Journal of Achievements in Materials and Manufacturing Engineering
VOLUME 29
ISSUE 2
August
2008

CNC extruder for varied section extrusion

H.J. Choi [a,*], S.J. Lim [a], H.T. Shin [b], S. Choi [c]
[a] Advanced Material Processing Team, Korea Institute of Industrial Technology (KITECH), Incheon, 406-840, Korea
[b] Technical Center, 397-2, Donghwa-ri, Bongdam-eup, Hwaseong, Kyongki-do, Korea
[c] Digital Production Processing and Forming Team, KITECH, Incheon, 406-840, Korea
* Corresponding author: E-mail address: hjoon@kitech.re.kr

Received 15.04.2008; published in revised form 01.08.2008

Manufacturing and processing

ABSTRACT

Purpose: The work presented in this paper might be used for basic data in the design of a lot extruded aluminum products using the variable section extrusion process.
Design/methodology/approach: The capacity of a CNC extruder was calculated and decided as analyzing the FEM results performed by commercial software DEFORM-2D. CNC extruder and die set for variable section extrusion was invented by field extrusion experts.
Findings: CNC extruder had a key role in variable extrusion process. Furthermore there was few die sets with mold feeding parts for aluminum extrusion. To be capable of extruding aluminum products with variable cross section are CNC extruder and the die set.
Research limitations/implications: For future research of developed CNC extruder, frame structures of the extruder would be analyzed and designed using FE analysis. In addition CNC extruder would be operated by the control program for variable section as a PC version.
Practical implications: Aluminum parts with variable section would increase as utilizing the CNC extruder and cost price of the parts be down. Many industrial products using the variable section extrusion process would be used in diverse fields.
Originality/value: Extruded aluminum part with variable section is rarely used since extruders don't be designed and developed for variable section extrusion. It is important that an extruder with CNC control, which could be easily handled and have accessible software to be operated by field user, are invented. As stated above, CNC extruder is needed for production of industrial products with variable section for today. Therefore design and development of CNC extruder having the die set for mold feeding parts was tackled in this paper as efficient approach using commercial FEM code.
Keywords: Extrusion; Varied section; CNC extruder; Al extrusion; Mold feeding

1. Introduction

Being a yardstick for the level of national industrial technology, the automobile industry that became the symbolic index of national competitiveness is deeply recognized as a key national industry, with its industrial importance increasing further by its technology intensive industrial characteristics and win-win collaborative industrial characteristics between large enterprises and small/medium enterprises. Therefore, the automobile industry is facing an extremely severe technically unlimited competition age for market dominance through advanced brand value.

As can be seen from the comparison and evaluation of major automobiles (GM, Toyota) around the world, the advancement of technology and rationalization of cost have become significant factors in regards to global competition. This is very suggestive in exerting efforts for the quality-wise growth of the domestic automobile industry. Brand value is the most important factor in the global environment related to car parts and it can be seen that this brand value is created by advanced management technique and production technology.

In the center of technology advancement are new engine development, new power train, IT integration, application of new raw material, etc. However, it can be said to be the established

theory that the effective and solid investment is the investment in IT integration and development of new material application in the short-term. The light-weight technology that reduces the weight of an automobile can achieve the regulations on exhaust gas, fuel efficiency improvement, etc. both economically and efficiently. Therefore, it is the core base technology that can realize early practicalization of next generation automobiles such as those equipped with new engines having relatively insufficient power and using alternative fuel.

In the case of light-weight raw material centered on aluminium [1-4], it is relatively expensive (the price of aluminum raw material is 4-5 times as expensive as Fe-based raw material) and the expertise on the manufacturing technology is insufficient. Therefore, an epoch-making quantum jump is necessary throughout overall manufactu- ring processes from raw material selection to manufacturing and assembling.

As an alternative to overcome these technical problems, the variable section extruding technology, which changes the section of the extruded material at the same time it is extruded, is being developed. Existing processes, when producing frame material for automobiles, have used the process in which the shape of the section was changed after extrusion of frame. However, the new variable section extrusion technology [5-11] applies, the process technology developed to change the section upon extrusion from the extruder, thus reducing the cost, which is one of the disadvantages of a light-weight raw material. Therefore, this research team has performed a study to develop variable section extrusion technology for the first time in Korea. First, it developed a CNC extruder to realize variable section extrusion. The following Sections describe the developed extruder.

2. Variable section extrusion process

2.1. Variable section extrusion process

The variable section extrusion process is a new process that changes the section of the extruded material by using the mold moving in the direction perpendicular to the direction of extrusion during the general extrusion process that extrudes rods or tubes. Fig. 1 presents the conceptual diagram for the principle of the variable section extrusion. Since the section is changed during the extrusion process, this process, if properly used, can be said to be effective for the commercialization and cost reduction of a new raw material, such as aluminum, whose cost is relatively high compared to Fe-based material, by eliminating the successive processes (hydro-forming and bending).

It can be seen from Fig. 2 that the variable section extrusion process was comparatively simplified, and therefore, it is more

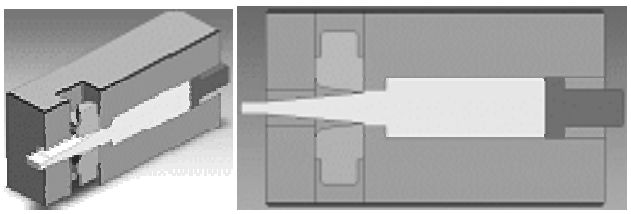

Fig. 1. Concept of variable section extrusion

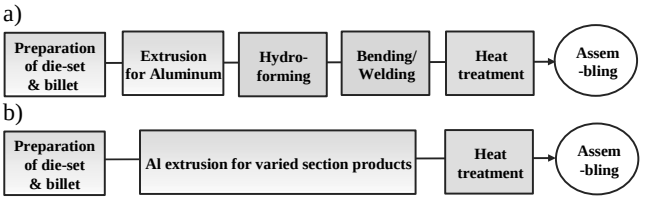

Fig. 2. Comparison of manufacturing process for car sub-frame: (a) General aluminum extrusion process, (b) Variable section extrusion process

advantageous compared to the existing sub-frame manufacturing process. This variable section extrusion process is used as a base for the reduction of the number of processes as well as integration of new processes to produce aluminum parts with low production cost and high reliability. It is urgently needed to develop products applying this process.

2.2. Object product group

The aluminum extrusion material, the object of this study, is used in the manufacture of car frames. Currently, automobile makers adopt aluminum extrusion material for most frames, etc. to lighten the weight of cars as shown in Fig. 3. As such, it is thought that there are many types of products that prove effective when applying variable section extrusion to those of car frames that are made by the extrusion process. Table 1 shows a group of products to which the variable section extrusion process can be applied among aluminum extrusion materials whose feasibility has been verified.

Fig. 3. Aluminum body parts (Audi)

Table 1.
Categorized group for car-parts producible by varied extrusion process

Group	Parts name
1	Seat Rail, Bus Seat Frame, Seat Frame, Bumper Back Beam
2	Space Frame, Engine Frame, In Panel, Front End Carrier
3	Front Side Member, Under Frame, Sub Frame, Space Frame
4	Knuckle, Lower Arm, Upper Arm, Shock Absorber, Outer Tube, Cross Member

3. Design of CNC variable section extruder

3.1. Capacity of the CNC section extruder

In order to decide the capacity of the variable section extruder, this study made a prediction about the extrusion load through

empirical equation with the group of products selected for this study as shown in Fig. 4. When the selected initial billet diameter was 80.0 mm, the maximum load was calculated to be 460 tons. Therefore, this study designed the extruder with a capacity of 600 tons. In addition, as this extruder is a variable section extruder, it requires force to feed the mold. Since this is a very important decisive design factor, this study simulated the design by varying the section of the rod to perform FEM analysis [12-15]. The mold feeding force obtained from the analysis result was one ninth (1/9) of the extrusion load. Therefore, this study designed the extruder equipped with a cylinder to feed the mold by setting the variable capacity to 100 tons so that the mold can be fed at maximum capacity of 600 tons (Fig. 5).

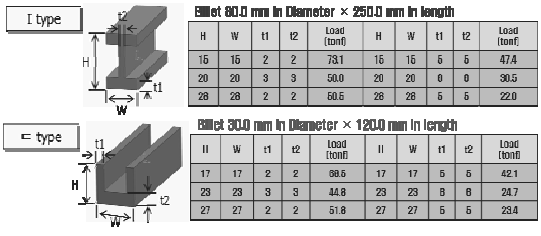

Fig. 4. Prediction of extrusion loads for various section shapes

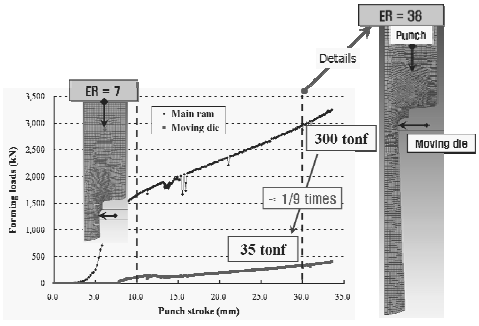

Fig. 5. Analysis of forming loads using FEM simulation

Unlike general extrusion processes, in the case of the variable section extrusion process, the section of extruded material is changed during extrusion. Therefore, the extrusion speed and the mold moving speed perpendicular to the direction of extrusion must be adjusted and synchronized within certain range during extrusion. Particularly, since this equipment used for this study is manufactured to examine major parameters of the process and equipment for future commercialization of variable section extrusion, it must be designed and manufactured to allow experiment at various speeds and under various load conditions. Therefore, the system of equipment was configured so that the main stem is controlled by the servo pump and the mold feeding is controlled by the servo valve.

3.2. CNC variable section extruder and extrusion mold

Fig. 6 presents the layout of the variable section extruder design, which shows the mold feeding section, CNC system applied section, and major assembling section. The extruder is composed of a mold feeding section for easy forming of the variable section by modifying the existing aluminum extruder, CNC control system that controls the extrusion speed and mold feeding speed, as well as a jig for mounting and removal of mold.

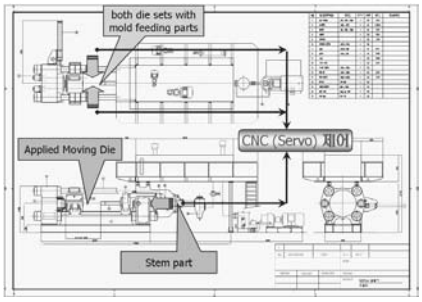

Fig. 6. Layout for CNC extruder with varied section

Major variables that have influence on the accuracy of a product in general extrusion processes include characteristics and temperature of the material, temperature of the mold, extrusion speed, mold shape, lubrication condition, etc. Therefore, proper design for the mold and process is essential to produce precision products. In addition to this, the variable section extrusion needs to consider, for example, sliding part design according to movement between molds and thermal expansion due to temperature difference since it moves one or more mold parts.

Since the purpose of this study is to investigate variables of the extruder, mold and process, as well as their influence, the mold was designed to have a strong structure. Fig. 7 shows the structure and overall assembly drawing of the designed mold.

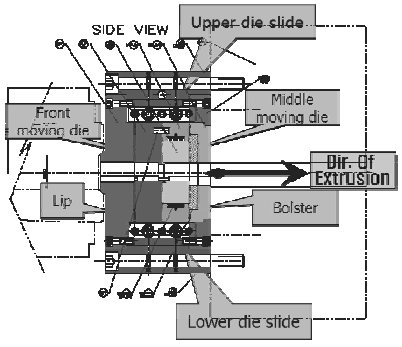

Fig. 7. Design of die set in varied extrusion process

4. Fabrication of CNC variable section extruder

Table 2 presents major specifications of the CNC variable section extruder fabricated after technical review and modification of the extrusion design. Fig. 8 provides the variable section extruder, the first extruder in Korea that was fabricated through such design.

Table 2.
Main specifications of CNC extruder

Item	Description
Capacity	Max. 600 Tonf
M/C size (L×W× H)	7.700 mm × 2.500 mm × 3.100 mm
Billet	80 mm Dia. × 250 mm Leng.
Moving die (L×W× H)	500 mm × 500 mm × 250 mm

Fig. 8. Apparatus of CNC extruder with varied section

Fig. 9 reveals the aluminum form extruded by the CNC control variable section extruder developed by this study. Through this extrusion experiment, the form with '7' shaped section was extruded varying the width from 60.0mm to 50.0mm (width variation of 10mm) with thickness remaining the same.

a)

b)

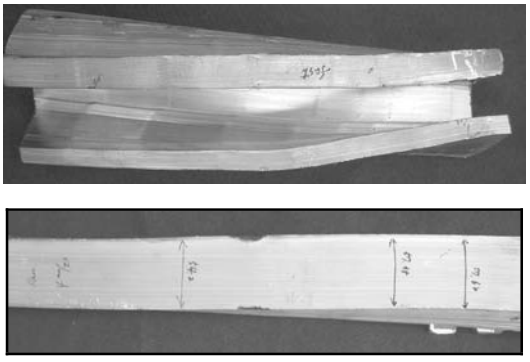

Fig. 9. Extruded products using A6063: (a) Enlarged width for constant thickness, (b) Reduced width for constant thickness

5. Conclusions

- This study designed and fabricated a CNC variable section extruder to realize variable section extrusion, and confirmed the possibility of commercialization of the variable section extruder and process from the experiment for variable section extrusion.
- This study designed and fabricated the mold with movable parts for variable section extrusion, and examined the possibility of variable section extrusion through trial extrusion.
- However, it was found that strict investigation and many experiments need to be performed in advance concerning the variables related to process, material, and mold in order to extrude precision products useful for industrial fields.
- Particularly, it could be found that the commercialization of this variable section extrusion process depended on the major variables including heat management of sliding structure, mold, and increased lifetime of mold.

Acknowledgements

This study was performed with support by the new next generation technology development project, "Project for Development of CNC Control Variable Section Extrusion Technology for Aluminum Material".

References

[1] Y.H., Jung, Aluminum alloy material for cars, Transactions of the Korea Society of Automotive Engineers 18 (1996) 38-52.
[2] F. Vollertsen, A. Sprenger, J. Kraus, H. Arnet, Extrusion, channel, and profile bending, a review, Journal of Materials Processing and Technology 87 (1999) 1-27.
[3] A. Koewius, Aluminium-Spaceframe-Technologie, Der Leicht-bau des Serienautomobils erreicht eine neue Dimension, Teil lund Teil 2. Aluminium 70 (1934) 38-48.
[4] J. Adamowski, C. Gambaro, E. Lertora, M. Ponte, M. Szkodo, Analysis of FSW welds made of aluminium alloy AW6082-T6, Archives of Materials Science and Engineering 28/8 (2007) 453-460.
[5] T. Makiyama, M. Murata, A technical note on the development of prototype CNC variable vertical section extrusion machine, Journal of Materials Processing Technology 159 (2005) 139-144.
[6] M. Hoshino, Journal of the Japan Society for Technology of Platicity 41 (2000) 453-455.
[7] S. Murakami, Journal of the Japan Society for Technology of Platicity 41 (2000) 460-465.
[8] H.J. Choi, S.J. Lim, H.T. Shin, S. Choi, Forming Experiment using Improved CNC Extruder and FE Analysis in Varied Section Extrusion Process, Transactions of the KSTP, Autumn Conference (2007) 128-131.
[9] H.J. Choi, S.J. Lim, H.T. Shin, S. Choi, Development of CNC Extruder for Variable Cross-section Extrusion Process and its Applied Research, Transactions of the KSTP 17 (2007) 130-134.
[10] K. Karita, Y. Kohiyama, T. Kobiki, K. Ooshima, M. Hashimoto, Development of Aluminum Frame for Heay-Duty Trucks, Technical Review in Japan 15 (2003) 81-84.
[11] S. Fukuoka, Journal of the Japan Society for Technology of Platicity 41 (2000) 442-446.
[12] A. Krauze, M. Kaczmarek, J. Marciniak, Numerical analysis of femur in living and dead phase, Journal of Achievements in Materials and Manufacturing Engineering 26 (2008) 163-166.
[13] W. Torbacki, Numerical strength and fatigue analysis in application to hydraulic cylinders, Journal of Achievements in Materials and Manufacturing Engineering 25 (2007) 65-68.
[14] M.S.J. Hashmi, M.D. Islam, A.G. Olabi, Experimental and finite element simulation of formability and failures in multi-layered tubular components, Journal of Achievements in Materials and Manufacturing Engineering 24/1 (2007) 201-218.
[15] T. Ohashi, H. Ito, K. Shinozaki, S. Ito, H. Watari, Lateral extrusion of a cross fitting with a lost core, Journal of Achievements in Materials and Manufacturing Engineering 24/1 (2007) 413-420.