Jurnal Mantik, 5 (2) (2021) 1741-1747

Published by:Institute of Computer Science (IOCS)

Jurnal Mantik

Journal homepage: www.iocscience.org/ejournal/index.php/mantik/index

Additive Manufacturing As An Application Of Information Technology As A Method Of Product Development In The Automotive Industry

Wibowo Harry Sugiharto[1], Muhammad Imam Ghozali[2]

[1 2] Informatics Engineering Study Program, Faculty of Engineering, Universitas Muria Kudus Jl. North Ring, Kayuapu Kulon, Gondangmanis, Kec. Bae, Kudus Regency Central Java 59327, Indonesia

E-mail: wibowo.harrys@umk.ac.id [1], imam.ghozali@umk.ac.id [2]

ARTICLE INFO

Article history:
Received: ...
Revised: ....
Accepted:....

Keywords:
Additive Manufacturing,
3d Printing,
3d Modeling

ABSTRACT

Additive manufacturing, or 3D printing, is revolutionizing manufacturing; it is a process for creating 3D objects in any form from 3D modeling simulations. 3D printed models can be created with a computer-aided design (CAD) package, via a 3D scanner, or with an ordinary digital camera and photogrammetry software. Additive manufacturing has been used in manufacturing, culinary industry, medical applications, healthcare, fashion industry, education, and the automotive industry. The Automotive Industry has contributed significantly to the national economy of Indonesia. The Automotive Industry is currently one of seven sectors prioritized in developing Industry 4.0 in accordance with the Making Indonesia 4.0 roadmap. The product development process using the additive manufacturing method is broadly divided into three stages: modeling, printing, and finishing. An example of the application of additive manufacturing technology in product development at the Automotive MSME level in the manufacture of velocity stack products. The working principle of this tool is to reduce intake air losses (intake air coefficient effect). The results of the velocity design test on the Yamaha MX King can increase engine power average in 1.45 HP and average torque 1.19 NM

1. Introduction

Additive manufacturing emerged as a technology for future production because it supported human life. More and more print products include many applications [1]. Additive manufacturing, or 3D printing, is revolutionizing manufacturing; it is a process for creating 3D objects in any form from 3D modeling simulations [2]. 3D printing using the software is accomplished by slicing the 3D model into several thin layers (0.01 mm thick or less). Each layer is then traced to the constituent layers by the printer, once the pattern is complete, the layer build is taken down, and the next layer is added on top of the previous one, known as additive manufacturing (AM) [3]. 3D printing goes through an additive process where successive layers of material are placed under computer control.

In April 1980, Hideo Kodama of the Nagoya Municipal Industrial Research Institute, discovered two additive methods for creating three-dimensional plastic models with photo-hardening thermoset polymers, in which the area of UV exposure is controlled by a mask pattern or scanning fiber emitter [4]. In 1986, rapid commercial prototyping was started by Hull, who realized the concept was not limited to liquids and therefore gave it the generic name "stereolithography" [5]. Hull built a patent portfolio covering many fundamental aspects of today's additive manufacturing technologies, such as data preparation via triangulation models (STL file format), slicing, and exposure strategies such as alternating hatch directions [6].

3D printed models can be created with a computer-aided design (CAD) package, via a 3D scanner, or with an ordinary digital camera and photogrammetry software. 3D printed models created with CAD produce relatively fewer errors than other methods. Errors in 3D printed models can be identified and corrected before printing [7]. additive manufacturing has been used in manufacturing [8][9], culinary industry

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

[10][11][12][13], medical applications [14], healthcare [15][16] [17] , fashion industry [18] [19] [20] , education [21] [22] [23] , and the automotive industry [24] [25] [26] [27] [28] .

The Automotive Industry has contributed significantly to the national economy of Indonesia. As seen from GDP data, the Transportation Equipment Industry will contribute about 1.35% of the national GDP in 2020 or about 7.57% of the GDP of the non-oil and gas processing industry [29]. The Automotive Industry is currently one of seven sectors prioritized in developing Industry 4.0 in accordance with the Making Indonesia 4.0 roadmap. The development of the automotive industry is supported by Indonesia's potential as the 17th largest vehicle sales market among ASEAN countries. Of the nine countries, Indonesia contributed about 30% to total car sales in ASEAN in 2019, or 1,032,907 units, with an average annual sales of around 86,000 units [29]. The high growth and demand for motorized vehicles stimulate the growth of MSMEs in the automotive sector [30]. Until the growth of manufacturing companies in the automotive sector. The use of 3d printing/additive manufacturing technology, which is now not a technology that the public can easily reach, becomes an opportunity to be utilized in product development. This paper aims to provide an example of the application of additive manufacturing technology in product development at the Automotive MSME level.

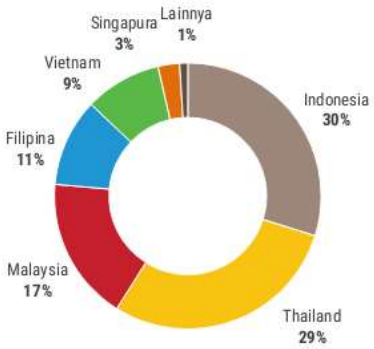

Fig 1. 2019 ASEAN car market share

2. Research Method

The product development process using the additive manufacturing method is broadly divided into three stages: modeling, printing, and finishing. However, generally will do product testing before being marketed.

Fig 2. Stages Of Additive Manufacturing

2.1. Modeling

3D printed models can be created with the help of a CAD design package or via a 3D scanner. Computer-aided design (CAD) is the use of a computer (or workstation) to assist in the creation, modification, analysis, or optimization of designs [31]. This software increases designer productivity, improves design quality, communicates through documentation, and create databases for manufacturing [32]. While the 3D scanner model is to scan physical objects to transfer them into a solid model into the computer, this model is generally in the form of STL. STL has several backronyms such as "Standard Triangle Language" and "Standard Tessellation Language" [33] [34]. Many other software packages support this file format, which is widely used for rapid prototyping, 3D printing, and computer-aided manufacturing [35]. The STL file is a translation of the 3D object, and the STL will encode the surface geometry of the object, the concept used in this step is called tessellation. Tesselation is the action of tiling surfaces with geometric shapes, especially triangles [36].

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

Fig3. STL Density Models 32, 64, and 128

2.2. Printing

After making the 3d model in STL form is complete, proceed with the slicing process, namely the process of making slices of the stl object. This field is then saved in gcode format. This layer will be printed using a 3d printer machine by melting the filament according to the slices stored in the gcode. Gcode also contains nozzle temperature, bed temperature, x,y, and z board width of the 3d printer. One thing that determines the quality of the printout is the diameter of the nozzle and the thickness of the slice layer. The thinner and smaller diameter of the nozzle will produce a smoother printout but has the disadvantage that the printing process takes longer. Meanwhile, wider diameter nozzles and thicker slices will take less printing time but have poorer print results.

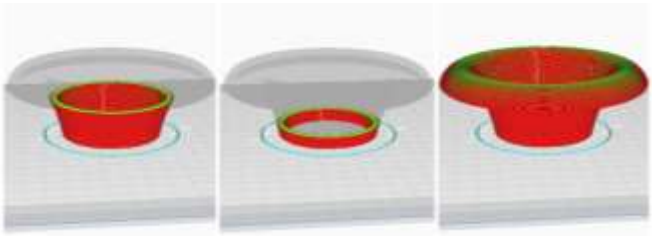

Fig 4. Slices in the STL Model Model

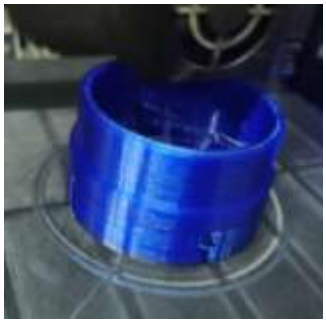

Fig 5. Print Process on a 3D Printer Machine

2.3. Finishing

Finishing the 3d printed object is finished because not all prints produce smooth results. Some prints are rough and need to be smoothed, or prints that are easily broken, so they need a hardening process, etc.

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

3. Results and Discussion

The An example of the application of additive manufacturing technology in product development at the Automotive MSME level in the manufacture of velocity stack products, velocity stack is an air funnel shaped like a trumpet that is placed at the inlet of a motorized vehicle before the throttle body on the injection engine and serves to expedite the air entering the combustion chamber. The working principle of this tool is to reduce intake air losses (intake air coefficient effect). [37] . Velocity made is for Yamaha MX King vehicles. The steps taken are

3.1 Velocity Modeling

The velocity model uses a bell mouth design to increase the air entering the combustion chamber. The STL Design shown in Fig 6.

Fig 6. STL Velocity Yamaha MX King

3.2 Velocity Printing

After the STL velocity model has been created, the next step is slicing to create gcode. From the gcode data with a slice thickness of 0.16mm, it can be predicted that the velocity printing process will be completed within 4 hours and 16 minutes. Slicing of STL shown in Fig 7. Velocity Stack Printing shown in Fig 8.

3.3 Finishing Velocity

The finishing process is done by sanding the velocity surface, adding resin, and hardening it to strengthen the velocity.

3.4 Velocity Test

The testing process is carried out to ensure whether the velocity functions appropriately in motorized vehicles' performance. This measurement is carried out using a dynamometer. The test results can be seen in Table 1 and Fig 9.

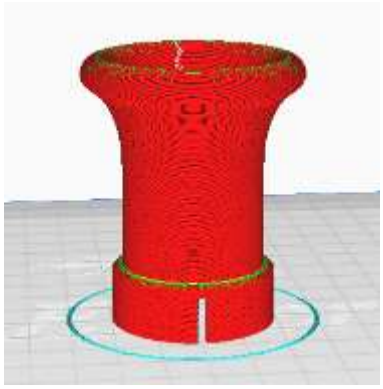

Fig 7. STL Velocity Slice Yamaha MX King

Fig 8. Yamaha MX King Velocity Printing

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

TABLE 1
POWER AND TORQUE TEST WITH DYNAMOMETER

RPM	With Velocity Stack		Without Velocity Stack		Gap	
	Horse Power (HP)	Torque (NM)	Horse Power (HP)	Torque (NM)	Horse Power (HP)	Torque (NM)
6250	9,30	10,54	7,70	8,73	1,60	1,81
6500	10,80	11,76	9,70	10,57	1,10	1,19
6750	12,20	12,85	11,70	12,26	0,50	0,59
7000	13,50	13,69	12,80	12,92	0,70	0,77
7250	14,40	14,12	13,50	13,15	0,90	0,97
7500	15,10	14,34	14,10	13,31	1,00	1,03
7750	15,70	14,34	14,70	13,38	1,00	0,96
8000	16,20	14,39	14,70	13,38	1,50	1,01
8172	16,70	14,44	15,10	13,36	1,60	1,08
8250	16,80	14,43	15,50	13,32	1,30	1,11
8500	17,10	14,27	15,80	13,18	1,30	1,09
8750	17,30	14,07	16,00	12,96	1,30	1,11
9000	17,50	13,81	16,10	12,79	1,40	1,02
9150	17,50	13,60	16,10	12,71	1,40	0,89
9250	17,40	13,37	15,60	11,98	1,80	1,39
9500	16,70	12,52	14,60	10,92	2,10	1,60
9750	15,50	11,28	13,00	9,50	2,50	1,78
10000	13,70	9,75	11,30	8,01	2,40	1,74
10250	10,60	7,37	8,50	5,91	2,10	1,46
		Average			**1,45**	**1,19**

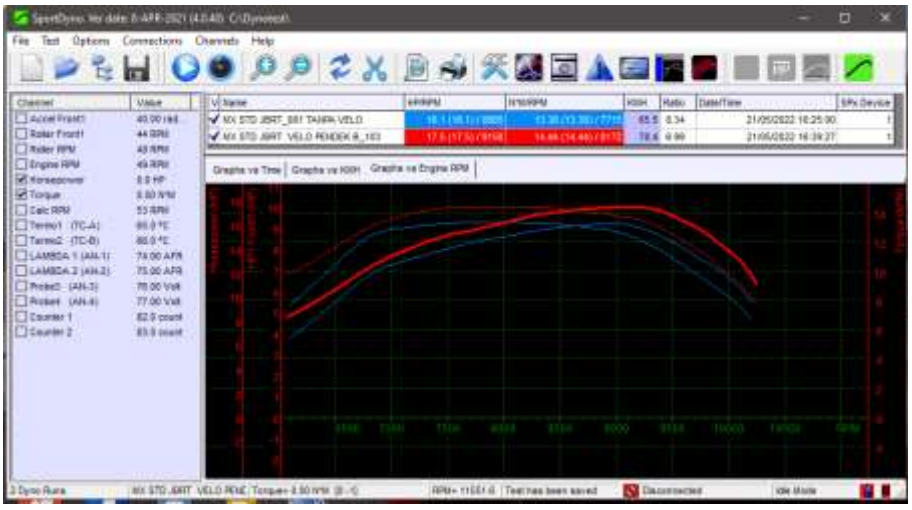

Fig 9. Power and Torque Test with Dynamometer

4. Conclusion

Additive manufacturing can assist in the process of developing spare parts before mass production is carried out. A physical description that can be directly or indirectly tested, thus ensuring that the spare parts produced later can work well. The printing process of the STL model is very dependent on the availability of the power supply, and if there is a power outage, the printing process may fail. The results of the velocity design test on the Yamaha MX King can increase engine power average in 1.45HP and average torque 1.19 NM.

References

[1] N. D. Nguyen, I. Ashraf, and W. Kim, "Compact model for 3d printer energy estimation and practical energy-saving strategy," *Electron.*, vol. 10, no. 4, pp. 1–14, 2021, doi: 10.3390/electronics10040483.

[2] C. Holt, L. Edwards, L. Keyte, F. Moghaddam, and B. Townsend, "Construction 3D Printing," in *3D*

Concrete Printing Technology, 2019, pp. 349–370. doi: 10.1016/b978-0-12-815481-6.00017-8.
[3] T. Rusianto and S. Huda, "A riview : jenis dan pencetakan 3d (3d printing) untuk pembuatan prototipe," *J. Teknol.*, vol. Volume 12, no. 28, pp. 14–21, 2019.
[4] T. Birtchnell and J. Urry, "A Brief History of 3D Printing," in *A New Industrial Future?*, 2018, pp. 18–42. doi: 10.4324/9781315776798-2.
[5] F. Prinz *et al.*, *Rapid prototyping in Europe and Japan*, vol. 1. 1997. [Online]. Available: http://www.wtec.org/loyola/rp/toc.htm
[6] M. Shellabear and O. Nyrhilä, "DMLS – Development History and State of the Art," *Lane 2004*, pp. 1–12, 2004.
[7] "Rapid prototyping & manufacturing— Fundamentals of stereolithography," *J. Manuf. Syst.*, vol. 12, no. 5, pp. 430–433, 1993, doi: 10.1016/0278-6125(93)90311-g.
[8] A. Bandyopadhyay and B. Heer, "Additive manufacturing of multi-material structures," *Materials Science and Engineering R: Reports*, vol. 129. pp. 1–16, 2018. doi: 10.1016/j.mser.2018.04.001.
[9] V. Melissinaki and M. Farsari, "3D Printing and Additive Manufacturing," in *Handbook of Laser Technology and Applications*, 2021, pp. 89–104. doi: 10.1201/9781315310855-8.
[10] L. Hao, S. Mellor, O. Seaman, J. Henderson, N. Sewell, and M. Sloan, "Material characterisation and process development for chocolate additive layer manufacturing," *Virtual Phys. Prototyp.*, vol. 5, no. 2, pp. 57–64, 2010, doi: 10.1080/17452751003753212.
[11] F. C. Godoi, S. Prakash, and B. R. Bhandari, "3d printing technologies applied for food design: Status and prospects," *Journal of Food Engineering*, vol. 179. pp. 44–54, 2016. doi: 10.1016/j.jfoodeng.2016.01.025.
[12] J. I. Lipton, M. Cutler, F. Nigl, D. Cohen, and H. Lipson, "Additive manufacturing for the food industry," *Trends in Food Science and Technology*, vol. 43, no. 1. pp. 114–123, 2015. doi: 10.1016/j.tifs.2015.02.004.
[13] J. Sun, Z. Peng, W. Zhou, J. Y. H. Fuh, G. S. Hong, and A. Chiu, "A Review on 3D Printing for Customized Food Fabrication," in *Procedia Manufacturing*, 2015, vol. 1, pp. 308–319. doi: 10.1016/j.promfg.2015.09.057.
[14] Q. Yan *et al.*, "A Review of 3D Printing Technology for Medical Applications," *Engineering*, vol. 4, no. 5. pp. 729–742, 2018. doi: 10.1016/j.eng.2018.07.021.
[15] B. I. Oladapo, S. O. Ismail, T. D. Afolalu, D. B. Olawade, and M. Zahedi, "Review on 3D printing: Fight against COVID-19," *Mater. Chem. Phys.*, vol. 258, 2021, doi: 10.1016/j.matchemphys.2020.123943.
[16] D. H. Ballard *et al.*, "Clinical Applications of 3D Printing: Primer for Radiologists," *Academic Radiology*, vol. 25, no. 1. pp. 52–65, 2018. doi: 10.1016/j.acra.2017.08.004.
[17] Y. Ma *et al.*, "Three-dimensional printing for heart diseases: clinical application review," *Bio-Design and Manufacturing*, vol. 4, no. 3. pp. 675–687, 2021. doi: 10.1007/s42242-021-00125-8.
[18] A. Vanderploeg, S. E. Lee, and M. Mamp, "The application of 3D printing technology in the fashion industry," *Int. J. Fash. Des. Technol. Educ.*, vol. 10, no. 2, pp. 170–179, 2017, doi: 10.1080/17543266.2016.1223355.
[19] Y. M. Kwon, Y. A. Lee, and S. J. Kim, "Case study on 3D printing education in fashion design coursework," *Fash. Text.*, vol. 4, no. 1, 2017, doi: 10.1186/s40691-017-0111-3.
[20] D.-R. Viziteu and A. Curteza, "3D PRINTING TECHNOLOGY IN TEXTILE AND FASHION INDUSTRY," *Fash. Ind.*, no. 3, pp. 41–44, 2021, doi: 10.30857/2706-5898.2020.3.2.
[21] J. Pernaa and S. Wiedmer, "A systematic review of 3D printing in chemistry education - Analysis of earlier research and educational use through technological pedagogical content knowledge framework," *Chemistry Teacher International*, vol. 2, no. 2. 2020. doi: 10.1515/cti-2019-0005.
[22] A. E. Ghazi and B. A. Teplitz, "Role of 3D printing in surgical education for robotic urology procedures," *Translational Andrology and Urology*, vol. 9, no. 2. pp. 931–941, 2020. doi: 10.21037/tau.2020.01.03.
[23] J. Yuen, "What Is the Role of 3D Printing in Undergraduate Anatomy Education? A Scoping Review of Current Literature and Recommendations," *Medical Science Educator*, vol. 30, no. 3. pp. 1321–1329, 2020. doi: 10.1007/s40670-020-00990-5.
[24] Beamler, "Business cases: 3D printing in the automotive industry," *Beamler*, 2018.
[25] T. Lecklider, "3D printing drives automotive innovation," *EE Eval. Eng.*, vol. 56, no. 1, pp. 16–19,

Accredited "Rank 4"(Sinta 4), DIKTI, No. 36/E/KPT/2019, December 13th 2019.

2017.
[26] inc. Stratasys, "Five Ways 3D Printing Is Transforming the Automotive Industry," *Tech Dir.*, vol. 77, no. 7, pp. 18–20, 2018.
[27] "EFFECT OF 3D PRINTING DIRECTION ON MANUFACTURING COSTS OF AUTOMOTIVE PARTS," *Int. J. TRAFFIC Transp. Eng.*, vol. 11, no. 1, 2021, doi: 10.7708/ijtte.2021.11(1).05.
[28] A. POSMYK and P. MARZEC, "Influence of 3d printing technology of automotive parts made of plastics on their tribological properties," *Tribologia*, vol. 294, no. 6, pp. 65–70, 2020, doi: 10.5604/01.3001.0014.8338.
[29] Kemenperin RI, "Dampak Pandemi Covid-19 Terhadap Industri Otomotif," *Kementeri. Perindustrian Republik Indones.*, pp. 1–35, 2021.
[30] M. S. Hakim and A. Kunaifi, "Peningkatan Kapabilitas Pengelolaan Keuangan UMKM Bidang Otomotif Melalui Pelatihan Pengelolaan Keuangan," *Sewagati*, vol. 2, no. 2, pp. 102–104, 2018, doi: 10.12962/j26139960.v2i2.4302.
[31] W. T. Couldwell *et al.*, "Computer-aided design/computer-aided manufacturing skull base drill," *Neurosurg. Focus*, vol. 42, no. 5, 2017, doi: 10.3171/2017.2.FOCUS16561.
[32] S. Wang and C. Qin, "Computer aided design and manufacturing of connecting rod mold," *Comput. Aided. Des. Appl.*, vol. 18, no. S1, pp. 65–74, 2020, doi: 10.14733/CADAPS.2021.S1.65-74.
[33] C. Lazo, "A Proof of Concept: Automatic 3D Segmentation for STL Teeth Models," in *ACM International Conference Proceeding Series*, 2019, pp. 21–24. doi: 10.1145/3383913.3383920.
[34] N. Ciobota, "Standard Tessellation Language in Rapid Prototyping," *Mater. Mech.*, vol. 7, no. 7, pp. 81–85, 2012.
[35] "Rapid Prototyping, Principles and Applications," *Assem. Autom.*, vol. 30, no. 4, 2010, doi: 10.1108/aa.2010.03330dae.001.
[36] R. Ahmad, M. I. Abu-Hassan, Q. Li, and M. V. Swain, "Three dimensional quantification of mandibular bone remodeling using standard tessellation language registration based superimposition," *Clin. Oral Implants Res.*, vol. 24, no. 11, pp. 1273–1279, 2013, doi: 10.1111/j.1600-0501.2012.02566.x.
[37] M. P. P, T. Sutrisno, P. Studi, T. Mesin, and U. Kristen, "PENGARUH VELOCITY STACK INTAKE TERHADAP PERFORMA KENDARAAN," pp. 1–7.