KINEMATIC ANALYSIS OF MONOBIKE MECHANICAL TOYS USING SOLIDWORKS

by Santoso Eko Budi

KINEMATIC ANALYSIS OF MONOBIKE MECHANICAL TOYS USING SOLIDWORKS

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ABSTRACT

Society 5.0 allows the use of cyber technology, in all aspects of life, including the toys industries. Three-dimensional printers as a key of the Society 5.0 agent the urgent role as a blueprint for products according to their original designs. Before it is printed using a three-dimensional printer into a product that ready for the market, the first is simulated to determine whether the toy is able to move based on the kinematics movement that we've designed. In this study determined toy that can mimic the motion of an object as precisely as possible, namely monobike that pedaling a bicycle. The research objective is to analyze the movement of monobike components theoretically and simulation using Solidworks software. This analysis includes linear and angular displacement, velocity, and acceleration of the monobike component which is limited to the third link. The methodology in this study is: Determine the dimensions and the drive component of monobike. Furthermore make a monobike kinematic diagram, and analyze the kinematic by using the vector position. Then simulate displacement, velocity, and acceleration using Solidworks, and analyze the kinematic motion specially of link 3. The linier displacment of link 3 is the farthest at 18.38 mm, and one cycle of motion takes 120 seconds. The maximum linear velocity of the monobike mechanical toys is 36.2 mm / sec. The maximum angular velocity of monobike mechanical toys is 183.95 deg/sec. Than the maximum angular acceleration of monobike mechanical toys is 854.55 deg/sec^2. Solidworks is recommended software that can be used to simulate the motion in kinematic analysis.

Keywords: Acceleration, Displacement, Kinematic, Monobike, Velocity

1. INTRODUCTION

Society 5.0 is characterized by cyber-physical systems which require humans to be connected with all things, for example with other humans, industrial machines, and with everything around them without any restrictions. In addition, between machines and other devices and equipment can also be connected to one another. In essence, all physical systems are interconnected through virtual processes and cyber systems. It is hoped that with the 4.0 industrial revolution it will be able to significantly increase productivity. The key technologies that marked the course of the industrial revolution 4.0 were the Internet of Things (IoT), Advanced Robotics, Artificial Intelligence, Human Machine Interface, and 3D Printing. 3D printing is emphasized here, because with a 3D printer can make a variety of toys, accessories, spare parts, sculptures, and also medical devices such as prosthetic limbs.

The domestic toy industry is predicted to grow by 10 percent in 2019, according to the Chairman of the Children's Toys Association (AMI) Sutjiadi Lukas (Deny, 2019). This has become a very promising market for the domestic toy industry. Toys can indeed provide a good process in the process of learning and child development. Director of Early Childhood Development Research Fisher Price, Deborah Weber (Gloria, 2019) views the importance of the STEM methods, namely Science, Technology, Engineering (Engineering), and Mathematics in the development of early childhood toys. The STEM method will stimulate children to solve problems, focus on solutions, build logical and systematic thinking, and sharpen critical thinking skills.

Generally, toys that can stimulate children's creativity and thinking are toys that can provide a variety of benefits from one such device. Mechanical toys are toys that utilize most of the mechanical processes that can be found in almost every machine such as cams, gears, ratchets and cranks (Zhu et al., 2012). There are several important steps to determine toys according to the child's age group, such as considering the physical, cognitive, social, and emotional aspects of the child (Gloria, 2019). At the age of 6-9 months, for example, when a child has begun to learn to move, the toys given must be able to hone a child's motor skills. There are several mechanical toys that have been sold in the market, for example the Code-A-Pillar toy from Fisher Price (Gloria, 2019), which has a shape like a caterpillar, and can be played on children aged three years and over. In this toy, children are challenged to arrange parts of the caterpillar's body with parts that have their respective directional functions. The child will be stimulated to analyze how the caterpillar can achieve certain goals with the proper arrangement of parts. This toy is an example of a mechanical toy utilizing technology for children's learning.

In this paper, the mechanical toy that will be discussed is Monobike (Juarez, 2016). Which is a toy in the form of a bicycle. Why was the bicycle chosen as a child's toy? Because cycling is the most popular activity for children. By cycling children practice to be brave, and develop gross motor skills (Masganti, 2015). Although cycling is a favorite activity, for children with special needs it is not easy. Cycling does require a certain level of balance and coordination so that for children who are not yet running smoothly and lack sufficient concentration and balance it will be difficult to use a bicycle.

his is what encourages researchers to develop research for children with special needs by using the media of one-wheeled bicycle toys, which are seen from the side of the movers (kinematics). Kinematics is the study of motion (H, Martin, 1985). The movement of an object is caused by a force of thrust. On a bicycle the thrust comes from the pedaling of the foot. The thrust carried out causes the vehicle which was initially stationary, to move with a certain acceleration and speed. In a Monobike mechanical toy, the driving force comes from the paddling of the foot which turns the pedal and moves up and down. The up and down pedal will turn the second wheel and cause the body of the doll holding the fan to move up and down. The Monobike mechanical toy is shown in Figure 1 below.

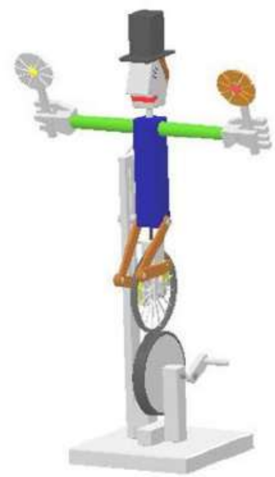

Figure 1. Monobike Mechanical Toys created from Solidworks (Juarez, 2016)

The main material for making this mechanical toy is PLA (Polylactic Acid) and is printed using a 3-dimensional printer, so it is very important to understand how the mechanism of action of the toy will be made. Making mechanical toys is an interesting thing, which includes a variety of skills, art, engineering and science. In making mechanical toys, it is still based on simple mechanics with one or more mechanisms.

The design of this product uses the Solidworks 2019 software tool (Chang, 2019). By using the Solidworks, product that has been drawn, it is simulated in advance to find out whether the toy product can move according to the kinematics movement that we have designed. After analyzing the kinematics, the next step is to synthesize that is to analyze the motion of each part of the planned mechanical toy based on the specified dimensions

(Wibowo, Sulardjaka, & Haryadi, 2015). Furthermore, toy products will be analyzed which include position and speed analysis using this software. While the force is not discussed here because the product is moved without acceleration and constant motion.

This paper discusses the application of mechanism in monobike mechanical toys (Juarez, 2016). Monobike chosen because bicycles can train children's motor skills and it is important in training the ability of concentration and balance in children (Desiningrum, 2016). Besides cycling is fun for children, so the manufacture of bicycles and bicycle-shaped toys are prospective activities in the toy industry.

Research Objective

The research objective is to analyze the component movements on Monobike theoretically and with Solidworks software simulation. This analysis includes the displacement, velocity, and linear and angular acceleration of the Monobike component. In this study the component movement analysis is limited to Link 3 in Figure 1.

2. METHOD

In this study determined toys that can mimic the motion of an object as precisely as possible, namely monobike mechanical toys. Monobike mechanical toys mimic human activities of pedaling a bicycle. The methodology in this research is as follows:

a) Determine the dimensions of the monobike component
b) Determine the monobike drive components
c) Make monobike kinematic diagrams
d) Perform kinematic analysis using the position vector of the monobike component
e) Perform kinematic analysis with Solidworks

3. RESULT AND DISCUSSION

Parts of a monobike mechanical toy are drawn with Solidwork as shown in Figure 2 below.

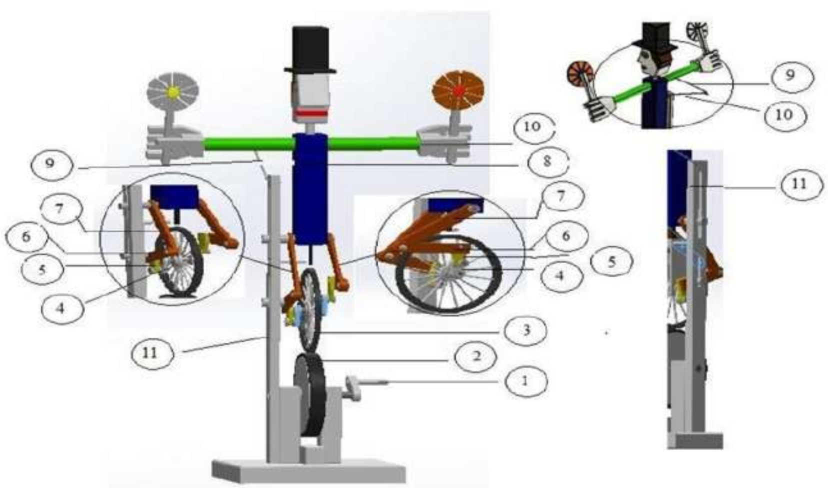

Figure 2. Monobike mechanical toys and their parts

Information :

1. lever	6. link 4
2. plates	7. link 5
3. wheels	4. link2
5. link 3	8. link 6
9. link 7	10. links 8
11. support	

Figure 2 explains the movement of monobike mechanical toys. Image detail to the right of figure 2, explains the left foot mechanism while pedaling a monobike. When the lever plates is turned one rotation (360□), it will move the wheel. Because both have the same diameter, the rotating plates moves the wheel one turn (360□) in the opposite direction. The movement can occur due to friction between the rotating plate and the wheel.

When the wheel was rotate 360□, the link 1 will rotate 360□. Link 1 and wheels are connected with a fix connection. Link 1 and link 2 are connected by pin connections. Link 1 moves rotation which will move link 2 which moves rotation and translation. Link 2 and link 3 are connected by pin connections. Link 2 moves link 3 which moves the rotation and translation.

Likewise, link 3 and link 4 that are connected by pin connections. Link 3 moves link 4 which also moves rotation and translation. While link 4 and the body are connected by a pin connection which is also connected to the support. Link 4 translates the body so that it moves up and down.

The movement of the right leg mechanism is the same as the left leg, but has a phase difference of 15o, shown in image detail to the left of figure 2. This is because link 1 left and link 1 right have a 180° angle difference so the links 2, 3, 4 left link and links 2, 3, 4 right have a 15° angle difference as shawn in Figure 3.

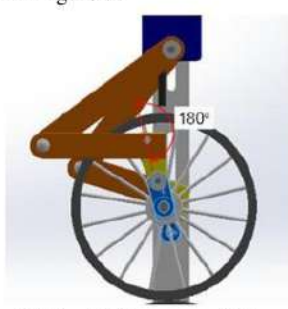

Figure 3. The Differences of Movement Phase in Mechanism Left and Right Leg

The mechanism that used in monobike mechanical toys, can be draw as the Kinematics Diagram in Figure 4 below.

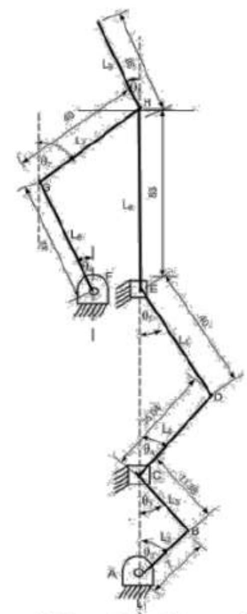

Figure 4. Monobike Kinematics Diagram

Table 1. Table Kinematics Analysis Using Solidworks

Angle θ2 (deg)	ω3 mm/sec	Vc mm/sec	Ac rad/sec2	α3 (deg)	ω3 mm/sec
0	8.976	36.667	149.621	-0.123	-1,225.485
30	13.135	43.273	-40.262	-109.110	-857.588
60	16.893	28.562	-238.091	-167.987	-348.173
90	18.380	0.153	-309.955	-184.534	2.315
120	16.888	-28.609	-237.806	-167.917	349.005
150	13.127	-43.281	-39.794	-108.938	858.725
180	8.969	-36.637	149.822	-0.053	1,225.485
210	6.129	-20.191	151.821	109.110	857.588
240	4.765	-8.057	94.406	167.987	348.173
270	4.380	-0.157	73.863	184.534	2.631
300	4.767	8.076	94.490	167.917	-349.005
330	6.133	20.221	151.940	108.938	-858.725
360	8.976	36.667	149.621	0.108	-1,225.485

Kinematics analysis in the above table is shown in the graph below:

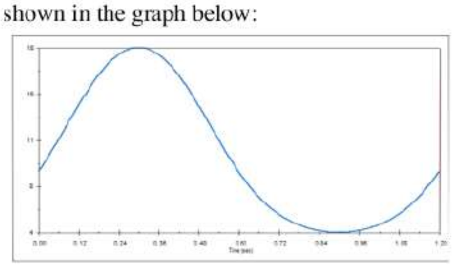

Figure 5. Linier Displacement of Monobike

Displacement is the end product of motion. It is a during a time interval under consideration. From figure vector that represents the distance between the starting 4 explain that the linier displacement of link 3 is the and ending positions of a point or link (Myszka, 2012).

Farthest at 18.38 mm, and one cycle of motion takes Linear displacement, is the straight line distance 120 seconds. Next, the graph of linear velocity is between the starting and ending position of a point explained in Figure 6.

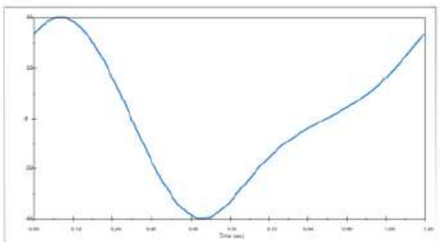

Figure 6. Linier Velocity of Monobike

Velocity analysis involves determining "how fast" Often the timing in a machine is critical Velocity is important because it associates mechanical toys is 36.2 mm / sec. the movement of a point on a mechanism with time. Often the timing in a machine is critical (Myszka, 2012). The maximum linear velocity of the monobike mechanical toys is 36.2 mm / sec.

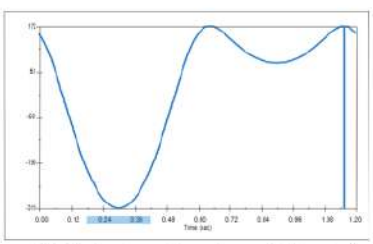

Figure 7. Linier Acceleration of Monobike

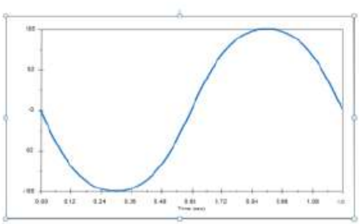

Figure 8. the maksimum angular.

Angular velocity of a link is the angular displacement velocity of monobike mechanical toys is 183.95 of that link per unit of time (Myszka, 2012). From deg/sec.

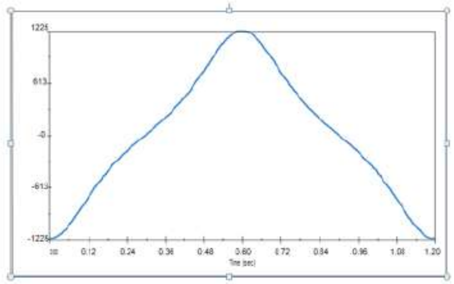

Figure 9. Angular Acceleration of Monobike

Angular acceleration is expressed in the units of angular velocity (angle per time) divided by time, or angle per squared time (Myszka, 2012). From Figure 9 we can explain that the maksimum angular acceleration of monobike mechanical toys is 854.55 deg/sec2

4. CONCLUSION

By using the Solidworks motion analysis model of the Crank and Linkage mechanism on a monobike mechanical toy can be simulated as planned.

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