USE AND BENEFITS OF KINEMATICS INVERSION OF SINGLE SLIDER MECHANISM A REVIEW PAPER.

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Abstract

The aim of this article is to develop a functional model of centric crank mechanism in ADAMS/View software, and its followingcomplete kinematical analysis. We deal directly with modelling the crank mechanism in ADAMS/View software. The next stage is the simulation with a set of different parameters to obtain its kinematical analysis. Finally, the data gathered in this process is compared andevaluated.

The control design using simulation is one of the techniques to control and analyse the performance and the effectiveness of the controllers. The simulation run and built in MATLAB/SIMULINK software based on the mathematical equation. The SIMULINK software capable to model the mathematical equation informs of block diagram which is the block diagram contain the operation and codes represented. This research presents a study on the position tracking response of a Proportional-Integral-Derivative (PID) controlled the slider crank mechanism which is driven by a two-phase stepper motor. In this study, the Newton Second Law of motion has been applied to formulate the mathematical equation of motion where the connecting rod and the crank are assumed to be rigid. The proposed control system is using PID controller to obtain the desired result according the input function. There are several input functions that has been used to monitor the performance which are sine wave, saw tooth, square and step function. The result shows that, the position tracking control structure model is able to give a good response. Then, the slider crank mechanism developed to study experimentally as well as to validate the result from the simulation. The results show that, the slider crank mechanism is able to track the desired displacement.

In industry, many applications of planar mechanisms such as slider-crank mechanisms (SCM) have beenfound in thousands of devices. A slider–crank mechanism is widely used in gasoline/diesel engines and quick-returnmachinery. Research works in analysis of the slider–crank mechanism has been investigated to date due to them significant advantages such as low cost, reduced number of parts, reduced weight and others. A variation of these four bars linkage is the inverted slide-crank mechanism (ISCM) which is obtained changing the grounded link of the SCMattaching the coupler link to the ground. It kinematic analysis is little studied when compared with the originalmechanism (SCM) but the ISCM may represent an important application in the automotive area, like modelling theMacpherson structure suspension. In this way this paper presents the kinematic analysis of an ISCM based in a vectorand matrix formulation for future adaptation to modelling the Macpherson struct. The

position, velocity andacceleration of the links is obtained as the maximum and minimum length of the coupler during it operation. In addition, the same ISCM will be modelled and validated in a multibody software (ADAMS/View®). The results agree inboth models: analytical and numerical. This kinematic analysis is the initial step for the future analytical multibodymodelling of the Macpherson suspension, since the ISCM may be a simplified model for this suspension with thecorrect adaptations and considerations.

Nomenclature

X =displacement (mm)
V = velocity (mm/s)
A =acceleration (mm/s2)
Φ =angle (degree)
Ѡ =angular velocity (rad/sec)
Α =angular acceleration (rad/sec2)
M =mass (kg)
L = length of connecting rod
R = Length of Crank shaft
φ = Angle of Crank
θ = Angle of Crank
Δ = Stepping angle
R = The resistance of the coils.
L = The inductance of the coils.
E = Electric time constant.

Introduction:

The rapid evolution brings along a sharp increase in requirements for faster production with increasingly greater accuracyat the lowest possible cost. This is associated with the rising demands of customers, market dynamism but mainly byglobalization. To satisfy these increasing demands some new, faster and more efficient methods for solving complexproblems must be found.

The rapid development of computer technology allowed the development of different kinds of simulation software. Bycomputer simulation can be solved a wide range of very difficult dynamic tasks. A computer model is compiled on the basisof mathematical analysis, defining the model having the properties of a real object. Since the created model has the same.

Mechanisms have been devised by people since the dawn of history. In last century, prior to World War II, mosttheoretical work in kinematics was done in Europe, especially in Germany. Since then, much new work has been done,especially in kinematic synthesis, by American and European engineers and researchers (Cervantes-Sánchez et al, 2009;
Liu and McPhee, 2007). It is common to think that this subject is already totally studied and dominated, so there aremany works even being developed in this area with new methods and techniques (Kim and Yoo, 2012; Talaba, 2012).

The kinematic analysis is an important step to the engineering design practice in order to investigate and assay thedesired motions or tasks and their consequences to the machine

considered. A mechanism can be defined as a devicethat transforms the movement to a desirable standard and typically develops very low forces and transmits low power.
A machine usually contains mechanisms that are designed to provide important strength and power transmissionsignificantly. Mechanisms lightly loaded and run at slow speeds, they may sometimes be treated as strictly kinematicdevices, i.e. they can be analyzed without regard kinematically forces. In general any machine or device that movescontains one or more kinematic elements such as linkages, cams, gears, belts, chains (Norton, 2003).
There are many applications where it is desirable to design a linkage mechanism which meets a specific functionalrelationship. A linkage is made by attaching and fixing one link of a mechanism to the ground. The kinematic analysisconsists of determining the position, velocity and acceleration of a specific link of this mechanism. There are many
applications where it is desirable to design a linkage mechanism that satisfies a particular functional relationship. Forexample, the steering system, wheel suspensions, and piston-engine in an automobile contain linkages. Even thewindshield wipers are linkage-driven (Jazar, 2009).
In the automotive area the study of the kinematic mechanism is very important for engineering applications,including improvement design and optimization of subsystems. A well-known automotive mechanism which may bemodeled like a closed loop linkage is the suspension subsystem. The Macpherson strut suspension is a very popularmechanism for independent front suspension of street cars, and its equivalent model may be the four-bar linkage like theinverted slider crank mechanism (Soni, 1974).
Actually many research have been developed in suspension subsystem due to its great importance in the vehicleperformance [Prawoto*et al*, 2008; Bar David and Bobrovsky, 2011]. This subsystem is the greater responsible forisolating the chassis from irregularities frequently present in the roadway, keeping tires aligned in the desired directionand to maintain the wheels with proper camber attitudes to the road surface, to respond to the forces produced by thetires during the maneuvers and to resist roll of the chassis (Gillespie, 1992). It is easy to note that the suspension designis closely related with the dynamic performance of the vehicle and consequently with the safety requisites in theautomotive area. This justify the great interest in improve this subsystem with modern techniques of modelling and
simulation.
Most works aims developing new numerical models for suspension subsystem, therefore the use o multibodytechniques is a tendency in the researchers' institutes (academics and industries). Liu *et al* (2008) uses multibodydynamics model combining with Finite Elements Analysis and these are an efficient method in optimizing thesuspension design. Fallah*et al* (2009) proposed a new nonlinear model (2 DOF) of the Macpherson strut suspension
system for ride control applications and it incorporates the suspension linkage kinematics. The results obtained werecompared with a multibody model and both agree. Aydın and Ünlüsoy (2012) developed and implemented a parameteroptimization methodology to improve impact harshness (IH) of road vehicles. The optimization results indicated that
the selected suspension parameters were capable of improving IH performance of the full vehicle multibody model(ADAMS®) by minimizing longitudinal and vertical acceleration responses.

As mentioned above, in general, the numerical model of the suspension subsystem may considers complex modelswith nonlinearities, finite element model with many DOFs or complete models with joints and links (multibody model).
Commonly, these models require a high computational cost, a large time of simulation in powerful computers and theuse of commercial software (license or using permission is required) which requires a professional with experience tomanipulate it. Although, this features needs to attend the great market competition and consumer demands which force
the vehicle manufacturers to decrease the time required for development of their products with the need of maintainingquality and performance requirements.
Due to the listed aspects, in this work, the authors propose to use the inverted slider crank mechanism to modeling aMacpherson suspension using therefore a simplified mechanism with appropriate considerations and adaptations. Thefinal aim is obtaining a simplified analytical model for the suspension subsystem based in kinematics and multibodyaspects. The slider crank is a well know mechanism and its description of operation can be found in the classicalliterature [Norton, 2003], so there are currently publications [Olyaei and Ghazavi, 2012; Wang and Chen, 2012] aboutthis subject due to the many and important applications of it in mechanical systems. The choice of this mechanism isjustified by their significant advantages such as low cost, reduced number of parts, reduced weight, less wear andclearance.
As the first step of the modelling proposed, in this article is presented the kinematic analysis of the four-bar linkageISCM using vector and matrix formulation with multibody aspects like the use of links and joints. The results showsome parameters as: position, velocity and acceleration of specific links of interest, as the length variation (maximumand minimum length) of the coupler. A numerical model of the ISCM was developed in ADAMS® software forcomparison purpose.

Kinematical analysis of crank slider mechanism

An inverted slider-crank mechanism is defined as a four-bar linkage. If the coupler link of a slider-crank mechanismis attached to the ground an inverted slider-crank mechanism is made. So, the inverted slider-crank is a simple inversionof a slider-crank mechanism. The shows both mechanisms for comparison purpose.
In the link number 1 is the ground, which is the base and reference link. The link number 2 (MA segment)is called the input link, which is controlled by the input angle _2 and the link number 4 is the slider considered as theoutput link. The horizontal distance between the slider and a fixed point in the ground (usually the revolute joint M) isthe output variable of this mechanism. The link number 3 (AB segment) is the coupler with angular position _3 and itconnects the input link to the output slider.
The is the inverted slider-crank mechanism illustration. As the link number 1 is the groundlink (reference link), the link number 2 (MA segment) is the input link which is controlled by the angle _2 and the linknumber 4 is the slider (output link). The mainly difference between both mechanisms is that the slider has a revolutejoint (N) with the ground and a prismatic joint with the coupler (link 3 or AB segment). Therefore, the output variable
can be the angle _4 of the slider with the horizontal or the length AB.

Conclusion:

The present paper aims to show the similarity in results of analytical and multibody models, related to angular andlinear velocities and accelerations of the slider block and coupler link of an inverted slider crank mechanism. Also, itpresents the limit positions (minimum and maximum) of the coupler link and the associated angle of each situation.

In this context, the results seem to be very suitable validating the multibody model proposed. This study represents afirst approach to develop an analytical and multibody models more adapted to a Macpherson structure.

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