e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:04/Issue:09/September-2022 Impact Factor- 6.752 www.irjmets.com

KINEMATIC ANALYSIS OF WALKING HUMNID GAIT

A. Durga Prasad*[1], B. Sandeep Kumar*[2], I.A. Vinay Kumar*[3]
*[1,2,3]Mechanical Engineering, Raghu Engineering College, India.

ABSTRACT

Many manmade machines and mechanisms, including robots and other mechanical functions based on the concept of nature inspired designs, so that they are performing according to the requirement of the design and copied animals or insect behaviour. Accordingly, walking robots use wheels and tracks to cross rough terrain efficiently and in a more stable way than conventional robots. Legged walking robots in particular remain in a discontinuous contact with the ground that provides them with the capability to select routes to avoid obstacles or holes. This article reports a study conducted on kinematic modelling and analysis of a walking machine (robot) leg mechanism that can operate on rough terrain. Its kinematic mechanisms were analysed. Symbolic computations are also implemented to parametrically optimize the motion parameters of the robot leg mechanism. The equation of motion was derived from the dynamic analysis using the Euler-Lagrange method which involves kinetic and potential energy expressions. Inorder to validate the performance of the robot leg mechanism and motion behaviours, the kinematic motion analysis was performed in solidedge. The leg mechanism used is effective for rough terrain areas because it is capable of walking on the terrain with different amplitudes in terms of surface roughness and aerodynamics.

Keywords: Walking Machine, Walking Robot, Kinematic Analysis, Motion Analysis, Denavit-Hartenberg, Rough Terrain.

I. INTRODUCTION

In early times humans are eagerly trying to develop the technology. at the inception they discovered the wheels for the transportation purpose and later they invented some advanced technology like robots to make work simple. In the evolution of the technology the word robot made the future very advanced and it helps the humans to discovered the robots. Later the human discovered the animal mimicking robots and human mimicking robots. This is the history of humanoid robots that helps to invent advanced version of humanoid gait. Recently, the interest in using robots that can mimic the natural motions of animals and insects to develop the robots that can improve productivity, safety, flexibility, controllability and accuracy, has significantly increased and is becoming more popular. Legged robot mechanisms in particular are nature-inspired models of cockroaches and insects [1]. With the support of powerful computers since the 1980s [2], in particular, the legged mechanisms of walking machines are being progressively developed because of their suitability for the applications that cannot be accomplished with tracked and wheeled walking machines. Recent developments have facilitated not only the design of the mechanisms, but also enabled effective control and automation of the complex motions of the mechanisms [3, 4]. Today's micro legged robots in their construction use the individual motor at each joint for actuation. The mechanisms were analysed by Rouleaux's [5, 6] primarily in machine elements, by studying their combinations and exposed those laws of operation from the early science of machine kinematics. In its work of "Theoretics Kinematic" of 1875, Rouleaux's [5, 6] Legged robot mechanisms in particular are nature-inspired models of cockroaches and insects in the one hundred years that followed Rouleaux's, the contributions of scientists such as Hartmann, et al. [7] developed the science of constructing mechanisms to satisfy specific motions, namely, kinematic synthesis. The techniques they used were based on mechanics and geometry. It was not until 1940 that Svoboda [8] developed the numerical methods to design a simple but versatile mechanism known as four-bar linkage to generate the desired function using sufficient precision for engineering resolutions. The input to the crank indicates the values of the parameter of a function, and that on the output crank indicated the result of the function. Naturally, this four-bar linkage can generate only a partial number of tasks because of the nature of the linkage itself. In early 1950s, the publication by Horne's and Nelson [9] of an "Atlas" containing approximately 10,000 coupler curves offered a very practical approach for the design engineers. This led to the progressive development of the kinematics of mechanisms as a popular area of study in engineering. This paper focuses on study of kinematic synthesis and analysis of the leg mechanism in a walking robot for a rough terrain. The leg mechanism is modelled kinematically using integration of linkages with an objective of reducing the number of motors ensuring a design that minimizes the machine cost. In addition, the parametrically derived dimensional synthesis was carried out in a vector form using forward kinematic and inverse kinematic analysis.

KINEMATIC ANALYSIS OF THE LEG MECHANISM OF A WALKING MACHINE

The kinematic analysis of a leg mechanism is investigated based on the mechanism geometry and the known characteristics or kinematic quantities such as position, angular velocity, angular acceleration, that have a great importance in the design and analysis. In turn, the position and velocity give an insight into the functional behaviour of the leg mechanism; the acceleration is related to the stresses and deformations in the leg components. The linkages are assumed to be fully rigid bodies for the kinematic analysis of the leg mechanism.

Definition of related concepts

In the past centuries, mechanisms have been configured into machines. Parallel with the development of kinematics of mechanisms as engineering science in the past forty years, regular terminologies and explanations were required to support its study. The definition of the concept mechanism by Rouleaux's [5, 6], as an arrangement of inflexible or rigid bodies designed and coupled so that they can move up on each other with definite relative motion, is seen as the foundation of the understanding of mechanisms. In the study of kinematics analysis of the walking machine leg mechanism, distinguishing the definitions and the roles of some terminologies such as links, linkages, frame, joints, as well as high and lower pairs are important. These terminologies are briefly explained below. Links are the individual parts of the leg mechanism which is considered as a rigid body and linked with supplementary links to transfer motion and forces. In principle, a true rigid body does not change its shape during motion due to the strains in members of walking machines. In reality, true rigid body does not exist, it is an idealization used in mechanisms that do not consider small deflections or are designed to minimally deform and are considered as a rigid body. In literature, real machine member links are considered as a perfect rigid body for modelling purposes [9, 10]. A linkage is part of a mechanism where rigid body parts are connected together to form a chain. In a four-bar mechanism, for instance, a combination of a number of pair elements is connected by rigid pieces or links, where a pin or pivoted joints allow relative motion between their parts. In kinematic chains, linkages represent an assemblage of rigid bodies connected by kinematic joints of lower pairs, though both mechanisms and machines can be taken as a link. The term linkage is, in general, limited to kinematic chains made of lower pairs [8, 11]. A frame is a part which serves as the frame of reference for the motion of all parts. It is a typical part that does not exhibit motions. It is stationary or a fixed link in a leg mechanism, and when there is no link, it is actually a fixed link which determines the relative motion of other links. It is the reference from which all motions of the leg mechanisms are accounted for. Any mechanical system can be classified according to its number of independent parameters which are needed to uniquely define the position in its space at any instant of time; i.e., degrees of freedom (DOF). The number of joints in a robot roughly translated to the DOF. In the design process, three different possibilities were considered. However, the up-down and forward-back motion is approximately linear and provides a method to propel forward or backward while adjusting to uneven terrain. For the leg mechanism of the walking machine, the general Gruebler-Kutzbach criterion can be applied to find the number of the DOF. This criterion is given as:

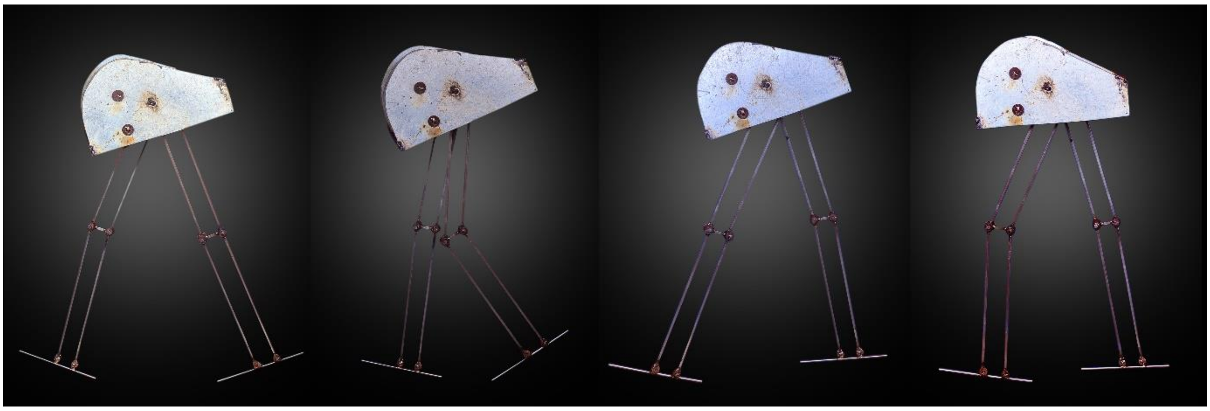
$$DOF = 6(nn - 1) - 2pp - h$$

where: n – number of linkages,

p – number of lower pairs and

h – number of higher pairs

It is desired for a walking machine to have the flexibility required for walking on rough terrain while still being able to achieve fast locomotion and requiring minimal actuation for walking on flat terrain. For a walking machine to be capable of walking on various terrains, each leg requires three DOF to carry out the back and forth motion, up and down motion, and turning motion. Since the turning motion can be separated from other two motions in a leg mechanism, a two DOF planar mechanism, which provides the back and forth and the up and down motions are of interest. If all three DOF need to be simultaneously actuated for a rough terrain walking, then the walking machines can be slow. Conversely, if a leg mechanism is designed that only one DOF is required to be actuated for normal walking, then the speed of the walking machine can be fast.



Kinematic motion analysis in Solid edge

A kinematic motion analysis is the imitation of the operation of a real-world process or system over time. It is a tool to evaluate the kinematic response of a system, existing or proposed, under different configurations of interest and over long periods of real time. The behaviour of a system that evolves over time is studied by developing a kinematic model. The motion analysis consists of building a computer model that describes the behaviour of a system with which system exploration and analysis that supports decisions are conducted. The mathematical model is used to determine the response of the system in different situations using one of the motion analyses functions available in SolidWorks such as animation, kinematic analysis, and motion analysis functionalities. Motion analysis is the most sophisticated analysis functions reflecting all the required features such as inertial properties, external forces, contacts, mate friction etc. [19]. The kinematic analysis is performed to determine the displacement, velocity, acceleration, and torque responses. The motion analysis is performed based on constant input functions and fluctuating input functions as flat and rough terrain, respectively.

II. CONCLUSION

In the study partly reported in this article, various previous works on the topic were reviewed and it was found that the leg mechanism is modified and the mechanism used by the mark plencik is too complex and is been modified. The part and assembly geometric modeling was conducted in SolidedgeV2020 and the motion analysis results were exported and analyzed in solid edge simulaton 2020. On the basis of the responses observed from the effect of variation of the kinematic behavior of the leg mechanism, it was concluded that the used special type of the crank and connecting rod mechanism is well-suited for the walking of the machine. The proposed and employed simple linkage integration also enabled the synthesis of the mechanism. It was further concluded that the parametric equation helps to derive scalable design to any size for constructing the machine. Finally, the design with reduced number of actuator is a significant factor for reducing the energy consumption.

III. REFERENCES

[1] Roennau, A., Kerscher, T. and Dillmann, R., Design and kinematics of a biologically-inspired leg for a six-legged walking machine, Proc. of the 2010 3rd IEEE RAS & EMBS Int. Conference on Biomedical Robotics and Biomechatronics, The University of Tokyo, Japan, Sept. 26–29, 2010.

[2] Bern's, K., IL, W., Deck, M., Albies, J. and Dillan, R., Mechanical construction, and computer architecture of the four-legged walking machine BISAM, IEEE/ASME Transaction on mechatronics, 4(1), 1999, 32–38.

[3] Collins, S.H., Wissen, M. and Ruina, A., A threedimensional passive-dynamic walking robot with two legs and knees, The Int. Journal of Robotics Research, 20(7), 2001, 607–615.

[4] Sosnowski, M. and Jaskowski, J., Didactic automated station of complex kinematics, Advances in Science and Technology Research Journal, 8(21), 2014, 18–23, DOI: 10.12913/22998624.1091873.

[5] McCarthy, J.M., Kinematics, polynomials, and computer: A brief history, Journal of Mechanisms Robotics 3(1), 2011, 010201, doi:10.1115/1.4003039.

[6] Moon, F. C., History of the dynamics of machines and mechanisms from Leonardo to Timoshenko, Int. Symposium on History of Machines and Mechanisms , H.S.Yan and M.Ceccarelli, Eds. 2009

[7] Denavit, J. and Hartenberg, R.S., Kinematic synthesis of linkages, McGraw-Hill, Inc. NY, 1964.

[8] Natesan, A.K., Kinematic analysis and synthesis of four-bar mechanisms for straight line coupler curves: Rochester Institute of Technology, 1994.

[9] Myszka, D.H., Machines and mechanisms: Applied kinematics analysis, 4th ed., Pearson Education Inc. NJ, 2012.

[10] Khurimi, R.S. and Gupta, J.K. Theory of machines. 8th ed., S. Chand & Company Ltd. 2005, 1070.

[11] Ravani, B., Kinematics and mechanisms. In: Richard C., Ed. Engineering Handbook California: CRC Press LLC, 2000.

[12] Waldron, K.J. and Kinzel, G.L., Kinematics, dynamics, and design of machinery. 2nd ed., Wiley & Sons, 2001.

[13] Sandor, G.N. and Erdman, A.G., Advanced mechanism analysis, Prentice-Hall Int. Inc. NJ, 1984. 701.

[14] Manjaree, S., Kinematics and dynamics of multidegree of freedom robotic systems using analytical and artificial intelligent techniques with experimental validation, The Northcap University, 2016.

[15] Spong, M.W., Hutchinson, S. and Vidyasagar, M., Robot dynamics and control. 2nd ed. 2004.

[16] Harrison, H.R. and Nettleto, T., Advanced engineering dynamics. Britain John Wiley & Sons Inc.; 1997.

[17] Yang, Ch., Ma, H. and Fu, M., Robot kinematics and dynamics modeling. Advanced Technologies