Editorial Corner

Aluminum Extrusion Research Opportunity for Future Development

Pradip K. Saha*
Technical Fellow, Boeing Research and Technology, Seattle, Washington, United States of America

* Corresponding author. E-mail: pksaha09@gmail.com DOI: 10.14416/j.ijast.2019.01.008

In a competitive world market, the uses of aluminum extrusion with its lightweight, diverse properties and improved performance in many applications including architecture, structural components, and automotive and aerospace industries have increased tremendously. Aluminum extrusion technology continues to be a subject of discussion and evaluation concerning its application to a growing customer base. Continuing education and fundamental research are necessary to upgrade knowledge of aluminum extrusion technology in both academic and industrial communities.

The principal variables that influence the successful extrusion and the quality of material exiting from the die are extrusion ratio or strain, initial billet temperature, speed of deformation or strain-rate, and alloy flow stress. The effect of principal variables on the extrusion process and their interrelationships works like a closed loop chain [1]. Tribology and thermodynamics in aluminum extrusion controls the exit extrusion temperature that have a direct influence on the shape accuracy, extrusion quality, and the heat treatment for certain alloys that get the press quench, and die life. The exit temperature is directly influenced by the extrusion parameters including the billet temperature, die design, extrusion speed and the friction conditions at the billet-container and die bearing and flowing material interfaces [2]. An understanding of the factors that control the exit temperature which is important in the optimization of the extrusion speed has been described [3]. An experimental study [4] has been done on the verification of the interactive effects of billet temperature and die temperature that influenced distortion and the variation in the shape of the extruded cross-section.

Wear mechanisms in the die bearing are dependent on many factors including temperature rise in the die, extrusion speed, shape and geometry of die, die bearing length and its surface condition, and the material properties of die steel and the extruding alloy. A useful review of die wear inference in metal forming operations has been done [5]. Die wear could be abrasive, adhesive or both. Abrasive wearing of the die bearing changes the extrusion surface quality, since the metal flowing through the die conforms to the bearing surface in the transverse direction. Adhesive wear on the die bearing may be caused by the continuous build-up of an adhesive layer of aluminum and its detachment from the bearing in each extrusion cycle. As a result, the flow characteristics of the metal leaving the die bearing may change since the real area of contact decreases as the wear mechanism progresses [6], [7]. The tribological processes in the die land to find their influence on the accuracy of shape and the surface quality of extrusion have been studied [8].

Various hard coatings and surface treatments with a higher hardness at the bearing surface reduce the tendency of adhesion of heated aluminum to the die bearings; this reduces the friction at the interface. These factors combine to improve die performance and quality in aluminum extrusion. Various methods of die surface hardening like nitriding, such as plasma, fluidized-bed, and nitrocarburizing, are available [9]–[11]. Further technology was developed on different hard coatings including TiC, TiN and VC deposited by CVD or PVD processes on extrusion dies to reduce friction and wear and to enhance extrusion surface quality and productivity [12]–[17].

Extrusion manufacturers are facing customer demands for excellent quality and higher productivity while providing complex product geometry from soft, medium and harder aluminum alloys. Fundamental research in aluminum extrusion technology [18] always brings value to the new and also the current extrusion industry personnel who will move the technology forward to the next level of improvements. Continuous process improvements and optimization of process variables at each stage of operations to improve the extrusion quality, productivity, and finally,

the economics of extrusion [19], will play a bigger role within the growing aluminum extrusion industry.

References

[1] P. K. Saha, *Aluminum Extrusion Technology*. Ohio: ASM International, 2000, pp. 22–27.

[2] P. K. Saha, "Influence of plastic strain and strain rate on temperature rise in aluminum extrusion," in *Proceedings of the 6th International Aluminum Extrusion Technology Seminar*, 1996, vol. 1, pp. 355–360.

[3] A. F. Castle, "Temperature control in aluminum extrusion," in *Proceedings of the 5th International Aluminum Extrusion Technology Seminar*, 1992, vol. 2, pp. 181–184.

[4] Y. Tashiro, H. Yamasaki, and N. Ohneda, "Extrusion conditions and metal flow to minimize both distortion and variance of Cross-sectional shape," in *Proceedings of the 5th International Aluminum Extrusion Technology Seminar*, 1992, vol. 2, pp. 191–205.

[5] J. A. Schey, *Tribology in Metalworking*. Ohio: ASM International, 1983, pp. 94–101.

[6] P. K. Saha, "Thermodynamics and tribology in aluminum extrusion," *Wear*, vol. 218, no. 2, pp. 179–190, 1998.

[7] P. K. Saha, "Use of tribology to improve performance and quality in aluminum extrusion," in *Proceedings of the 8th International Aluminum Extrusion Technology Seminar*, 2004, vol. 2, pp. 277–287.

[8] W. W. Thedja, B. K. Muller, and D. Ruppin, "Tribomechanical process on the Die Land Area during extrusion of AA6063 alloy," in *Proceedings of the 5th International Aluminum Extrusion Technology Seminar*, 1992, vol. 2, pp. 467–474.

[9] A. Czelusniak, M. J. Korwin, and Y. Robert, "Economics of nitreg process use in nitriding of aluminum extrusion dies," in *Proceedings of the 5th International Aluminum Extrusion Technology Seminar*, 1992, vol. 1, pp. 261–264.

[10] D. Pye, "Plasma nitriding, An alternative nitriding method for aluminum extrusion dies," in *Proceedings of the 5th International Aluminum Extrusion Technology Seminar*, 1992, vol. 1, pp. 265–273.

[11] R. Gonzales, "User experience with fluidized-bed nitriding and nitrocarburizing of extrusion dies," in *Proceedings of the 5th International Aluminum Extrusion Technology Seminar*, 1992, vol. 1, pp. 207–217.

[12] B. J. Janoss, "Surface enhancement technology for metal extrusion," in *Proceedings of the 6th International Aluminum Extrusion Technology Seminar*, 1996, vol. 2, pp. 201–206.

[13] D. Pye, "A review of surface modification techniques for Pre-Heat-Treated H13 extrusion dies and emerging technologies," in *Proceedings of the 6th International Aluminum Extrusion Technology Seminar*, 1996, vol. 2, pp. 197–200.

[14] M. Sundqvist, T. Bjork, S. Hogmark, and I. Srinivasan, "Tribological evaluation of surface treatments for extrusion dies," in *Proceedings of the 6th International Aluminum Extrusion Technology Seminar*, 1996, vol. 2, pp. 1–4.

[15] M. B. Karamis, "The role of PVD TiN coating in wear behavior of aluminium extrusion die," *Wear*, vol. 217, pp. 46–55, 1998.

[16] T. Bjork, J. Bergstrom, and S. Hogmark, "Optimization of nitriding parameters for extrusion dies, evaluated in an extrusion simulation test," in *Proceedings of the 7th International Aluminum Extrusion Technology Seminar*, 2000, vol. 2, pp. 317–325.

[17] M. J. McCabe, "How PVD coatings can increase life and improve performance in aluminum extrusion," in *Proceedings of the 7th International Aluminum Extrusion Technology Seminar*, 2000, vol. 2, pp. 305–310.

[18] P. K. Saha, "fundamental research and future developments of aluminum extrusion technology," in *Proceedings of the 11th International Aluminum Extrusion Technology Seminar*, 2016, pp. 689–701.

[19] P. K. Saha, "Economics of aluminum extrusion for aerospace applications," in *Proceedings of the 10th International Aluminum Extrusion Technology Seminar*, 2012, pp. 357–366.

Pradip K. Saha