Decagon-shaped Water Bottle Design with Ergonomic Handle

Dwi Cahyadi[1], Etwin Fibrianie Soeprapto[1], Muhammad Kadafi[2], Hertina Susandari[3] and Sukmawati[4]
[1]*Design Department, Politeknik Negeri Samarinda, Jl. Ciptomangunkusumo, Samarinda, Indonesia*
[2]*Accunting Department, Politeknik Negeri Samarinda, Jl. Ciptomangunkusumo, Samarinda, Indonesia*
[3]*Design Department, Institut Teknologi Sepuluh Nopember Surabaya, Jl. Dispro, Surabaya, Indonesia*
[4]*Lembaga Penjamin Mutu Pendidikan, Jl. Ciptomangunkusumo, Samarinda, Indonesia*

Keywords: Ergonomic, Water Bottle, Decagon Shape, Handle, Amthropometry.

Abstract: Water bottle commonly found in Indonesia in the form of tubes that hold 19 liters of water. In the process of moving, the water bottle is lifted and there is a risk of slipping so that the water bottle can falls and rolls because water bottles are generally in the form of a tube and do not have a special handle. For this reason, it is necessary to design a drinking water bottle shape with an ergonomic handle so that it is easy to move and lift. The purpose of this study is to redesign a decagon-shaped drinking water bottle that has a handle according to the anthropometry of the Indonesian hand. This study uses the application of hand anthropometric data for 95 percentiles of Indonesian men aged 18-25 years. The results of this study obtained a water bottle design in the form of an ergonomic decagon and has a bottle handle with a length of 10 cm, with four finger grips each measuring 2.5 cm. The contribution of this research proposes a drinking water bottle design that is different from the previous one and has an ergonomic handle to reduce the risk of accidents when lifting it.

1 INTRODUCTION

Water as consumption such as drinking water is very important for the human body because it functions to transport minerals, vitamins, proteins, and other nutrients throughout the body. Water is a lubricant for body tissues as well as a cushion for joints, bones, and muscles. About 80% of the human body consists of water and of the organs of the body, blood, and brain is the highest water content. Healthy drinking water has the main and important characteristics, namely odorless, tasteless, colorless and does not contain harmful substances and microorganisms. (Sari, 2014);(Aryani, 2017).

By looking at the main needs of this water, many companies are pushing to make new innovations in the field of drinking water to make it easier for consumers to meet the needs of healthy and fast water. Bottled drinking water is one solution. Packaging is an important element in a beverage product. Bottled drinking water uses a lot of plastic because of its ease of use and low production costs (Aversa et al., 2021); (Prarudiyanto, Werdiningsih, & Rokilah, 2018).

Packaging such as plastic bottles has become part of daily activities, especially in activities related to mineral water packaging. The use of plastic bottles for mineral water packaging is a practical and concise alternative (Wijayanto & Rusdi, 2017). Bottled water in 19 liters in Indonesia is mostly used for daily needs in households and offices because of the more water capacity and practicality. Along with the increasing need for bottled mineral water, the need in this case the process of lifting and moving this 19 liter water bottle from one place to another is a problem that is often faced by consumers and producers. (Sasongko & Purnomo, 2017); (Setiawan, Kirana, Cahyani, & Suryoputro, 2019).

The current bottle has problems in lifting it to the top of the dispenser because of the tubular shape of the gallon and the heavy volume of 19 liters of water. The tubular shape of the bottle has a risk of slipping when lifted so that it can fall and roll on the ground. In addition, the shape of the tube without a handle adds to the difficulty in moving and lifting the bottle. Thus the purpose of this research is to innovate the design of changing the shape of the bottle accompanied by an ergonomic handle to make it easier to lift the bottle, which is needed to solve

Cahyadi, D., Fibrianie Soeprapto, E., Kadafi, M., Susandari, H. and Sukmawati, .
Decagon-shaped Water Bottle Design with Ergonomic Handle.
DOI: 10.5220/0010942800003260
In *Proceedings of the 4th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2021)*, pages 227-231
ISBN: 978-989-758-615-6; ISSN: 2975-8246

problems that often occur when lifting and moving it. This research contributes positively to society by innovating a different bottle shape than before and by adding the added benefit of an ergonomic handle for easy moving and lifting of water bottles.

2 LITERATURE REVIEW

2.1 Ergonomics in Product Development

Definition of ergonomics according to the World Health Organization -WHO (1972) Ergonomics is a science-oriented field of work design technology based on its users, namely humans, including the fields of anatomy, physiology and psychology. According to Wignjosoebroto (1995); (Nurmianto, 1998) Ergonomics can be referred to as human factor engineering which is defined as a scientific discipline that studies humans in relation to the work they do.

According Salvendy (2012); Lehto and Landry (2013) Ergonomics is one of the disciplines that discusses the understanding of the interaction of humans and their environment of a system. Ergonomics emphasizes the importance of applying theories, principles, and methods in terms of optimizing safety, comfort and human well-being and overall system performance. One of the important fields in ergonomics is anthropometry. Anthropometry is used as a standard for determining dimensions in product manufacturing and development.

2.2 Anthropometric Data as Product Dimension Determination

Anthropometry is the measurement of the dimensions of the human body as a basis for measuring ergonomics for products and the workplace by considering ethnicity, gender, body defects, body position and posture during activities, as well as the type of work performed. Anthropometric data is used in ergonomics to determine the physical dimensions of workspaces, equipment, and products used by humans. Anthropometry is usually displayed in tabular form by dividing its size into 5th percentile, 50th percentile and 95th percentile sizes. Where the 5th percentile is a measure of the data for the population with a small body size, the 50th percentile is for the average body size and the 95th percentile is used for the larger body size. Several studies on anthropometry for variations and redesign of products such as furniture were carried out by changing the dimensions of the consumer's body based on age and ethnicity (Kahya, 2019); (Lee, Kim, Lee, & Yun, 2018); (Yanto, Lu, & Lu, 2017); (Taifa & Desai, 2017).

According Adnan and Dawal (2019) W. Lee et al. (2018), Gonzalez, Barrios-Muriel, Romero-Sanchez, Salgado, and Alonso (2020); Wang and Cai (2020) designing tools, equipment, and furniture according to the size of the human body, can provide maximum benefits. Recent usage data from anthropometry can synchronize users and products produced to suit the user Anthropometry has been widely used to design products and workplaces that are safe and sustainable (Castellucci et al., 2020);(D Cahyadi, Fibrianie, Irwan, Susandari, & Tantrika, 2019). In designing product handles, paying attention to ergonomic principles by using anthropometric tables can improve hand posture, increase comfort, and reduce discomfort when working with these products. (Veisi, Choobineh, Ghaem, & Shafiee, 2019);(Ranger, Vezeau, & Lortie, 2019);(Cahyadi, 2014)

3 METHOD

The design of the 19 liter mineral water bottle was carried out in two stages, namely designing and measuring the bottle handle according to anthropometric data of the Indonesian human body and the second was designing the shape of a mineral water bottle with an ergonomic handle and the design of a ten-shaped bottle using 3D software. Anthropometric data used are hand width (HW) dimension data, finger width (FW) and finger depth (FD), male gender 95 percentile aged 18-25 years like seen in table 1 (Purnomo, 2014).

Table 1: Anthropometric data hand width (HW), finger width (FW) and finger depth (FD).

No	Anthropometric Data	Percentile		
		5%tile	50%tile	95%tile
1	Hand width (HW)	7,2 cm	8,2 cm	9,1 cm
2	Finger width (FW)	1,6 cm	1,8 cm	2,2 cm
3	Finger depth (FD)	1,3 cm	1,7 cm	2,0 cm

4 RESULT AND DISCUSSION

In this research, anthropometric data used were Asian ethnic groups from Indonesia with male gender aged

18-25 years. For the initial stage, determine the length of the bottle handle using anthropometric hand width data. From the anthropometric data in the table 1, the 95th percentile value is 9,1 cm.

This value is the minimum value of the handle length to be the lower limit of the ergonomic grip size. Due to the dynamic movement of the fingers when lifting the bottle, this product is designed to be 10 cm for the length of the hand grip. In Figure 1, this size is labeled with hand wide (HW).

To determine the size of the grip width on the bottle handle, the Finger Wide (FW) size is used as shown in Figure 1. Anthropometric data taken is finger width data from the 95th percentile of male gender. The value obtained in the anthropometric data is 2,2 cm.

This value is a minimal value, so the value used in the product is 2.5 cm to provide dynamic motion of the finger. The number of handles designed is 4 indentations to strengthen the grip when lifting the bottle using the index finger, middle finger, ring finger and little finger.

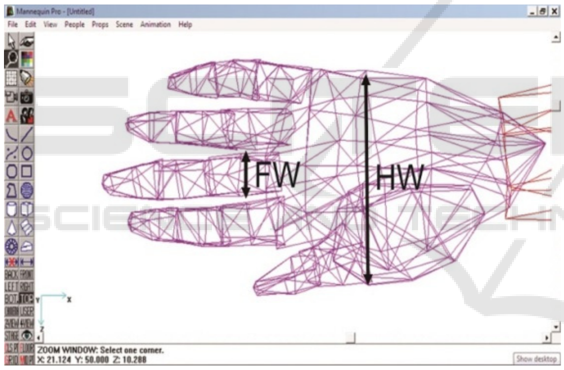

Figure 1: Anthropometric measurements of hand width (HW) and finger width (FW) (mannequin pro software).

To determine the width of the grip, the finger depth (FD) dimension is used as shown in figure 2. The width of the grip space is designed so that there is comfortable movement in the area between the bottle body and the finger grip when lifting the bottle.

Finger depth is taken from anthropometric data of the 95th percentile of men. The value obtained from anthropometric data is 2 cm. This value is the minimum value of the width of the hollow in the bottle handle. In the design of this product, the designed depth is 7 cm.

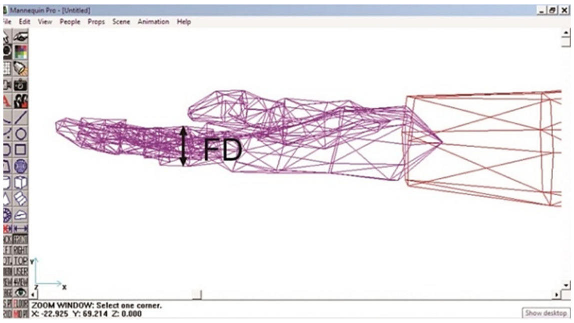

Figure 2: Anthropometric finger depth (FD) measure (mannequin pro software).

The results of 3D modeling and rendering will look like in Figure 3 and 4. Figure 3 and 4 are an image of the shape and size of the bottle design. The shape of the handle on the bottle is a box with a length of 10 cm and a width and height of 2.5 cm. The size of the ergonomic handle that has been analyzed through the use of anthropometric data is applied to the bottle design.

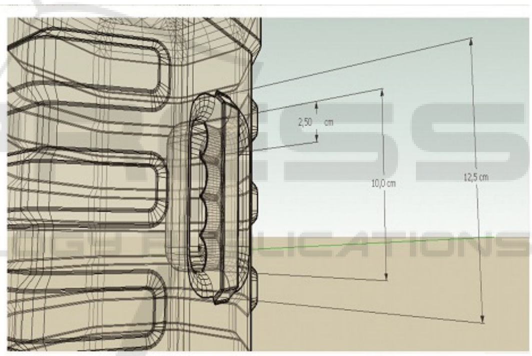

Figure 3: The size of the bottle handle side view.

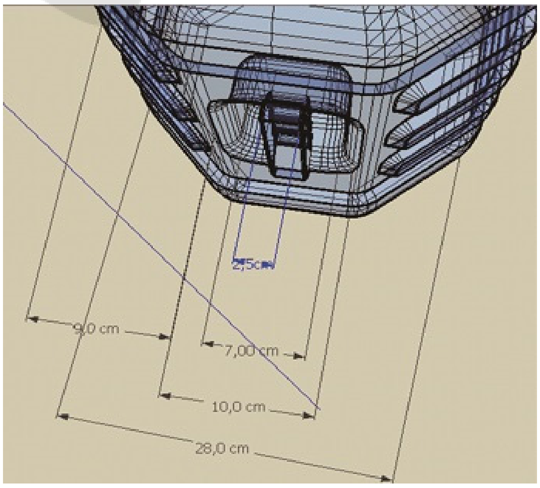

Figure 4: The size of the bottle handle top view.

The next stage is the application of these dimensions to bottle products using 3D software. The software used in designing the decagon bottle is google sketchup. Decagon is a ten-sided polygon that has composed golden triangle (base angle 72^0 and vertex 36^0) as shown in figure 5. (Kimberly, 2011).

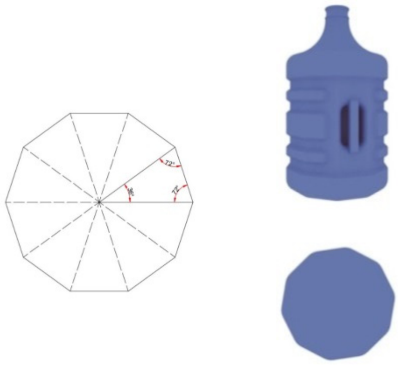

Figure 5: Application of the Golden section triangle to the bottle design (decagon shape).

Figure 6: Modeling a decagon bottle with an ergonomic handle.

Figure 6 is the final image of the bottle design rendering process using 3D software. This rendering aims to show the final result of the rectangular bottle design and the position of the handle on the bottle.

5 CONCLUSIONS

Bottled mineral water that is commonly found in Indonesia is in the form of a tube with a size of 19 liters of water. In the process of moving the water bottle containing the water, the water bottle is lifted and sometimes slips occur so that the water bottle falls and rolls. The results of this study obtained a decagon-shaped drinking water bottle design that is ergonomic and has the shape of a handle on a box-shaped bottle with a length of 10 cm and a width and height of 2.5 cm. On the handle of the bottle there are four grooves for the grip of the four fingers, namely the index finger, middle finger, ring finger and little finger.

This grip design has 7 cm of grip space to provide comfort and safety when fingers enter and exit the grip area. For further research, it can be developed from the side of the geometric shape and material of the handle on the bottle.

REFERENCES

Adnan, N., & Dawal, S. Z. M. (2019). Applied anthropometric for wheelchair user in Malaysia. *Measurement, 136*, 786-794. doi:10.1016/j.measurement.2018.11.002

Aryani, T. (2017). Analisis Kualitas Air Minum Dalam Kemasan (AMDK) di Yogyakarta ditinjau dari Parameter Fisika dan Kimia Air. *Media Ilmu Kesehatan, 6*(1). doi:10.30989/mik.v6i1.172

Aversa, C., Barletta, M., Gisario, A., Pizzi, E., Prati, R., & Vesco, S. (2021). Design, manufacturing and preliminary assessment of the suitability of bioplastic bottles for wine packaging. *Polymer Testing, 100*. doi:10.1016/j.polymertesting.2021.107227

Cahyadi, D. (2014). *Aplikasi Mannaquin Pro Untuk Desain Industri*: Leutikaprio.

Cahyadi, D., Fibrianie, E., Irwan, M., Susandari, H., & Tantrika, C. F. M. (2019). *Design of workstation in the home industry of Amplang crackers production.* Paper presented at the iCAST-ES 2019.

Castellucci, H., Viviani, C., Arezes, P., Molenbroek, J. F. M., Martínez, M., Aparici, V., & Dianat, I. (2020). Applied anthropometry for common industrial settings design: Working and ideal manual handling heights. *International Journal of Industrial Ergonomics, 78*. doi:10.1016/j.ergon.2020.102963

Gonzalez, A. G., Barrios-Muriel, J., Romero-Sanchez, F., Salgado, D. R., & Alonso, F. J. (2020). Ergonomic assessment of a new hand tool design for laparoscopic surgery based on surgeons' muscular activity. *Appl Ergon, 88*, 103161. doi:10.1016/j.apergo.2020.103161

Kahya, E. (2019). Mismatch between classroom furniture and anthropometric measures of university students. *International Journal of Industrial Ergonomics, 74*. doi:10.1016/j.ergon.2019.102864

Kimberly Elam, 2011, Geometry of Design: Studies in Proportion and Composition, 2nd Edition Revised and Updated, Princeton Architectural Press, New York.

Lee, W., Yang, X., Jung, D., Park, S., Kim, H., & You, H. (2018). Ergonomic evaluation of pilot oxygen mask designs. *Appl Ergon, 67*, 133-141. doi:10.1016/j.apergo.2017.10.003

Lee, Y., Kim, Y. M., Lee, J. H., & Yun, M. H. (2018). Anthropometric mismatch between furniture height and anthropometric measurement: A case study of Korean primary schools. *International Journal of Industrial Ergonomics, 68*, 260-269. doi:10.1016/j.ergon.2018.08.010

Lehto, M., & Landry, S. J. (2013). *Introduction to Human Factors and Ergonomics For Engineering* (Second edition ed.): CRC Press

Nurmianto, E. (1998). *Ergonomi Konsep Dasar dan Aplikasinya* (First Edition ed.): Guna Widya.

Prarudiyanto, A., Werdiningsih, W., & Rokilah, R. (2018). Pengaruh Kombinasi Kemasan Dan Masa Simpan Terhadap Beberapa Komponen Mutu Bumbu Plecingan Instan (The Effect of Combination of Package and Self-life on The Some Qualities of Instant Seasoning Plecingan). *Jurnal Ilmiah Rekayasa Pertanian dan Biosistem, 6*(1), 60-68. doi:10.29303/jrpb.v6i1.76

Purnomo, H. (2014). *Pengukuran Antropometri tangan Usia 18 Sampai 22 Tahun Kabupaten Sleman Yogyakarta.* Paper presented at the Seminar Nasional IENACO.

Ranger, F., Vezeau, S., & Lortie, M. (2019). Tools and methods used by industrial designers for product dimensioning. *International Journal of Industrial Ergonomics, 74*. doi:10.1016/j.ergon.2019.102844

Salvendy, G. (2012). *Handbook of Human Factors and Ergonomics* (G. Salvendy Ed. Fourth Edition ed.): John Wiley & Sons, Inc.

Sari, I. P. T. P. (2014). Tingkat Pengetahuan Tentang Pentingnya Mengkonsumsi Air Mineral Pada Siswa Kelas IV di SD Negeri Keptran A Yogyakarta. *Jurnal Pendidikan Jasmani Indonesia, 10*(2).

Sasongko, D. A., & Purnomo, H. (2017). *Perancangan Ulang Rak Penyimpanan Galon dan Alat Bantu Angkat dengan Metode Ergonomi Partisipatori*. Paper presented at the Seminar Nasional Teknik Industri Universitas Gadjah Mada.

Setiawan, M. S., Kirana, I. W., Cahyani, A. D., & Suryoputro, M. R. (2019). *Penilaian Postur Pekerja Pengangkatan Galon Dengan Metode REBA dan Biomekanika.* Paper presented at the Seminar dan Konferensi Nasional IDEC.

Taifa, I. W., & Desai, D. A. (2017). Anthropometric measurements for ergonomic design of students' furniture in India. *Engineering Science and Technology, an International Journal, 20*(1), 232-239. doi:10.1016/j.jestch.2016.08.004

Veisi, H., Choobineh, A., Ghaem, H., & Shafiee, Z. (2019). The effect of hand tools' handle shape on upper extremity comfort and postural discomfort among hand-woven shoemaking workers. *International Journal of Industrial Ergonomics, 74*. doi:10.1016/j.ergon.2019.102833

Wang, C. Y., & Cai, D. C. (2020). Hand tool handle size and shape determination based on hand measurements using a contour gauge. *Human Factors and Ergonomics in Manufacturing & Service Industries, 30*(5), 349-364. doi:10.1002/hfm.20846

WHO. (1972). *Introduction to Ergonomics* (W. T. Singleton ed.): WORLD HEALTH ORGANIZATION

Wignjosoebroto, S. (1995). *Ergonomi, Studi Gerak dan Waktu* (First ed.): PT. Candimas Metropole.

Wijayanto, A., & Rusdi. (2017). Pendampingan Kelompok Usaha Pencacahan Limbah Plastik di Kabupaten Malang. *Jurnal Pambudi, 1*(1).

Yanto, Lu, C. W., & Lu, J. M. (2017). Evaluation of the Indonesian National Standard for elementary school furniture based on children's anthropometry. *Appl Ergon, 62*, 168-181. doi:10.1016/j.apergo.2017.03.004