International Journal of Engineering and Applied Technology (IJEAT)
Vol. 1 | May 2018
ISSN: 2620-9632

Load Static Simulation of Transmission Rod for Design of Chinese Spinach (*Ipomoea Reptans Poir.*) Harvester

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Abstract

The harvesting machine for Chinese spinach (*Ipomoea reptans* Poir.) has never been designed. Moreover, appropriate technology is needed for Chinese spinach farmers in Indonesia. Therefore, this paper begins by developing the concept of Chinese spinach harvesters integrated with hand tractors. One of the most important parts of this integration process is the part of the transmission system that connects the power source to the harvesting unit. The proposed design concept is to use a rod transmission system. The transmission of the rod becomes crucial, so it is essential to perform dimensional analysis and determine its material type. Therefore, this study is to simulate the rod of the transmission system through load static simulations approach. Load static simulations run with the help of CAD applications. The material tested consisted of AISI 1010, AISI 1020, AISI 4340 with a material thickness of 2 mm, 4 mm and 5 mm respectively. The simulation results show that the AISI 1020 meter is better to use with a thickness of at least 2 mm. This result is also supported by an analysis using the laws of classical mechanics which state that the minimum thickness of the transmission rod is 0.6692 mm. The power to be transmitted to the harvesting machine is 1.3 hp.

Keywords: load static simulation, rod, CAD, chinese spinach, harvester

1 Introduction

Chinese spinach (*Ipomoea reptans* Poir.) is a trendy vegetable today in Indonesia. This plant can grow in various land and climate conditions so that vegetable farmers in Indonesia like to do cultivation. Besides, the plant does not require intensive care. Consumer demand for vegetables is also relatively stable both in traditional markets and supermarkets. In general, these vegetables are sold with price range Rp 1500 - Rp 3000 per 300 gr.

Things that have not been developed in the process of vegetable cultivation is handling technology. This happens from the pre-harvest process to the post-harvest of these vegetables. Vegetable farmers are doing soil processing and making landfill still using hoes. On the other hand, soil tillage and bundling equipment have been developed in other plant species such as Sitorus *et al.* (2017a) and Sitorus *et al.* (2017b) for corn crops. However, it is important to make adjustments to such mechanization equipment. Likewise with the harvesting process, Chinese spinach farmers generally still use the sickle. In that case, the soil processing equipment used in the pre-harvest (hand tractor) can be used as multifunctional equipment. The source of such hand tractor traction can be integrated with the harvesting unit. This makes the mechanization equipment for Chinese spinach plants more useful.

One of the crucial parts in the process of integrating hand tractor equipment with its implementation is the transmission system (Bukashkin *et al.* 2017; Didikov *et al.* 2017). This is important because it involves channeling power from the engine to the unit to be driven in the implementation. On the other hand, hand tractors are also not a type of tractor that has PTO. This becomes a complex design when using a hand tractor as a driving power source.

Various types of transmission systems have been widely developed (Paul *et al*. 2013; Akinnuli *et al.* 2015; Sitorus et al 2019). One form of a transmission system that researchers are interested in is to apply the type of transmission system rod. This is a concern because this system does not require a large space so that it suits the conditions of hand tractors. The system also looks more practical when assembling and disassembling. Furthermore, the crucial is to determine the dimensions and materials used in the transmission rod. It is important to do before fabrication to reduce the risk of failure in the manufacturing process.

Approach load static simulation is one method that can be used to predict the strength of a material. This simulation utilizes the Finite Element Method (FEM) as the equation it uses. According to several researchers (Zaccariotto *et al.*

2018, G.Ortiz-de-Zarate *et al.* 2018; Chaofeng Zhang et al 2018), this method is good enough to reduce the risk of failure in fabricating an apparatus. The load static simulation approach can generate stress analysis, displacement analysis, and strain analysis parameters visually to be analyzed further. Therefore, the purpose of this study is to simulate the transmission system rod from the Chinese Spinach harvester.

2 Methodology

2.1 Research Procedure

Simulated material for transmission rod design is AISI 1010, AISI 1020, AISI 4340. The selection of several types of AISI standards is based on the availability of readily available materials in Indonesia. Material characteristics are presented in Table 1.

Table 1 Characteristics of AISI materials used in a simulation

Karakteristik	**AISI 1010**	**AISI 1020**	**AISI 4340**	**Unit**
Yield strength	180	350	710	Mpa (N/mm^2)
Tensile strength	325	420	1110	Mpa (N/mm^2)
Mass density	7870	7870	7,850	Kg/m^3
Elastic modulus	200,000	205,000	205,000	Mpa (N/mm^2)
Poisson's ratio	0.29	0.29	0.32	-

2.2 Laws of Classical Mechanics Analysis

The laws of classical mechanics are used to verify the size of the thickness of the material used (Bulat *et al.* 2017; Khurmi and Gupta 2005). Transmission of pipe-shaped rods with both ends is flanged. The length of the transmission rod is 140 mm in outer diameter (d) 25.4 mm. The distance between the center of the transmission rod to the flange loading center is (L) 247 mm. The transmission angle of the rod is maximum is 60 °. The load to be borne by the transmission rod is a minimum of (b) 30 × one-piece Chinese spinach (Tp_{cs}) cut resistance. Cutting resistance of one piece of Chinese spinach is 0.85 kgf. The value of the safety factor coefficient (S_f) used is 1.5. Conceptual transmission rod harvester is shown in Figure 1.

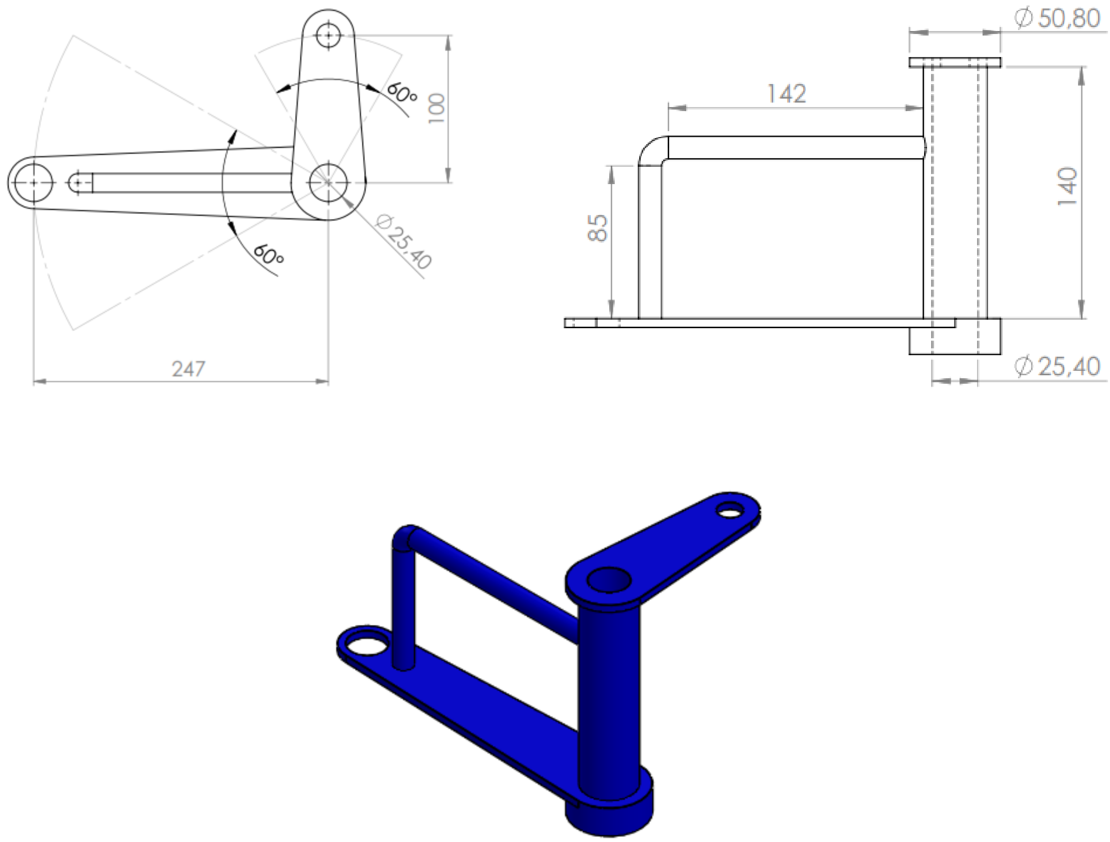

Figure 1 Conceptual transmission rod harvester

The total force received by the transmission rod can be calculated using Equation 1 (Persson 1987). The received moment up to the center of the transmission rod is computed using Eq. 2. The cross section modulus of the estimated moment is calculated using Eq. 3. The type of transmission rod used is a hollow shaft. The relation of the sectional modulus to the diameter of the transmission rod can be calculated using Eq. 4. The minimum thickness of the transmission rod is calculated by Equation 5. Power requirement for cutting spinach chines can be calculated using Equation 6.

$$F = Tp_{cs} \times b \times s_f \tag{1}$$

$$M = F \times L \tag{2}$$

$$Z = \frac{M}{\sigma_i} \tag{3}$$

$$Z_{xx} = Z_{yy} = \frac{\pi\left(d^4 - d_1^4\right)}{32d} \tag{4}$$

$$t = d - d_1 \tag{5}$$

$$P = \left(F \times L\right) \times \frac{2\pi \cdot n}{60}$$

2.3 Load Static Simulation

The Static simulation was conducted to know the strength or the ability of a material to receive the load, and its can support engineering design analysis. Its drawn with Solidworks software helped. Solidworks is one of CAD software to create engineering drawing and do some simulation. Solidworks can do one of simulation is static load simulation. The design has been analyzed and right following the engineering design criteria then its called the conceptual model. After that, its generate in the form of detailed engineering drawings.

3 Results and Discussion

3.1 Conceptual Machine Harvester

Conceptual Chinese spinach harvesters are presented in Figure 2. The length of the hand tractor and harvesting equipment is 2240 mm with the height of the blade of the ground 224 mm. The height of the blade can be adjusted to the needs of Chinese spinach to be cut. The harvester portion of the equipment is integrated into the front of the hand tractor. The transmission system used is a pulley-belt-crank connected to the cutting blades. The cutting knife consists of a dynamic cutter and a static cutter. The number of knives is 30 pieces with a total length of one meter.

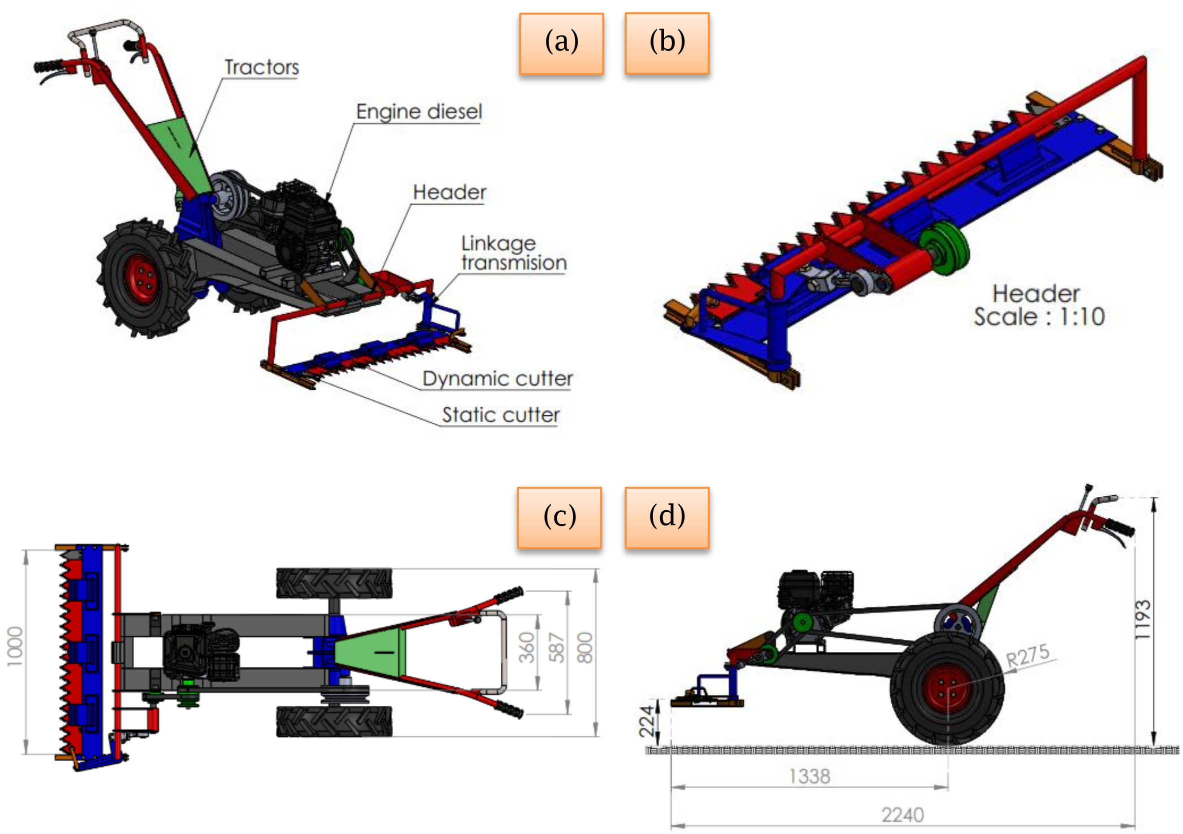

Figure 2 Harvesters chinese spinach (a) conceptual isometric design (b) harvester header (c) top view (d) side view

3.2 *The Need for Thick Transmission Rods and Analysis Power Requirement*

The result of the calculation through the classical mechanical law approach obtained by the total force (*F*) received by the transmission rod is 375.23 N. The moment received by the transmission rod (*M*) is 92,681.81 N·mm. The material permit voltage used (σ_i) is 58 kg / mm^2, so the cross-sectional modulus is (*Z*) of 162.89 mm^3. The outer diameter of the transmission rod (*d*) used is 25.40 mm to obtain a diameter in the transmission rod (d_1) of 24.73 mm. The minimum thickness of the transmission shaft (*t*) required is 0.6692 mm. The power supplied by the engine (*P*) with a rotation speed (*n*) 100 rpm to the harvester via the transmitting rod is 970 watts (1.30 hp).

3.3 Stress Analysis

The simulation results of the transmission rod stress parameters at maximum and minimum conditions are presented in Figure 3 and Figure 4, respectively. At the maximum requirements, it is known that any rod material that is tested to be simulated decreases the stress on increasing the thickness of the transmission rod. At minimum conditions, it is understood that there is an increase in stress if the thickness of the transmission shaft is increased. This phenomenon indicates that the 2 mm transmission bar stem with AISI 1010 and AISI 1020 type materials is better than AISI 4340 when subjected to loading. It also shows that 2 mm of material thickness is more likely to be selected as transmission bar material when viewed from stress parameters.

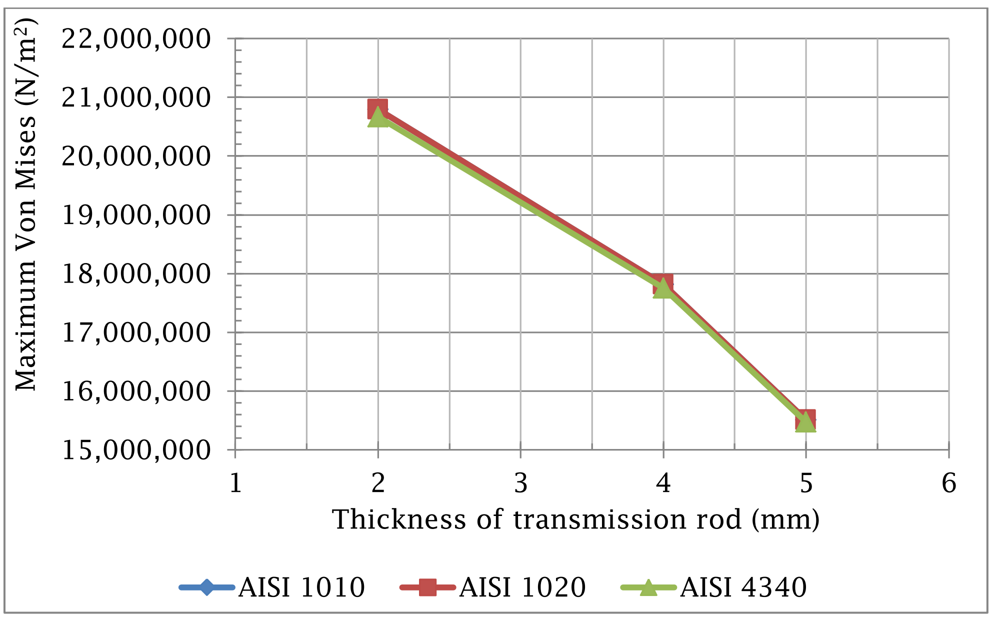

Figure 3 Simulations maximum Von Mises (N/m^2) of transmission rod

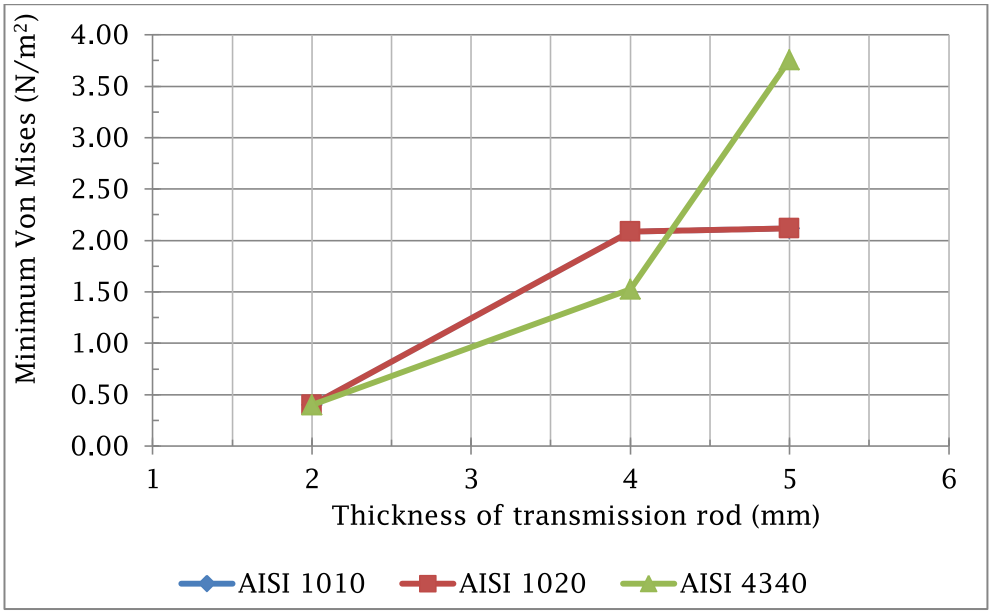

Figure 4 Simulations minimum Von Mises (N/m^2) of transmission rod

3.4 Displacement Analysis

The simulation result of parameter displacement analysis is shown in Figure 5. These results indicate that there is a decrease in displacement if the thickness of the transmission rod is added. This is following the results of Bulan *et al.* (2017) which states that the displacement phenomenon will decrease along with the thickness of the added material under the same loading conditions. This parameter also indicates that the AISI 1020 material has a better potential to be applied to the transmission rod. For the chosen suit is 2 mm although with 5 mm thickness has a lower displacement. This is because the difference of displacement between the thickness of 5 mm and 2 mm is not significant at 1.048%.

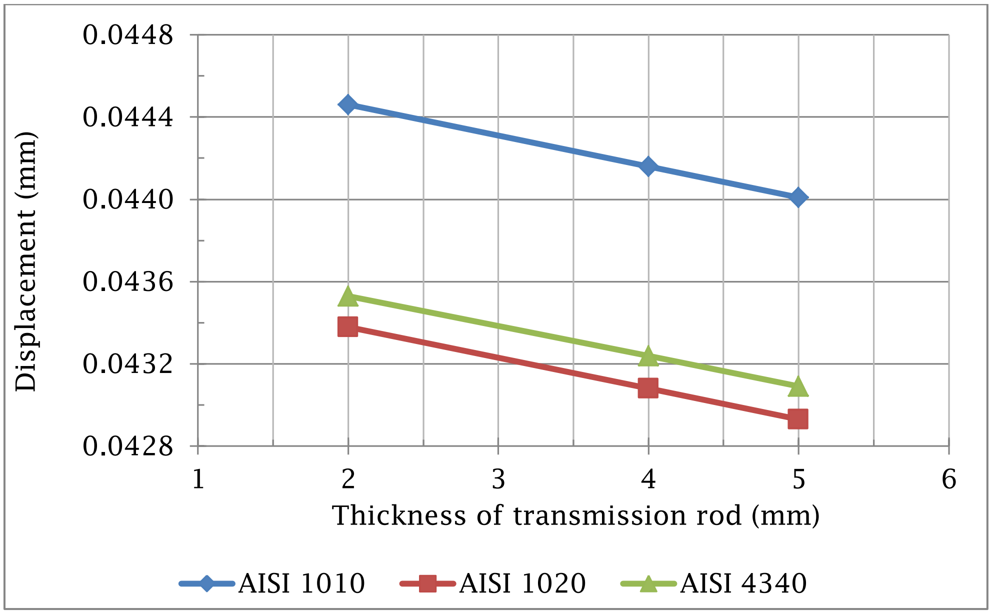

Figure 5 Simulation displacement of the transmission rod

3.5 Strain Analysis

The simulation results of strain analysis parameters at maximum and minimum conditions are presented in Figure 6 and Figure 7, respectively. At maximum strain conditions, it can be seen that the thicker the transmission rod will give the smaller strain as well. In contrast to that, under minimum strain conditions, the more compressed states of the transmission rod give greater strain. However, when examined more deeply, AISI 1020 material provides a smaller strain condition than other materials at all levels of thickness. This indicates that the AISI 1020 material is more potential for use in all material thickness conditions.

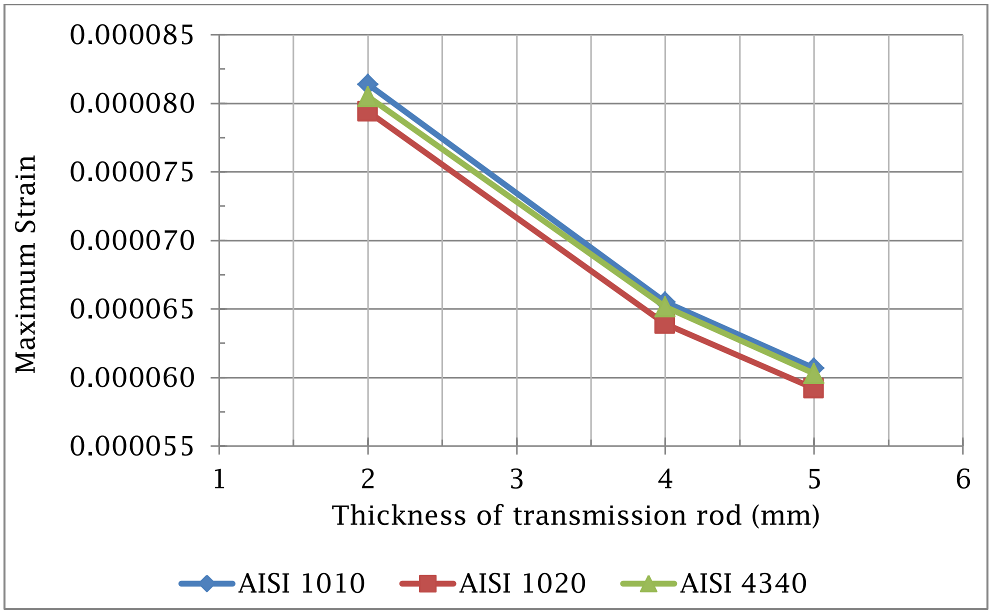

Figure 6 Simulasi maximum strain of transmission rod

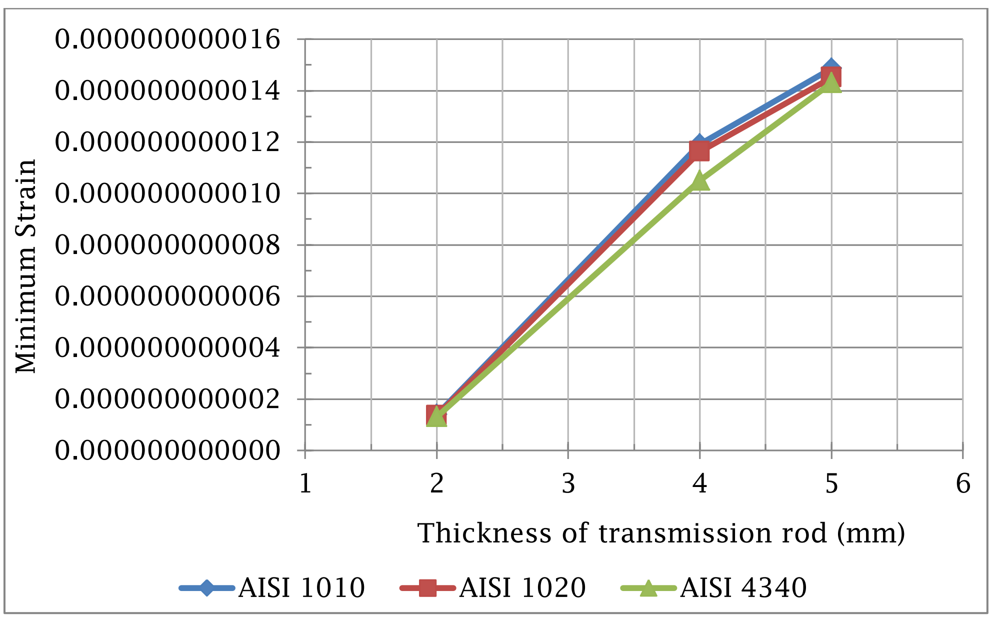

Figure 7 Simulasi minimum strain of transmission rod

4 Conclusion

Conceptual Chinese spinach harvesters have been designed with the focus of analysis on this paper is the transmission rod. The harvesting machine will be integrated with hand tractor. The number of Chinese spinach rods that can be harvested in one harvest path is 30 pieces. Analysis of the classical mechanical law approach found that it required a force to cut the 30 Chinese spinach bars to be 375.23 N. The power to be transmitted by the hand tractor to the harvesting machine is 1.3 hp. With that much power than the required transmission rod thickness of at least 0.6692 mm. Static load simulations verify the results of this classical mechanics law. The results show that the AISI 1020 material type can be used as transmission material with a thickness of 2 mm.

References

Akinnuli, B.O., C.O., Osueke, P.P., Ikubanni, O.O., Agboola, A.A. Adediran. 2015. Design Concepts Towards Electric Powered Gari Frying Machine. International Journal of Scientific & Engineering Research (IJSER). 6(5): 1043-1051.

Bukashkin A. Yu, R. Yu. Dobretsov, Yu. V. Galyshev. Split Transmission of Tractor with Automatic Gearbox. Procedia Engineering. 206: 1728-1734.

Bulan R, Safrizal, T. Saiful Bahri. 2017. Conceptual Design Portable Chopper Machine for Palm Oil Frond : Laws of Classical Mechanics and CAD Approach. International Journal of Scientific & Engineering Research. 8 (6): 120-126.

Didikov R.A., R. Yu. Dobretsov, Yu. V. Galyshev. Power Distribution Control in Perspective Wheeled Tractor Transmission. Procedia Engineering. 206: 1735-1740.

Khurmi, R. S., Gupta, J. K. 2005. Machine Design. S. Chand.

Ortiz-de-Zarate G., A. Madariaga, A. Garay, L. Azpitarte, I. Sacristan, M. Cuesta, P.J.Arrazola.2018. Experimental and FEM analysis of surface integrity when broaching Ti64. Procedia CIRP. 71: 466-471.

Persson S. (1987). Mechanics of cutting plant material. st. Joseph Michigan. An ASAE Monograph.

Paul, S., Pawan G., Milan, S., Navmesh, S. 2013. Conceptual Design and Development of Automated Drilling system. International Journal of Scientific & Engineering Research (IJSER). 4(7): 1138-1142.

Sitorus A, Wawan H, Radite P.AS. 2017a. Design and performance of combine corn transplanter powered by hand tractor. International Conference on Computing, Engineering, and Design (ICCED), IEEE.

Sitorus A, Dewi Sartika T. 2017b. Analysis of design combine transplanter power by hand tractor: Transmission system and furrow opener," International Conference on Computing, Engineering, and Design (ICCED), IEEE.

Zaccariotto M, Teo Mudric, Davide Tomasi, Arman Shojaei, Ugo Galvanetto. 2018. Coupling of FEM meshes with Peridynamic grids. Computer Methods in Applied Mechanics and Engineering. 330 (1): 471-497.

Zhanga C, Longfei Wang, Chuan Sun, Meiping Wu. 2018. Feasibility of the evaluation of the deformation capacity of the shear panel damper by FEM. Journal of Constructional Steel Research. 47: 433-443.