THE ALGORITHM FOR DETERMINING THE OPTIMAL ANGLE OF THE SOLAR PANEL DURING THE DAY

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Annotation- The article deals with the movement of the solar panel in continuous mode of keeping track of the Sun by moving the angle and direction of solar panels placing. A motion algorithm of mobile panel keeping track of the Sun was developed.

Keywords- Solar panel, panel keeping track of the Sun, mobile panel, helioenergetics, alternative energetics.

The density of the solar energy which incident on the panel depends not only on the flux density of solar radiation, but also on the angle between the module and sun rays. In case if the absorber plate and the solar radiation are perpendicular to each other, the flux density of the radiation incident on the panel is maximal. As the angle is changing the resulting flux density of solar radiation is decreasing.

For evaluation of the optimal position of the solar cell it is necessary to consider the basic angle parameters: geographical coordinates of placing location, hour angle, solar declination angle, elevation angle, azimuth angle.

Hereafter we present a sequence of the the motion algorithm steps of mobile panel keeping track of the Sun. Figure 1 displays a control-flow chart of algorithm consisting of the following operations:

1 Setting in of input data, such as geographical coordinates of installation location (latitude, φ, longitude, λ), and the reference time;

2 Start of cycle from 1 to N;

3 Computation of number of days from the beginning of the year to the current time;

4 Computation of the local solar time [1]:

$$LST = LT + \frac{TC}{60},$$

where LT – current local time,

TC – time adjustment factor [1]:

$$TC = 4(\lambda - LSTM) + \eta,$$

η – equation of time [1]:

$$\eta = 9{,}87\sin 2B - 7{,}53\cos B - 1{,}5\sin B$$

,

where $$B = \frac{360}{365}(d - 81)$$

in degrees, and d – number of days from the beginning of the year.

LSTM – local standard time meridian [1]:

$$LSTM = 15° \cdot \Delta T_{GMT},$$

ΔT_{GMT} – The difference between local time and Greenwich Mean Time in hours.

5 Computation of hour angle [1]:

$$\omega = 15°(LST - 12).$$

6 Computation of declination angle [1]:

$$\delta = 23.45° \sin B.$$

7 Computation of elevation angle [1]:

$$\mathrm{H} = sin^{-1}(\sin\delta\, sin\varphi + \cos\delta\cos\varphi\cos\omega)$$

.

8 Computation of sunrise time and sunset time [1]:

$$\text{Восход солнца} = 12 - \frac{1}{15°}cos^{-1}(-tan\varphi\, tan\delta) - \frac{TC}{60}$$

,

$$\text{Заход солнца} = 12 + \frac{1}{15°}\cos^{-1}(-\tan\varphi\tan\delta) - \frac{TC}{60}$$

.

9 If the hour angle ω < 0, then azimuth angle [1]:

$$A = cos^{-1}\left[\frac{\sin\delta\cos\psi - \cos\delta\sin\psi\cos\omega}{\cos\alpha}\right],$$

otherwise azimuth angle:

$$A = 360° - cos^{-1}\left[\frac{\sin\delta\cos\psi - \cos\delta\sin\psi\cos\omega}{\cos\alpha}\right]$$

.

10 If the elevation angle H < 0, then the panel seats on a horizontal surface and is directed to the south (β = 0, ψ = 0), otherwise the panel is rotated relative to the horizon through $\beta = 90° - H$ and relative to the south through $\psi = A$;

11 Evaluation of the next timepoint by adding of 1 minute to the current timepoint.

12 Repetition of the cycle N times.

As a result of work of this algorithm values of the panel rotation angles are computed every minute. Thus, solar radiation will always be perpendicular to the solar panel plane, thereby we obtain the maximum amount of solar energy.

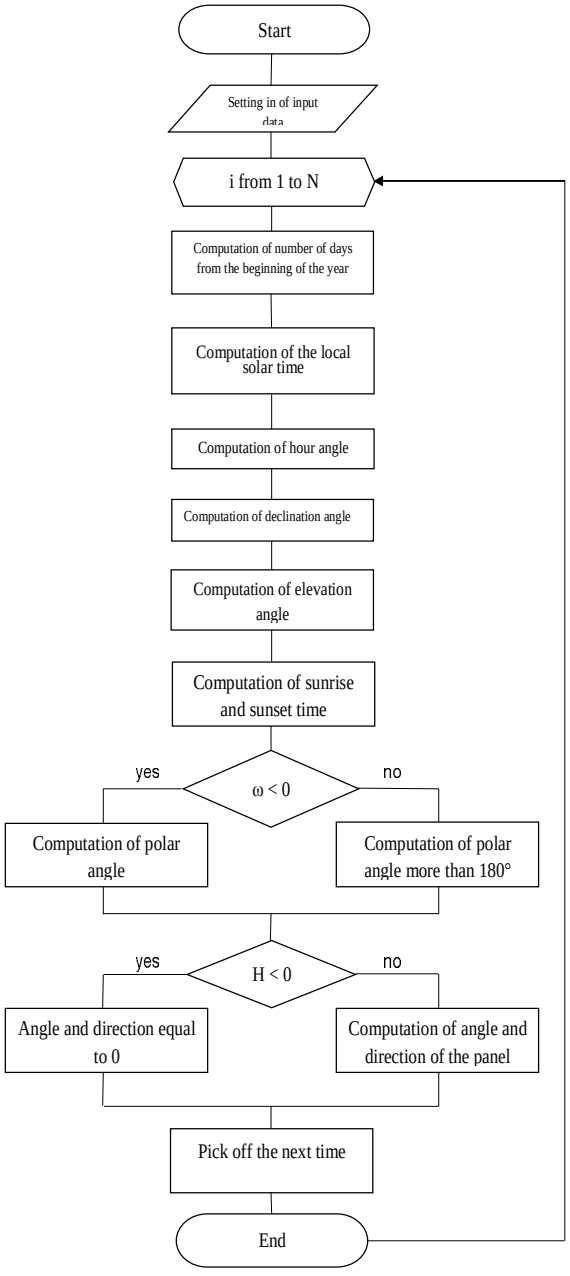


Figure 1 – Control-flow chart of motion algorithm of mobile panel keeping track of the Sun

The data inputs of the algorithm were:

– Almaty as a geographical location with coordinates 43.25° N and 76.95° E;

– the beginning of the time marking date was January 1, 2015.

Figure 2 shows a software module of panel keeping track of the Sun in Matlab environment.

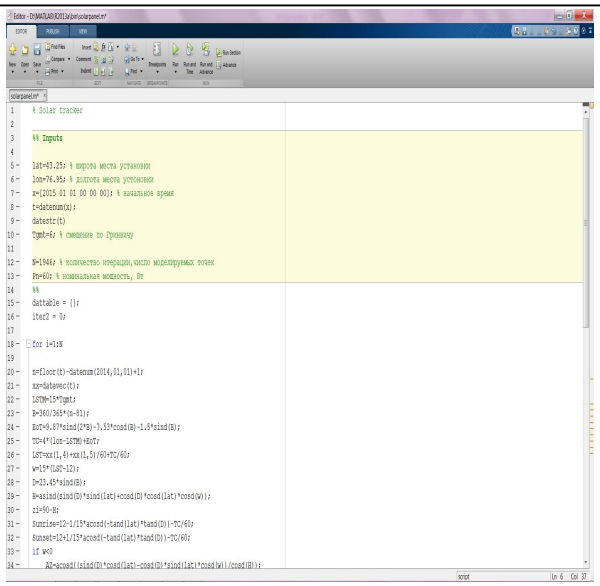


Figure 2 – A software module of the panel keeping track of the Sun

The result of the work of simulation model is shown in the tabular form (Figure 3).

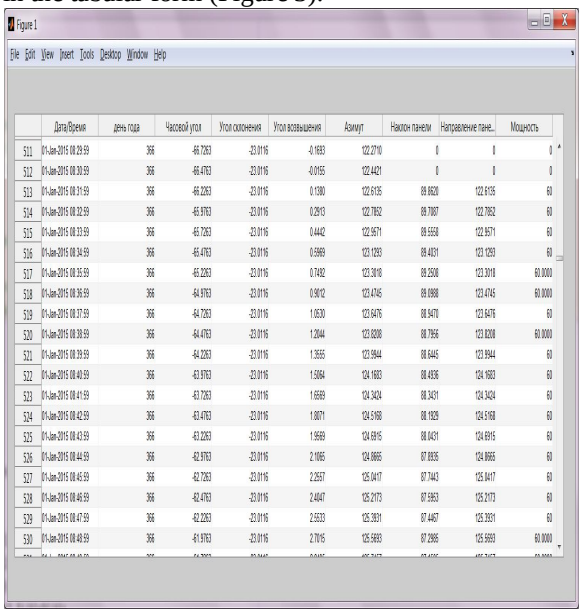


Figure 3 – The result of the simulation model

As a result of the work of algorithm for the evaluation of the optimal angle of the solar panel during the day, information on the hourly angle, declination angle, elevation angle, azimuth angle and an angle of panel rotation in space is provided, also information on the capacity of solar panel at each timepoint is provided.

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