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Investigating the Performance of Embossing on Fins Wheel of Agricultural Tractor

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***Abstract*— The Fins wheel of the tractor was the most important part of a tractor to plough the field. Fins wheel was damaged due to lack of ability fins tractor wheels withstand bending loads as well as influenced by the age of the fin itself. This study was conducted to determine how the effects of embossing on the maximum bending load, deflection, ultimate tensile strength, and hardness which occur by using variations of the embossing number 1 and 2, and high embossing of 4, 5, 6 mm. The type of material used is JIS 3101 SS 400 with a thickness plate of 3.8 mm. This research was conducted by starting the design and press tool manufacture (punch & dies), manufacturing materials to be formed into fins wheel tractor, forming plates become fins wheel tractor, perform bending test to determine the maximum bending load strength and deflection that occurs. The experimental results showed that the finned wheel of the tractor which has two embossing with embossing height 6 mm would generate the smallest deflection of 4.93 mm and the maximum bending load of 4.0 kN. Fin wheel tractor with embossing can hold maximum bending loads greater than the soil pressure of 1.6 kN. Increasing the height of embossing will increase the hardness and ultimate tensile strength. The higher value of hardness and ultimate tensile strength was obtained at embossing height of 6 mm for 167,66 HB and 586,81 N/mm2 respectively.**

Keywords—Bending; Deflection; Embossing; Fins Wheel; Hardness

I. INTRODUCTION

Historically, the tractor was originally designed to replace the animals with a more powerful engine. Hand tractor used to pull of earth moving like a plough. As a means of earth moving, hand tractors have a high adaptability to land conditions in Indonesia. Hand tractors consist of several constituent components, one of which fin iron wheel tractor became one of the vital components of several components. This is because the iron wheel tractor fin serves to reduce soil compaction on agricultural land [1].

Ploughing is usually determined by the type of plant and the thickness of the upper soil layer. The depth of topsoil on the rice plant is approximately 18 cm; there was even a land to be ploughed more deeply about 20 cm [2]. The presence of hard stones in the ground to be a problem for the Plough used, it will give significant detainees against fin tractor wheels so it can make the fin wheel tractor into a curve.

The cost can be reduced by using a thin metal sheet from a normal plate [3]. It needs to be improved the strength and stiffness by making some bending and reinforcement. Testing can be done with the help of experiments and software for various types of sheet metal with the embossing method. The results showed that the method is used to improve the stiffness of the sheet plate. Furthermore, the increasing the rigidity must consider several parameters such as the number, position, height and spacing of embossing. This technique did not only emphasise the increasing rigidity of the sheet metal, but it could be to make sheet into desired shapes such as panels, car doors, and part - another spare [4, 5].

Muhammad Arsyad Suyuti has developed a bending tool which can also be used for forming the fin wheel tractor hands. Bending tool using a hydraulic system with a bending stage, and two embossing shaped radius as reinforcement [6]. Fins are produced according to the required dimensions, and fin wheel has to emboss as reinforcement, so it was not easy to warp and become stronger. However, the manufacturing fin wheel of the tractor has not performed an analysis of the effect of embossing to the strength of the finned wheel of tractor hands. This paper aims to determine the hardness and bending strength fins wheel for embossing radius shaped with high variation and the amount of embossing.

II. FINS WHEEL OF TRACTOR

As a reference, the type of tractor used was a specification tractor with G600 Quick brands and using RD8r Kubota engine. These hand tractors using the finned wheel to operate in the agricultural areas. These fins wheel presses into the ground and brings the forces acting on fins wheel.

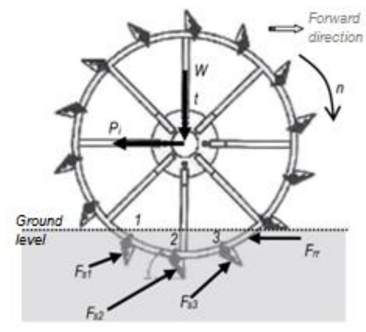

Fig. 1. The forces acting on the fins wheel

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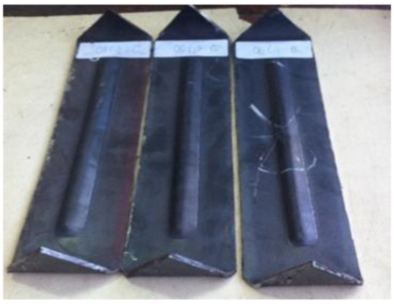
Reaction force vertical direction exceeds the weight of the tractor and wheel (325 kg) for one wheel which is 162.5 kg (1.6 kN). Horizontal ground reaction force direction is not less than the tensile load and wheel roll resistance force of 0.9 kN on one wheel. The compressive force was assumed to 0.6 from the ground reaction forces against the pressure plate, noting that at the time of measurement plate hit the ground intact [7].

III. EXPERIMENTAL METHOD

The materials used for the manufacture of fins wheels was a low carbon steel with a length of 270 mm and a width of 80 mm to a thickness of 3.8 mm plate. Making the specimens was performed using a grinding machine in the Workshop Welding of Politeknik Negeri Ujung Pandang. These specimen was formed by press equipment hydraulic jack with using a press tool equipped with a punch and dies. All of the processes were conducted in the Mechanic Workshop.

IV. RESULT AND DISCUSSION

Fins wheel tractor that has been established was released from the dies and obtained the results as shown in Fig. 2, then followed by measuring the height of embossing.



(a)

(b)

Fig. 2. Fins wheel with a) one embossing and b) two embossing

Before it shaped, the material of fins wheel has been tested with the hardness HB 121.08 and the ultimate tensile strength (UTS) 417.97 N/mm^2. Koda et al. were performed hardness testing to determine the effect hardness material on cutting performance of TiAlN and CrAlN coated carbides [8]. Wang et al. were using the data of ultimate tensile strength and elongation of the material of additive manufacturing were still less than an annealed 304L plate [9].

Fins wheel tractor that has been given embossing was performed the hardness testing by using Brinnel method with a diameter of indenter 2.5 mm, long loading 10 seconds and a given load is 1840 N. Hardness testing was conducted at 13 points as shown in Fig. 3.

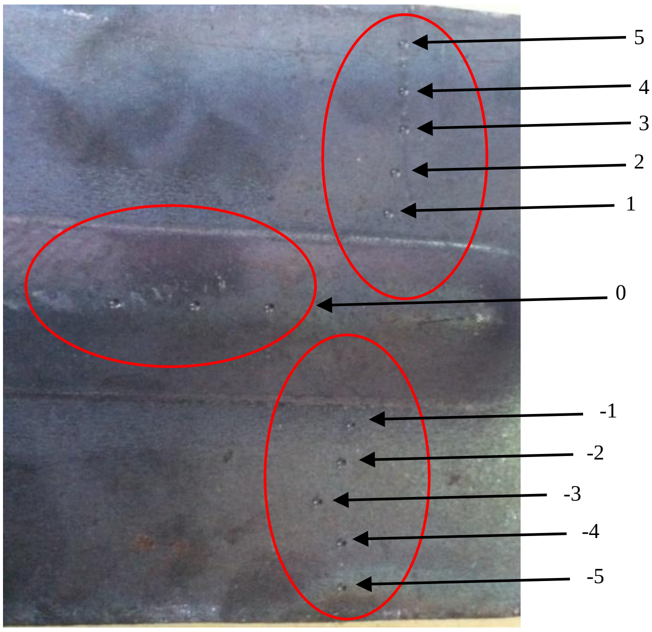


Fig. 3. Penetrating point on the fins wheel tractor

The red circles were the penetrating points of hardness test. The data of hardness obtained are shown in Table 1.

TABLE I. HARDNESS RESULT ON FINS WHEEL OF RADIUS AND TRIANGLE MODEL EMBOSSING WITH A HEIGHT OF 4, 5, AND 6 MM

Penetration Point	**Average of Hardness Brinnel (HB)**		
	Embossing Height of 4 mm	***Embossing Height of 5 mm***	***Embossing Height of 6 mm***
5	133,1	138,3	130,8
4	131,5	131,9	129,4
3	129,7	131,0	129,5
2	125,3	124,4	127,8
1	129,9	138,6	131,8
0	156,4	160,3	167,7
-1	133,9	137,1	136,8
-2	130,3	130,3	126,8
-3	133,1	127,4	129,5
-4	135,1	134,5	132,4
-5	133,5	138,6	138,3

From the results obtained hardness value to facilitate in determining embossing which has a hardness greater, then the data are presented in graphical below:

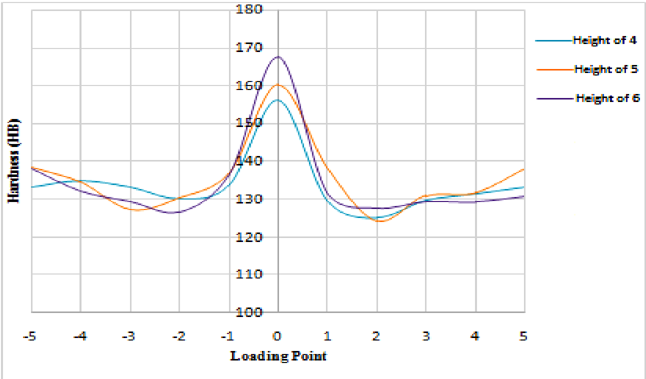


Fig. 4. Graph of hardness for embossing of radius model

Based on Fig. 4, it found that hardness will increase very significantly occurs in the embossing at fin wheel of a tractor. High of embossing was affect the hardness, which is the upper embossing it will make the metal plate became harder. Testing on the fins wheel performed to determine the tensile strength and hardness of the embossing that can be seen in the table equal tensile strength and hardness of steel. The equation results of tensile strength and hardness embossing are shown in Table 2:

TABLE II. THE POWER OF EMBOSSING BASED ON THE EQUATION OF ULTIMATE TENSILE STRENGTH (UTS) AND HARDNESS

No	Type of Embossing	Embossing Height	Hardness (HB)	UTS (N/mm2)
1	Radius	4	156,41	547,435
2	Radius	5	160,33	561,155
3	Radius	6	167,66	586,81

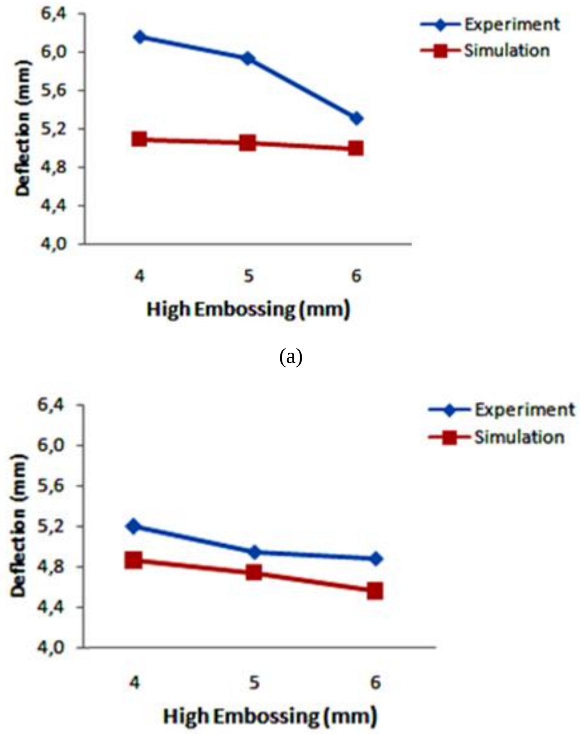
From the results of the equation table for tensile strength and hardness, it can be seen that the ultimate tensile strength of the fin wheels material before embossing was 417.97 N/mm^2, and after formed by embossing 547,435 to 586,81 N/mm^2. The resulting deflection of Autodesk Inventor 2014 software has a difference with experimental results bending test. There are shown in Table 3.

TABLE III. THE STRENGTH OF EMBOSSING BASED ON THE EQUATION OF ULTIMATE TENSILE STRENGTH (UTS) AND HARDNESS

No	Embossing of fin tractor wheels			F max (kN)	Experiment Deflection (mm)	Simulation Deflection (mm)
	Type	*Qty*	*Height*			
1	Radius	1	4	2,583	6,16	5,078
2	Radius	1	5	3,166	5,93	5,045
3	Radius	1	6	3,500	5,31	4,984
4	Radius	2	4	2,966	5,26	4,909
5	Radius	2	5	3,200	5,00	4,779
6	Radius	2	6	4,000	4,93	4,590
7	none	none	none	1,766	6.53	5.145

The bending test results show that the fins wheels of the tractor without embossing only able to hold a maximum load of 1,766 kN compared with the embossing of 2,583 kN to 4.0 kN. The test results also show that the finned wheel of the tractor with embossing can hold a larger load than the soil pressure (1.6 kN).

The results of the experiment deflection were higher than the deflection simulation. The maximum force of experimental results was applied to the simulation using Autodesk Inventor software. It is intended to determine the deflection occurring based on simulation. Comparison between simulation and experiment are presented in graphical form as follows:



(b)

Fig. 5. Results of deflection between simulation and experiment for (a) 1 embossing and (b) 2 embossing

Based on Fig. 5, the deflection simulation was a smaller value than experimentally. Moreover, also the two embossing smaller deflection of the deflection of the one embossing this shows that the two embossing wheel tractor fin was more rigid than a single embossing.

Process parameters affect the embossing produced both experimentally and simulated. The use of simulation can be utilised as a testing to determine the effect of fabrication error [10]. This is in line with the results of research conducted by [11], which states that the pressure in the workpiece can be reduced and the feature depth can be increased in the embossing process assisted with the high-density electric current. In the other study, Vivek et al. stated that the aluminium plate AA2024-T3 could be embossed in a die with different depth [12]. Mai et al. presented that an embossing process that can be done in a continuous and discontinuous mode in a roll-to-roll embossing process with micro-pattern replication with feature size up to 0.5 μm [13].

Cultivation of agricultural land needs to be done wisely by considering the aspects of the farm land. For the case of rice cultivation on farmland can be done by using a plough like a tractor, but fertiliser is also required to improve soil quality and fertilise agricultural land [14, 15]. Improvement of farmland can be made by examining surface soil samples which are then collected and analysed to determine the total concentration of certain elements (e.g., Cd, Cr, Cu, Fe, Mn, Ni, Pb, and Zn), before calculating the pollution index for each item [16].

This experiment can also be performed to calculate the power consumption for the bending process as well as was done by [17, 18]. They have analysed the use of the power consumption in the turning process of aluminium alloys.

V. Conclusion

The conclusion of this research is based on the data analysis of using bending and hardness test on the finned wheel of a tractor. For radius models embossing, bending loads occurring fin wheel tractors will be even greater by increasing the number and height of embossing. Fins wheel of the tractor has a number embossing 2 for models radius with height at the 4, 5, and 6 mm, and it can hold a bending load higher than the fin wheel tractor without embossing. The value of hardness on the fin wheel tractor will increase in the embossing zone. The top hardness value is obtained at hight embossing 6 mm. The fin wheel of the tractor with embossing was able to hold the maximum bending load (2,583 kN to 4.0 kN) and it was larger than a given load on the ground pressure (1.6 kN).

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References

[1] Hasnan, K. and A. Ab Wahab. First Design and Testing of an Unmanned Three-mode Vehicle. International Journal of Advanced Science, Engineering and Information Technology. 2(1): pp. 13-20, 2012.

[2] Smith, H.P. Farm Machinery and Equipment. Morse Press, 2011.

[3] Parameswaran, M.A. Mechanical Design: A Practical Insight. Alpha Science International Limited, 2016.

[4] Namoco Jr, C.S. Improving the Rigidity of Sheet Metal by Embossing and Restoration Technique. Mindanao Journal of Science and Technology. 8: pp. 25-34, 2010.

[5] Namoco Jr, C.S. Investigation of Sheet Metals Subjected to Simultaneous Embossing on Both Sides Utilizing Multiple Punches. Mindanao Journal of Science and Technology. 11: pp. 21-36, 2013.

[6] Suyuti, M.A., R. Nur, and Asmeati. The Influence of Punch Angle on the Spring Back during V-Bending of Medium Carbon Steel. in Advanced Materials Research. Trans Tech Publ, 2015.

[7] Hermawan, W., A. Oida, and M. Yamazaki. Measurement of soil reaction forces on a single movable lug. Journal of Terramechanics. 33(2): pp. 91-101, 1996.

[8] Koda, R., H. Usuki, M. Yoshinobu, K. Morishita, S. Koseki, K. Inoue, and M. Hagino. Effect of Work Material's Hardness on Cutting Performance of TiAlN-and CrAlN-Coated Cutting Tools. in Key Engineering Materials. Trans Tech Publ, 2015.

[9] Wang, Z., T.A. Palmer, and A.M. Beese. Effect of processing parameters on microstructure and tensile properties of austenitic stainless steel 304L made by directed energy deposition additive manufacturing. Acta Materialia. 110: pp. 226-235, 2016.

[10] Ab-Rahman, M.S., F.S. Ater, K. Jumari, and R. Mohammad. Study of Periodic Fabrication Error of Optical Splitter Device Performance. International Journal on Advanced Science, Engineering and Information Technology. 2(1): pp. 24-27, 2012.

[11] Xu, Z., L. Peng, and X. Lai. Electrically assisted solid-state pressure welding process of SS 316 sheet metals. Journal of Materials Processing Technology. 214(11): pp. 2212-2219, 2014.

[12] Vivek, A., R. Brune, S. Hansen, and G. Daehn. Vaporizing foil actuator used for impulse forming and embossing of titanium and aluminum alloys. Journal of Materials Processing Technology. 214(4): pp. 865-875, 2014.

[13] Mai, J., L. Peng, X. Lai, and Z. Lin. Electrical-assisted embossing process for fabrication of micro-channels on 316L stainless steel plate. Journal of Materials Processing Technology. 213(2): pp. 314-321, 2013.

[14] Haque, M., R. Bell, A. Islam, K. Sayre, and M. Hossain. Versatile multi-crop planter for two-wheel tractors: an innovative option for smallholders. 2011.

[15] Hermawan, B., E. Suparjo, K.S. Hindarto, R. Silalahi, and F. Barchia. A Quick Dielectric Method to Determine Insitu Soil Water Content for Precision Water Use under Sustainable Agricultural Practices. International Journal on Advanced Science, Engineering and Information Technology. 7(3), 2017.

[16] Cheraghi, M., B. Lorestani, and H. Merrikhpour. Investigation of the effects of phosphate fertilizer application on the heavy metal content in agricultural soils with different cultivation patterns. Biological trace element research. 145(1): pp. 87-92, 2012.

[17] Nur, R., M. Noordin, S. Izman, and D. Kurniawan. Power Demand Calculations in Turning of Aluminum Alloy. Advanced Materials Research. 845: pp. 786-789, 2014.

[18] Nur, R., M.A. Suyuti, and T.A. Susanto. Optimizing cutting conditions on sustainable machining of aluminum alloy to minimize power consumption. AIP Conference Proceedings. 1855(1): pp. 020002, 2017.