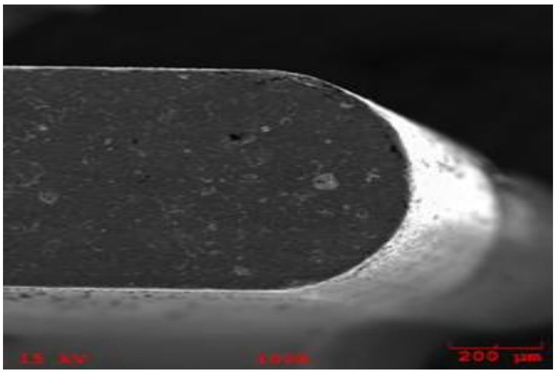


Figure 10. Edge surface wear and flank wear of plain punch



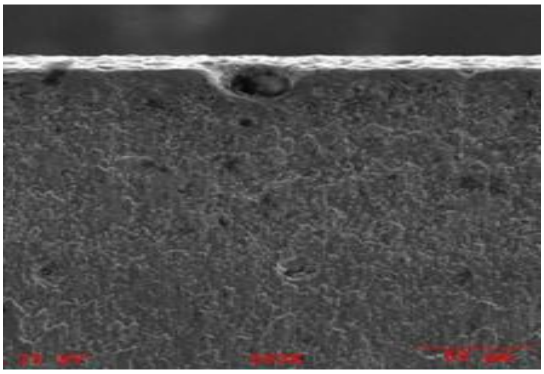


Figure 11. Edge surface wear and flank wear of TiN coated channeled D2 tool steel punch

Figure 12 shows the effect of geometry and coating on the average burr height formation during number of measured strokes. As seen in Figure 12, the least wear-related burr height was seen in the plain punch, while the highest average burr height was seen in the channeled punch. The punch surfaces were sharp and without wear, high-quality holes and scraps were obtained. Although the average burr height at 5000 strokes was 82 µm in the plain punch, the average burr height was measured as 191 µm with increasing punching numbers at 55,000 strokes. The burr height increased in all punch geometries with increasing strokes. The largest height difference was seen between the plain punch and the channeled punch at 55,000 strokes, and the channeled punch created a 10% worse product surface. TiN coated punch performance was between these two values. In previous studies, burr height increased with increasing stroke numbers, and again, burr heights showed differences depending on different geometric positions and punch materials (Arslan et al., 2015, Arslan, 2020, Uygur et al., 2025). In these studies, as stated, different types of sheet metals were cut in series using WC, HSS and X30Cr13 cutting punches, and wear as well as burr height were determined. Additionally, a very high number of punching operations were carried out in these studies. The results obtained from these studies are quite similar to the current paper (Goijaerts et al., 2010, Klaasena et al., 2006, Bressan et al., 2001).

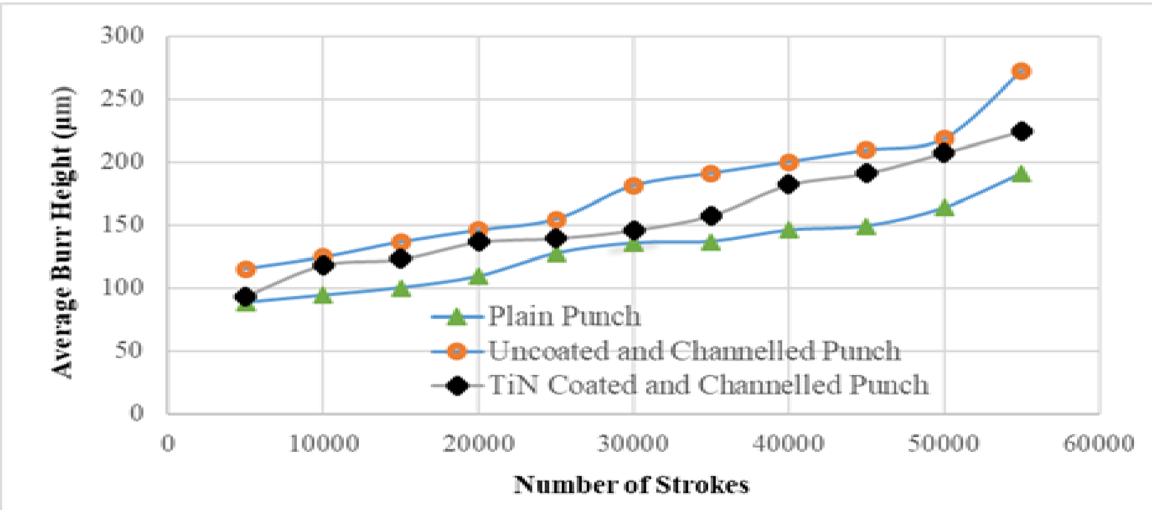


Figure 12. Average burr heights against number of tested strokes for various punches

Conclusions

In this study, sheet metal punching operations were carried out with punches having three different geometries made of AISI D2 tool steel and the following results were obtained.

1. The average burr height increased with increasing strokes. This increase is related to wear on the tool surface.
2. Holes obtained with a flat punch generally have better surface quality and the lowest burr height.
3. The channeled punch has the highest burr height and the worst scrap surface quality.
4. TiN coating improved the punching performance on average 5% of the channeled punch

5. Channeled punches undergo intense plastic deformation and abrasive and adhesive wear during punching operation and as a result more worn surfaces can be seen.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest

Funding

* Authors would like to thank GUNES PLASTIC Cooperation in Kocaeli for support of this study.

Acknowledgements and Notes

* This article was presented as an oral presentation at the International Conference on Technology, Engineering and Science (www.icontes.net) held in Antalya/Türkiye on November 12-15, 2025.

References

Akgun, M., Ozlu, B., & Kara, F. (2023). Effect of PVD-TiN and CVD-Al2O3 coatings on cutting force, surface roughness, cutting power, and temperature in hard turning of AISI H13 steel. *Journal of Materials Engineering and Performance, 32*(3), 1390–1401.

Akincioglu, S., Gokkaya, H., & Uygur, I. (2015). A review of cryogenic treatment on cutting tools. *The International Journal of Advanced Manufacturing Technology, 78*(9–12), 1609–1627.

Arslan, Y. (2020). The effects of cryogenic process on the AISI M2 punch materials and on the hole edge geometry of the DIN EN 10111-98 sheet metal control arm parts. *Advances in Materials Science and Engineering, 1*, Article 9236783.

Arslan, Y., Uygur, I., & Jazdzewska, J. (2015). The effect of cryogenic treatment on microstructure and mechanical response of AISI D3 tool steel punches. *Journal of Manufacturing Science and Engineering, 137*(3), 034501.

Bressan, J. D., Hesse, R., & Silva, E. M. (2001). Wear mechanisms of electrical steel sheets, hard metal and high speed steel pins coated with TiAlN and TiCN. *Meccanica, 36*(2), 683–690.

Cavusoglu, O., & Gurun, H. (2016). Investigation and fuzzy logic prediction of the effects of clearance on the banking process of CuZn30 sheet metal. *Kovove Materialy, 54*, 125–131.

Ghosh, A., & Mallik, A. K. (1984). *Manufacturing science*. East-West Press.

Goijaerts, A. M., Govaert, L. E., & Baaijens, F. P. T. (2010). Evaluation of ductile fracture models for different metals in blanking. *Journal of Materials Processing Technology, 110*(3), 312–323.

Jin, S. Y., Pramanik, A., Basak, A. K., Prakash, C., Shankar, S., & Debnath, S. (2020). Burr formation and its treatments-a review. *The International Journal of Advanced Manufacturing Technology, 107*(2), 2189–2210.

Klaasena, H., Kubarsepp, J., & Eigi, R. (2006). Peculiarities of hardmetals wear in blanking of sheet metals. *Tribology International, 39*(4), 303–309.

Miguel, V., & Bressan, J. D. (2002). A computational approach to blanking processes. *Journal of Materials Processing Technology, 125–126*, 206–212.

Samuel, M. (1998). FEM simulations and experimental analysis of parameters of influence in the blanking process. *Journal of Materials Processing Technology, 84*, 97–101.

Uygur, I., Gerengi, H., Arslan, Y., & Kurtay, M. (2015). The effects of cryogenic treatment on the corrosion of AISI D3 steel. *Materials Research, 18*(3), 569–574.

Uygur, I., Oktem, H., Karasungur, H., & Gerengi, H. (2025). Investigations of burr height for sheet metal process of medium duty casters in industrial kitchens. *International Conference on Basic Sciences and Technology (ICBAST)*, Budapest, Hungary.

Uygur, I., Oktem, H., & Soy, G. (2025). The effects of punch materials on the burr height for blanking operation. *2nd International Conference on Engineering, Natural Sciences, and Technological Developments (ICENSTED 2025)* (pp. 251–256).

Author(s) Information

Ilyas Uygur
Duzce University, Faculty of Engineering; Department of Mechanical Engineering,
Duzce/Türkiye

Halit Karasungur
Kocaeli University
Natural Science Institute/Polymer Science and Technology
Güneş Plastic Mold Coorperation, Kocaeli/Türkiye

Sıtkı Akincioglu
Duzce University, Faculty of Engineering.
Düzce University, Faculty of Art Design
Department of Industrial Design
Duzce/Türkiye

Hasan Oktem
Kocaeli University
Hereke Asım Kocabıyık Vocational
Natural Science Institute/Polymer Science and Technology,
Kocaeli/Türkiye
Contact e-mail: *hoktem@kocaeli.edu.tr*

To cite this article:

Uygur, I., Kocasungur, H., Akincioglu, S., & Oktem, H., (2025). Punch geometry and burr height on blanking process for garbage container wheel parts. *The Eurasia Proceedings of Science, Technology, Engineering and Mathematics (EPSTEM), 38*, 559-566.