PLAN MECHANISMS SYNTHESIS WITH THE FACILITIES OF "WATT" EDUCATIONAL SOFTWARE

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Abstract: Most available software on dynamics or kinematics is used to analyze the behavior of a mechanism. However, to start with, the Engineer has to 'invent' a mechanism before he can analyze it. This is not a trivial task. With available methods and handbooks this can take several days if not weeks. Watt Mechanism Design Tool solves this problem. From specification of the required movement and constraints on pivot locations, transmission angles, dimensions, it searches and finds a variety of approximate or exact solutions within minutes. The user can interactively set specifications, evaluate the offered solutions and add or relax constraints.

Keywords: mechanism, link, synthesis, design, modeling, velocity, acceleration.

1. SYNTHESIS OPTIONS.

1.1. General facilities

a) Link length penalty on: If checked it prevents generation of linkages with very long link length, by adding a penalty during the search process.
b) Restrict Link Length to: In certain applications it may be advisable to restrict link lengths to a maximum value.
Minimum transmission angle: small values of the transmission angle can lead to blocking of the mechanism. Restrict to at least 5 degrees.
c) Allow solutions outside area: If no solutions present itself, this may be caused by too restrictively set Ground Pivot Areas or Output Link Areas. Without changing the actual areas, the search areas can be increased by a percentage of surface area to find out if any solutions are available outside the current settings.
d) Specified total input rotation: if the application requires a specific rotation of the input angle and all rotations in between do not matter, select this option instead of setting the input rotation in the Curve Point Settings.
e) Full Input Link Rotation required: Check this option if you require a mechanism of which the input link must be able to rotate full 360 ° without blocking. (Version 1.5)

1.2. How to select a mechanism type

Select a mechanism appropriate to the problem stated. It is always a good idea to start with a four bar is

1. Four bar (fig. 1.a)
2. Four bar slider (fig. 1.b)
3. Five bar belt-wheel (fig. 1.c)
4. Watt 1, six bar (fig. 1.d)
5. Watt 2, six bar (fig. 1.e)
6. Stephenson 1, six bar (fig. 1.f)
7. Stephenson 3, six bar (fig. 1.g)

8. Eight bar, parallel motion (fig. 1.h)

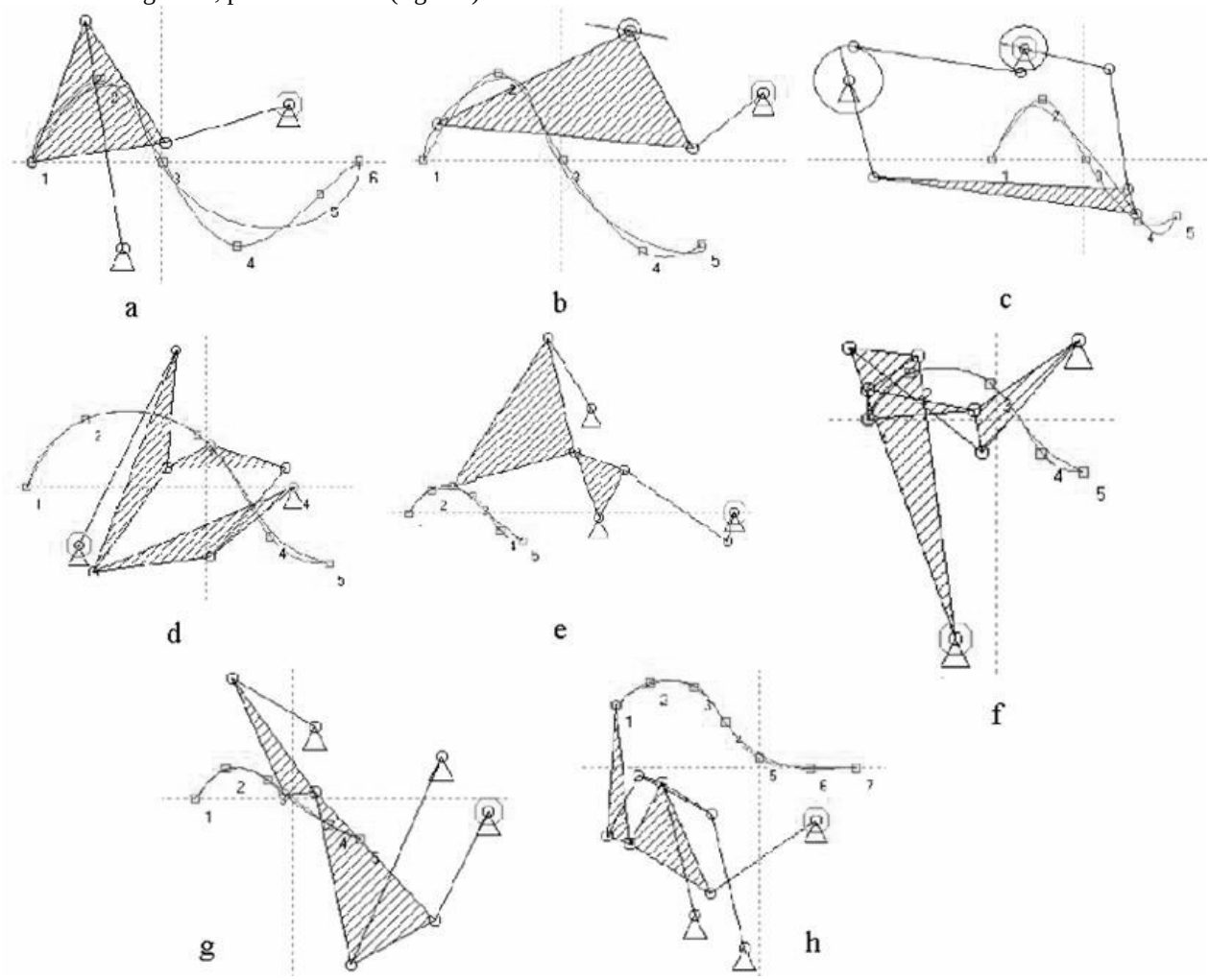

Fig. 1. Mechanism types

Four bar
When to use: A fourbar mechanism is the most versatile and simple linkage.
Problems: Setting a path, output rotation and input rotation at the same time does rarely result in any solutions. Parallel motion is impossible.

Four bar slider
When to use: Like a fourbar this mechanism is a very versatile and simple.
Problems: Setting a path, output rotation and input rotation at the same time does rarely result in any solutions. Parallel motion is impossible.

Five Bar
A five bar with a wheel and belt connection between both grounded links.
When to use: Best suited if the Output Link rotation is set.

Watt 1, six bar
Watt 1 is a four bar mechanism with a function generator between one grounded link and the output link.
When to use: Best suited if the Output Link rotation is set. If output rotation is free, parallel motion is assumed.

Watt 2 six bar

When to use: Best suited if the Input Link rotation is set. If no input rotation is set, the mechanism will be generated in such a way that a 360 degree rotation of the input link moves the path point up and down the path. The input joint can be moved without affecting the path.
Problems: Hardly any solutions, when ground pivot areas are set.

Stephenson 1, six bar
The Stephenson 1 six bar mechanism can be seen as a Five Bar with a function generator mechanism between both ground links.
When to use: Well suited if Output Link rotation is set.
Problems: Restricted range of motion due to function generator

Stephenson 3, six bar
When to use: When Output Link Areas or output link rotations are set.
Problems: Multiple rotations of output link and bad transmission angles.

Eight bar parallel motion
When to use: The eight bar mechanism generated by Watt is set to provide only parallel motion. All pivots except the output point can be moved without affecting the resulting path.

2. SYNTHESIS, GENERATING.

The minimum data needed to start generating mechanisms is a required path. If this path is defined, click the Generate button to start the search for suitable mechanisms.
At the bottom of the List Window a progress bar gives an indication of the time left to complete the search.
Solutions will appear in the list window. Each solution gets a sequence number. The mechanism at the top of the list best fits the desired qualifications. At any time click in the list to view the mechanism, without stopping the search process.
Double clicking will stop the search process and start animating the selected mechanism.
Click the Generate button to resume the search.

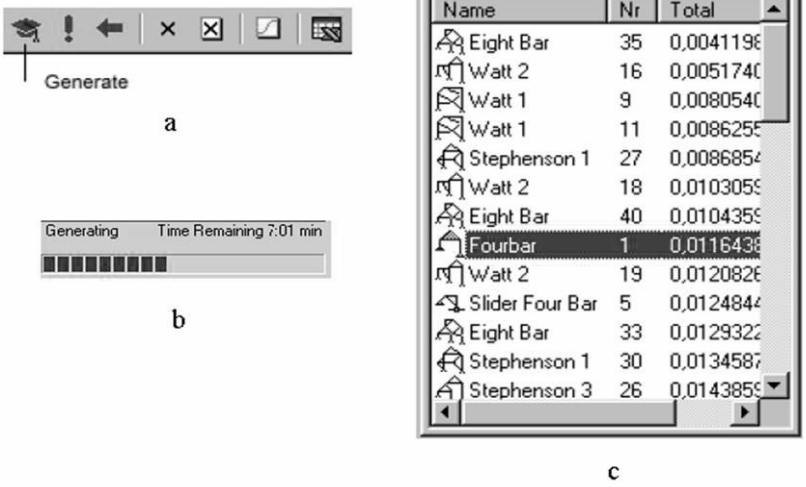

Fig. 2 Generate the path

Note: if no (suitable) solutions appear, it may be the selected mechanism is unable to comply with all restriction. Try other mechanism types, rethink your constraints and set Synthesis Search Options to Thorough Search.
A fourbar is limited by its configuration in what it can do. Most linkages generate paths that can be seen as part of a distorted figure 2.

3. EVALUATE RESULTS

Animation. A visual scan and animation of mechanisms from the list is the next best step after completing the search process. Use the buttons in the animation toolbar.

1. Step Back (Left Arrow),
2. Stop
3. Pause (Space bar)
4. Start (Space bar)

5. Step Forward (Right Arrow)
6. Low animation speed
7. Medium animation speed
8. High animation speed

Mark a mechanism for future reference by right clicking on the mechanism in the list window and selecting **Mar**k. The mechanism icon will turn green.
Note: the animation speed does only affect the speed of animation and **not** the velocity and or accelerations of the mechanism.

4. GRAPH

Apart from the path error and transmission angle, the graph window displays velocity and accelerations of input link, output link and the path point. These values depend on the selected input function and the timing set.

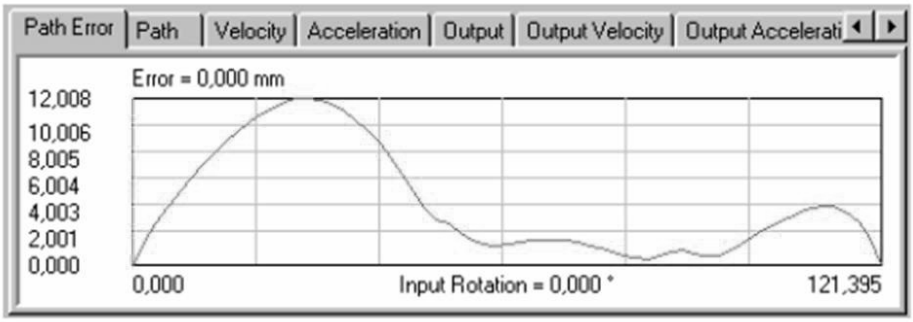

Fig. 3 Graph Window

To adjust the input function click the input funtion button at the top of the list window.

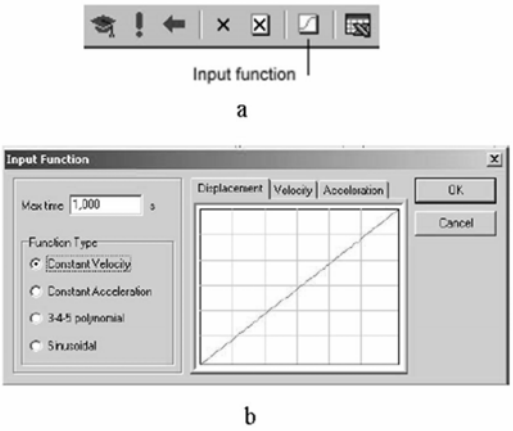

Fig. 4 Input Function Window

Max Time: time to complete movement along the path from start to finish.
Function Type:

1. Constant velocity = e.g. electromotor running at constant speed
2. Constant acceleration = e.g. spring, pneumatic or hydraulic actuator.
3. 3-4-5 polynomial = cam or servo
4. Sinusoidal = cam or servo

Velocity and acceleration profiles are visible for each function.

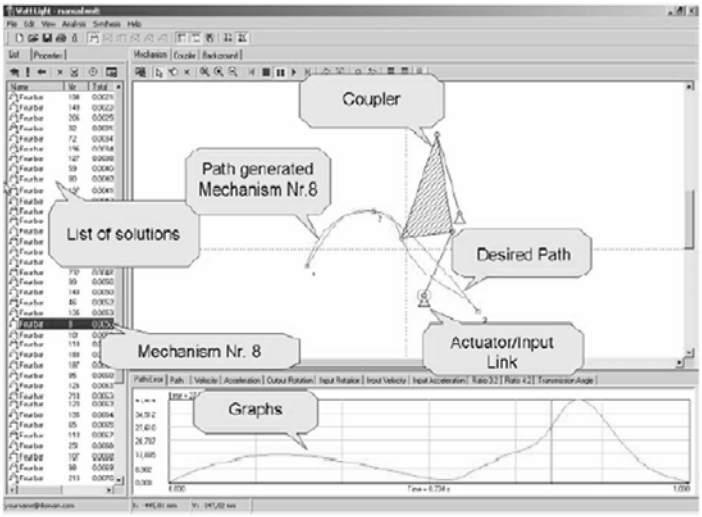

Fig. 5 Generated Solutions

5. OPTIMIZE

A selected mechanism can be optimized, to make it fit the requirements even better.

- •To start, click the Optimize button.
- •At completion the icon of the mechanism turns red.
- •An optimized mechanism will move higher up the list.

If the optimized mechanism is less suitable, the effect of Optimization can be undone. Figure 3-6 and Figure 3-7 show how path error has significantly decreased after optimization.

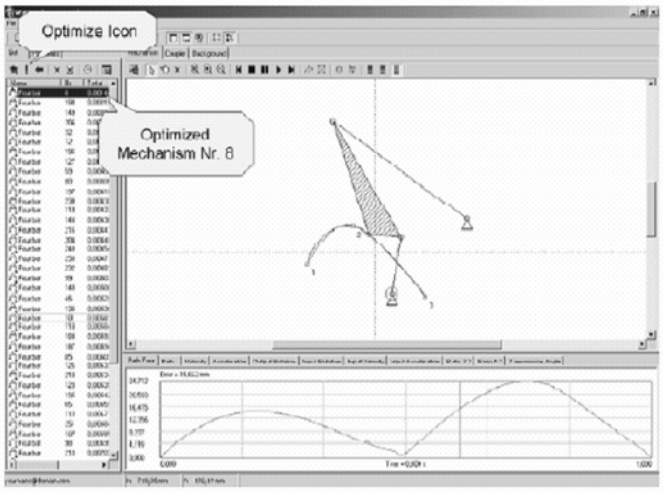

Fig. 6 After Optimization

6. EXPORT TO EXCEL

This option generates a Microsoft Excel workbook or folder (depending on the Excel version installed on your computer). It contains several sheets.

1. Mechanism dimensions
2. Data related to the motion of the mechanism
3. Graphs related to motion data

Data can be used:

- •As input for CAD programs.
- •Further processing or calculation

Note: unit and coordinate system settings affect the output and number formatting.

7. HTML REPORT

All properties of the selected mechanism are saved to a HTML file and shown in your default browser (Netscape or Explorer). This file is saved in the same directory as the current project. A HTML file can be edited by Word, Frontpage, StarOffice etc.
The graph data displayed depends on the selected graph tab. No graph data is displayed when the graph window is hidden. Velocity and acceleration values are dependent on the input function
settings.
Note: unit and coordinate system settings affect the output and number formatting.

8. CONCLUSIONS

Watt uses Heron's unique Generating Technology to search for solutions, not using a limited database, but the rules of physics and kinematics. Designing the user interface puts the Engineer in charge. Watt is easy to use, every command just one click away. No stacking dialogs, no crawling through menus. Watt uses a single window user interface. Important information is always visible. User intervention is always allowed which enables a very interactive working method. Start, stop, change, optimize… etc.

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