Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2016, 3(4):131-135**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Analysis of Slider Crank Mechanism using Computer Programming

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Abstract Analysis of slider crank mechanism was done and set of equations were derived and solved and the solutions were converted to Qbasic computer programming. The results obtained are precise and accurate when compared with graphical and analytical solutions. Furthermore, the approach saves time when compared to the time spent on obtaining solution with graphical and analytical methods. It also eliminates the possibilities of errors if the simple rules are known and strictly adhered to; it reduces the high skill requirement by the other methods. Finally, it guarantees the accurate result of velocity and acceleration in the mechanism.
This study is limited to slider crank mechanism. It is recommended that similar computer programming analysis should be carried out on other mechanisms.

Keywords Mechanism, Velocity, Acceleration, Analysis, Q basic.

Introduction

Over the years, the problem of mechanism has received an appreciable attention by many mechanical engineers. Owing to this, vigorous work has been done and some methods have been adopted to solve the problem. These include graphical method (for a single position of the crank) [1], instantaneous centre method, and relative velocity method (for velocity in mechanisms only), [2]. Analytical, Kliein's construction, Rennet's construction and Rither Lans construction methods can also be used, [3]. Most of these methods have one short coming or the other and some have accurate result but rather generate approximated results. Examples of these are analytical method and construction method, [4]. Some are time consuming in use e.g. Graphical method and Analytical method, [5]. Even other may prove cumbersome in use.
Sequel to short comings in the previous methods and approaches, this study use computer programming approach. Also, computer program is generated using Qbasic programming language.

Objective of the Study

This study analyzes the linear and angular velocity and acceleration of slider crank mechanism taking all the associated parameter into consideration. Based on this, the overall objective of the study is to use computer programming approach to solve slider crank mechanism problem both in mechanical system and robotic engineering. The specific objectives are:

i. To provide the use of computer application to determine the velocity and acceleration of the mechanism, in order to produce a desired output motion for given input motion.
ii. To provide an approach which is so simple, less skilled, time and labour saving in a way that if the simple rules are strictly adhered to a workman with most elementary knowledge of the computer will be able to get the desired result.
iii. To eliminate the possibilities of errors if the simple rules are known and strictly adhered to.
iv. To reduce the time consumption which are required by the other methods.
v. To reduce the high skill requirement by the other methods.
vi. To guarantee the accurate result of velocity and acceleration in the links of mechanism.

Materials and Method

In this study, linear and angular velocity and acceleration of slider crank mechanism are analyzed and the associated equations were generated after which the equations are developed into Qbasic computer program. The computer program was tested and was found satisfactory for solving slider crank mechanism problem.

Result and Discussions

In developing a computer program for the mechanism, the following are put into consideration:

i. Slider crank mechanism was analyzed
ii. The vector diagram is considered to develop the required velocity and acceleration equations.
iii. Qbasic is used for the programming of the results obtained from the analysis.

Considering a slider crank mechanism ABCD, as shown in Fig.1, the slider is attached to the connecting rod BC of length **b**, let the crank AB or radius **a** rotates in anticlockwise direction with uniform angular velocity **v**, rad/s and an angular acceleration $\propto_1$ in rad/s^2. Let the crank makes an angle Θ with the x-axis and the slider reciprocates along a path parallel to the x-axis i.e at an eccentricity CD= e_1 as shown in Fig 1.

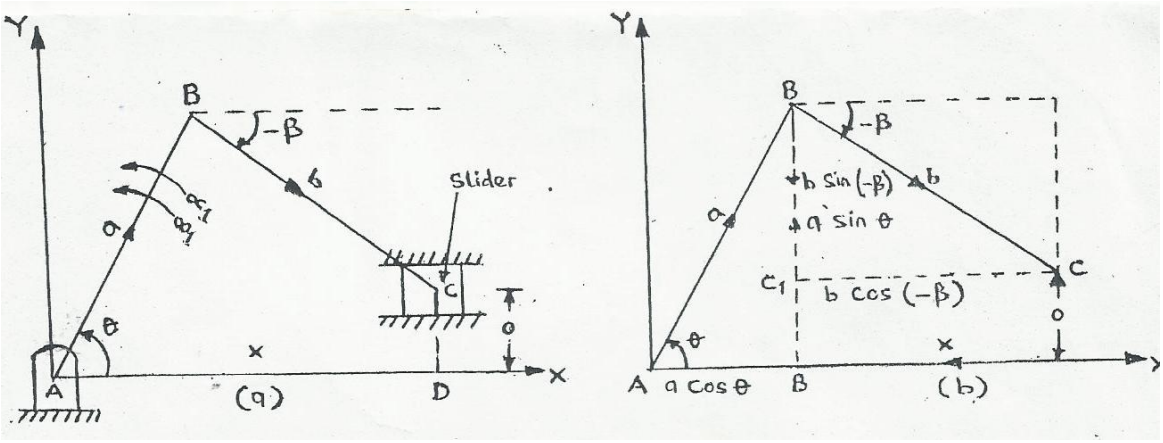

Figure 1: Analysis of slider crank mechanism

From Fig. 1

$$X = -k_1 \pm \frac{\sqrt{(K_1^2 - 4K_2)}}{2}$$

Where $K_1 = -2a\cos\theta$ and $K_2 = a^2 - b^2 - e^2 - 2ea\sin\theta$

From this expression, the output displacement **x** may be determined if the values of a, b, e and θ are known.

The position of the connecting Rod BC (i.e angle β is given by)

$$\beta = \sin^{-1}\left(\frac{e - a\sin\theta}{b}\right)$$

When the slider lies on the **x** axis, i.e the line of the stroke of the slider passes through the axis of rotation of the crank then eccentricity, e = 0.

In such case,

$$\beta = \sin^{-1}\left(\frac{-a\sin\theta}{b}\right)$$

To determine the velocity, let

w_1 = Angular velocity of the crank AB = $\frac{d\theta}{dt}$

w_2 = Angular velocity of the connecting rod BC = $\frac{d\beta}{dt}$

Vs = Liner velocity of the slider = $\frac{dx}{dt}$

$$w_2 = \frac{aw_1\cos\theta}{b\cos\beta} \quad \frac{dx}{dt} = \frac{aw_1\sin(\beta - \theta)}{\cos\beta}$$

To determine the acceleration, let

$\propto_1$ = Angular acceleration of the crank AB = $\frac{dw_1}{dt}$

$\propto_2$ = Angular acceleration of the connecting rod = $\frac{dw_2}{dt}$

as = Liner acceleration of the slider = $\frac{d^2x}{dt^2}$

$$\propto_2 - a(\propto_1 \cos\theta - w_1^2\sin\theta) - bw_2^2\sin\beta)$$

$$\frac{}{b\cos\beta}$$

In designing the computer program for the generated equations, the detailed specification of the solution to the problem are represented by the detailed logical stages to the solution in form of a descriptive language called Pseudo code or a diagrammatic representation in form of a flow chart. As such, seven stages will be taken into consideration in developing the program. These are:

1. Logarithm preparation
2. Algorithm preparation
3. Flow chart design
4. Coding into a high level language
5. Input preparation
6. Compilation
7. Correction (De bugging)
8. Testing process.

The computer program developed is shown in **index I**

Index I

```
C       PROGRAM TO FIND THE VELOCITY AND ACCELERATION IN A SLIDER CRANK
        MECHANISM
        READ (*, 5) A, B, E, VA, ACC, THA
5       FORMAT (6F5.1)
        PI= 4* ATAN (1.)
        TH= 0
        IH= 180/THA
        DTH= PI/IH
        DO  10  I=1 ,2  *IH
        TH= (I-1)*DTH
        BET= ASIN (E-A*SIN (TH) /B)
        VS= -A*VA*SIN (TH-BET)/ (COS (BET) *1000)
        VB= -A*VA*COS (TH)/B* COS (BET)
        AC1=A*ACC*SIN (BET-TH) - B*VB**2
        AC2= A*VA**2*COS (BET-TH)
        ACS= (ACI-AC2)/ (COS (BET)* 1000)
        AC3= A*ACC*COS (TH)-A*VA**2*SIN (TH)
        AC4= B*VB**2*SIN (BET)
        ACB= - (AC3-AC4)/ (B*COS (BET))
        IF (I.EQ.1) WRITE (*, 9)
9       FORMAT (3X, 'TH', 5X, 'BET', 4X, 'VS', 4X, 'VB', 4X, 'ACS', 4X, 'ACB')
10      WRITE (*, 8) TH *180/PI, BET* 180/PI, VS, VB, ACS, ACB
8       FORMAT (6F8.2)
        STOP
        END
```

Plate1 shows the result of the computer program when it was tested. **VEL** is used to open the computer program.

Conclusion

In the attempt to solve slider crank mechanism problem, sets of equations were generated and Qbasic computer programming language was developed from the equations to solve the mechanism problem. When the program was tested, the following advantages were discovered

i. It provides an approach which is so simple and labour saving in a way that if the simple rules are strictly adhered to a workman with most elementary knowledge of the computer will be able to get the desired result.
ii. It eliminates the possibilities of errors if the simple rules are known and strictly adhered to.
iii. It reduces the time consumption which are required by the other methods
iv. It reduces the high skill requirement by the other methods.
v. It guarantees the accurate result of velocity and acceleration in the mechanism.

RESULT OBTAINED FOR SLIDER CRANK MECHANISM

MS-DOS Prompt

```
VELO2      FOR          1,771  03-10-04   8:05a VELO2.FOR
VEL        FOR          1,798  03-10-04   9:30a VEL.FOR
        23 file(s)        720,102 bytes
         2 dir(s)         684,032 bytes free

A:\FORTRAN>edit"

A:\FORTRAN>velo
0200007500005000020000100000300
  TH      BET      VS      VB      ACS      ACB
   .00     3.82     .27   -5.32  -101.15     -.78
 30.00    -3.82   -2.23   -4.61   -83.69    49.72
 60.00    -9.46   -3.80   -2.63   -35.62    91.14
 90.00   -11.54   -4.00     .00    14.33   108.87
120.00    -9.46   -3.13    2.63    44.71    93.85
150.00    -3.82   -1.77    4.61    55.11    54.35
180.00     3.82    -.27    5.32    58.58     4.56
210.00    11.54    1.29    4.53    62.42   -47.90
240.00    17.31    2.84    2.55    57.93   -93.34
270.00    19.47    4.00     .00    30.28  -113.14
300.00    17.31    4.09   -2.55   -21.45   -96.14
330.00    11.54    2.71   -4.53   -75.44   -52.61
Stop - Program terminated.

A:\FORTRAN>
```

RESULT OBTAINED FOR FOUR BAR MECHANISM

MS-DOS Prompt

```
 330.00    11.54     2.71    -4.53   -75.44   -52.61 -
Stop - Program terminated.

A:\FORTRAN>edit

A:\FORTRAN>vel
00300000360000360000600000010000030000030 0
   THET      PHI      BETA      VELC      VELB      ACCC      ACCB
    .00  -114.62    -65.38    -10.00      9.00    -50.74 4380.68
         114.62     65.38    -10.00    -10.00     15.9720635.78
  30.00  -144.88    -82.70     -8.69      1.16     12.2829162.61
          97.30     35.12      -.84     -7.82     66.24-3245.15
  60.00  -166.19    -73.81     -6.02     -7.98    -83.3227300.67
         106.19     13.81      6.02     -6.12     57.08*********
  90.00   174.73    -47.86     -8.26     -8.60   -208.18 6389.99
         132.14     -5.27     12.26     -6.45    261.63*********
 270.00  -132.14      5.27     12.26      7.09   -200.98*********
        -174.73     47.86     -8.26      9.03    169.97*********
 300.00  -106.19    -13.81      6.02      6.36    -23.90*********
         166.19     73.81     -6.02      9.21     68.2914231.57
 330.00   -97.30    -35.12      -.84      7.69    -69.09*********
         144.88     82.70     -8.69     -1.41    -63.7130598.68
Stop - Program terminated.

A:\FORTRAN>
```

Setup MSN Internet A... | Start | Microsoft Word | MS-DOS Prompt | 5:03 PM

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