Appropriate Technology: Solar tracker

To design, model and make a low cost solar tracker for use in developing world countries.

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Tear Fund

- Tackle root causes of poverty to make a long term difference.
- Provide advice, training and consultancy.
- Funding of initiatives to address major global issues.

Solar Tracking

- Attempts make sunlight contact the solar panel surface normally, at all times throughout the day.
- Electronic / Passive tracking
- Improves efficiency of solar panel.
- Suppliers have quoted ~ 30% increases

Current Electronic Solar Trackers

- Motor driven tracking using electronic sensors to detect sunlight.
- Inefficient - Motor uses solar panel power.

Current Passive Solar Trackers

© Zomeworks Corporation

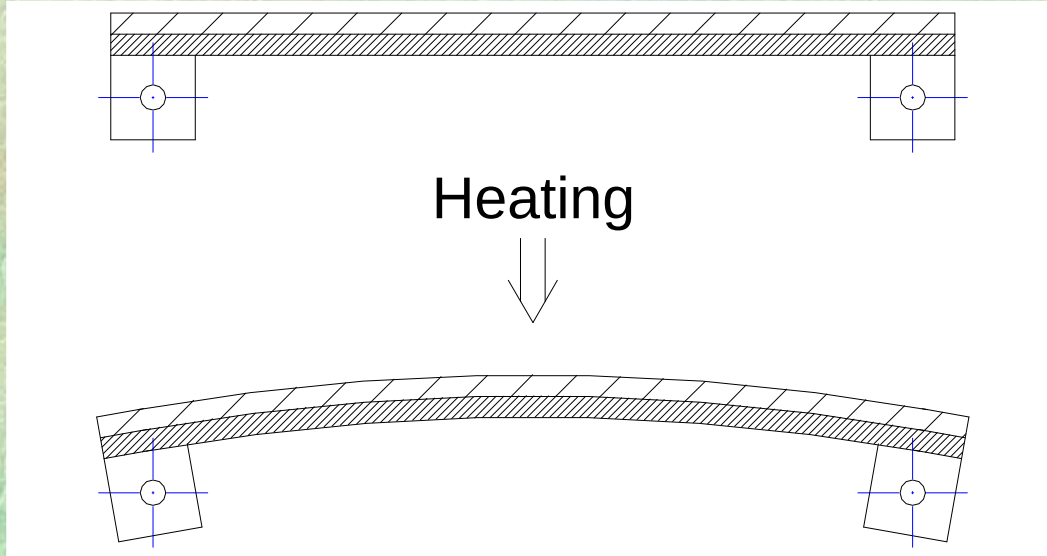
Control using the sun's heat to move partially pressured liquid from cylinders positioned at equal distances either side of a central pivot to offset balance.

Possible New Designs

- Redesign of partially pressured fluid system (Zomeworks). E.g. Including a night return mechanism.
- Expanding fluid in a piston. E.g. Greenhouse window opener.
- Heated air in a piston to instigate movement. E.g. Sterling engine

Chosen Design - Passive Sensor

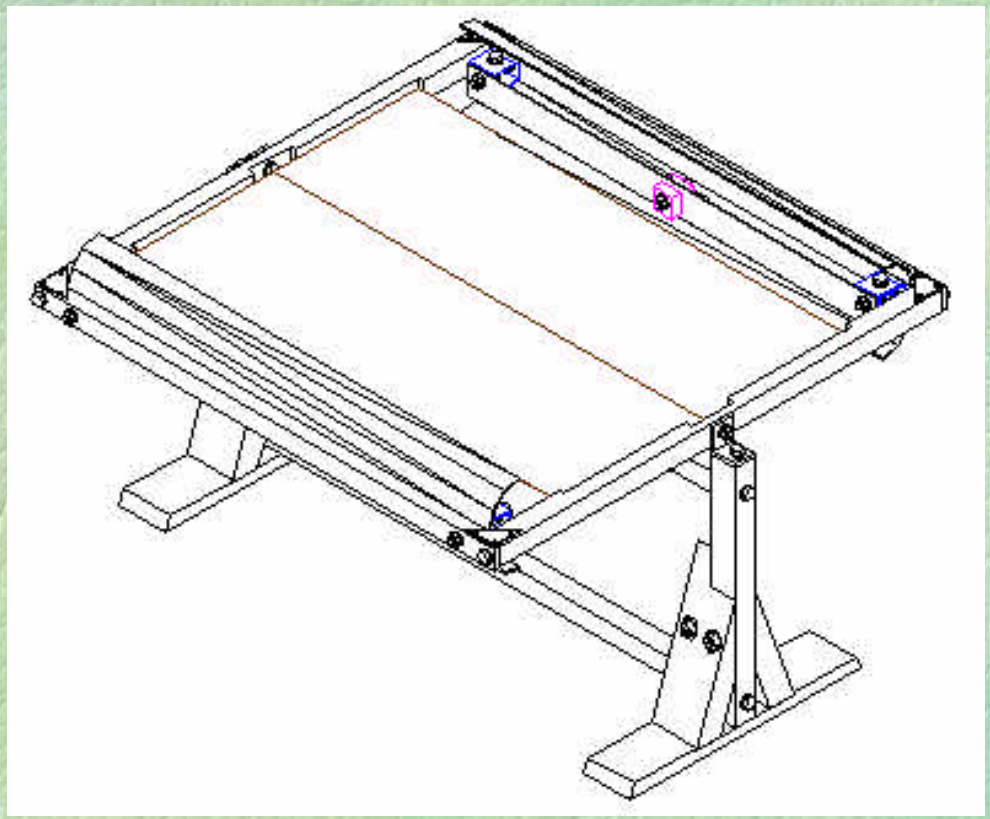
- Aluminium/Steel Bimetallic strip.
- Differential thermal expansion causes bending.



- Cheap, obtainable, low maintenance.

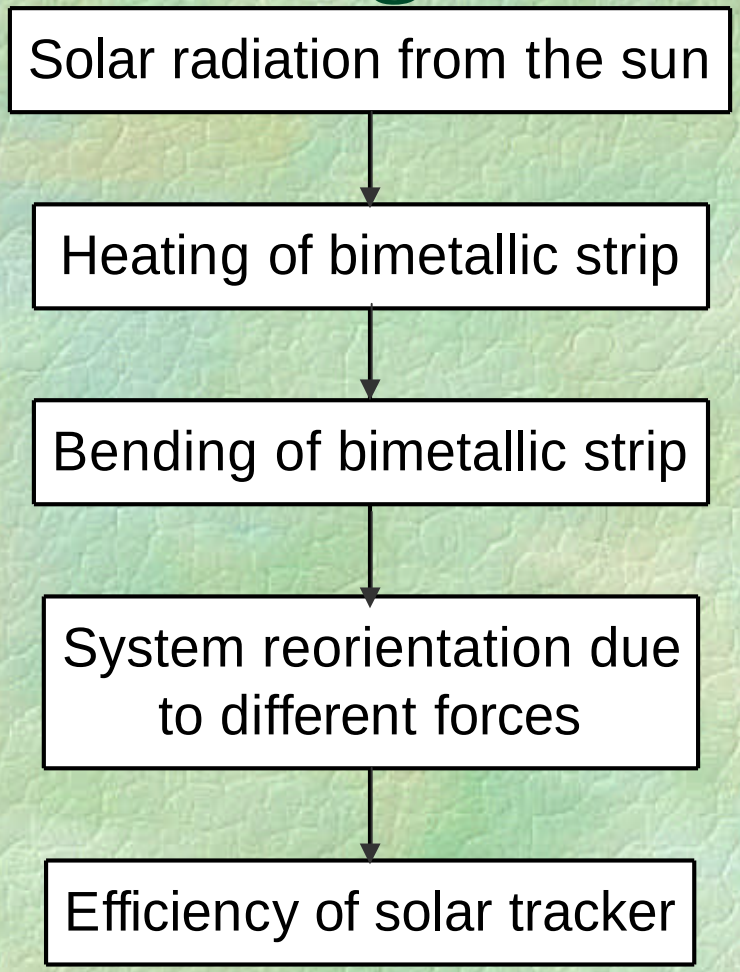
Chosen Design

- Two bimetallic strips; oppositely positioned equal distances from a central pivot.
- Bimetallic strip bending (towards central pivot) creates an imbalance in the system and produces movement.
- Damping controls movement.



Modeling the design

- C Program models tracking movements throughout the day.
- Program integrated over many small time periods.
- Efficiency calculated for entire day



Bimetallic Strip Thermodynamics

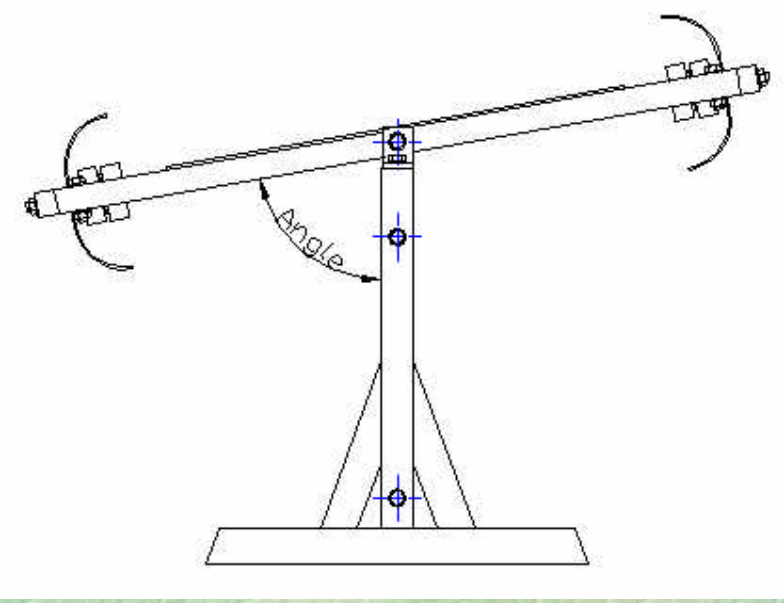
Conduction through bar	=	Solar Radiation	-	Thermal Losses

- Losses increase with temperature, seeking an equilibrium.
- Modelled as a lumped mass system.
- $$\Delta T_{AL} = \frac{\sum Q.\Delta t}{m.C_p}$$

Bimetallic Strip Bending

- For the materials at the same temperatures, differential expansion causes produces a bending moment.
- Thermal bending moment calculated first without loading, then other moments (e.g. block mass) superimposed.
- Hence deflection found.

Solar Tracker Reorientation



- BMS deflection alters the moment about the central pivot - accentuated by point masses.
- Forces about pivot are considered: Friction, damping, inertia and mass forces
- Integrative numerical approach used to find angle of solar tracker.

Solar Tracker Efficiency

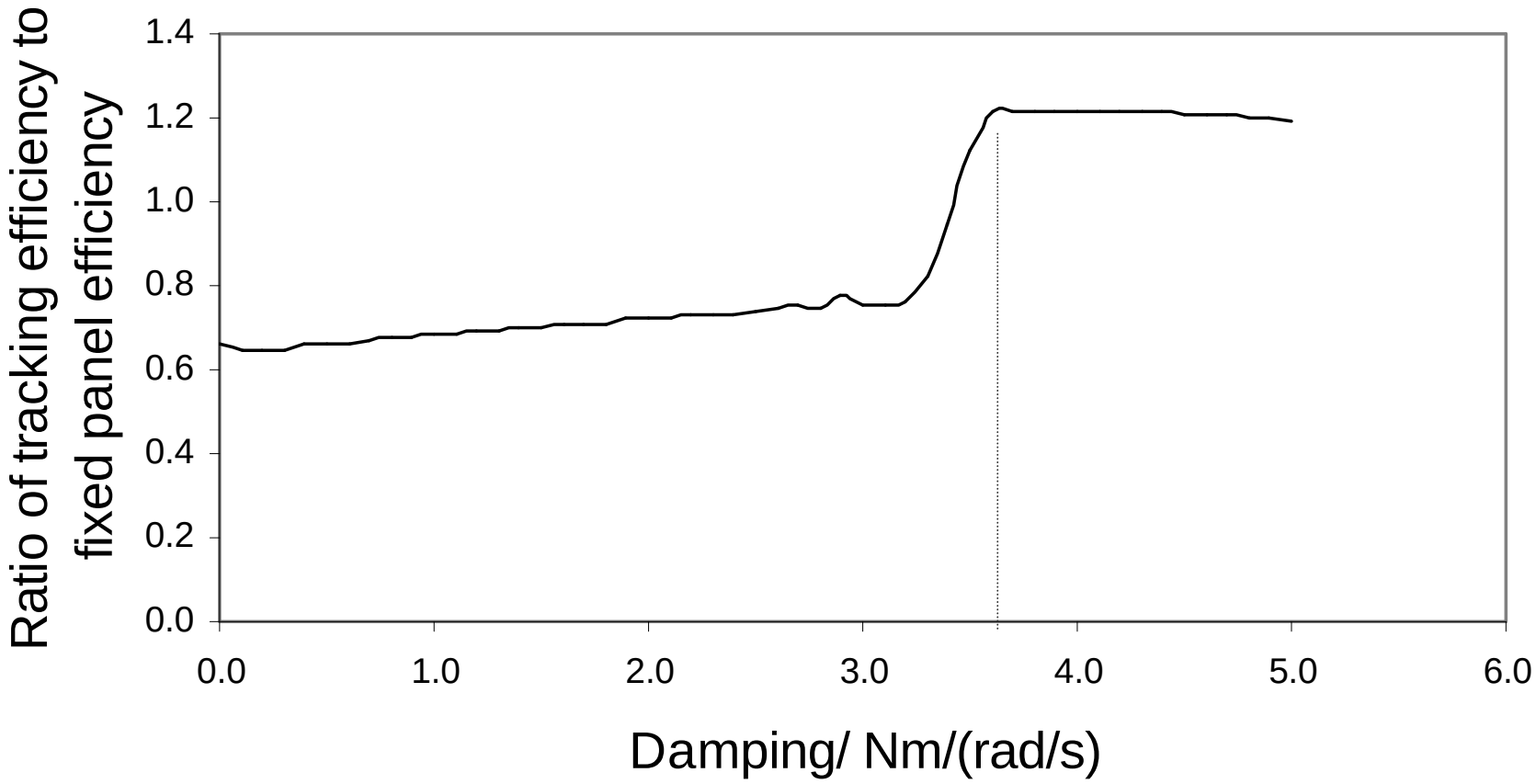
- Efficiency ;cos(Angle of contact)
- For each timestep, the incremental power obtained is summed:

$$Power \propto \sum \left(\frac{\text{Solar Radiation}}{\Delta t} \right) \times \cos \left(\begin{matrix} Solar \\ Angle \end{matrix} - \begin{matrix} Tracking \\ Angle \end{matrix} \right)$$

- Hence efficiency can be found:

$$\text{Extra efficiency}_{\text{TRACKER}} = \frac{Power_{\text{TRACKED PANEL}}}{Power_{\text{FIXED PANEL}}}$$

Sensitivity to parameters



Sensitivity to parameters

- *External disturbance counteraction*

e.g.Wind

Significant damping minimises effects

- *Bimetallic strip thickness:*

Speed of response Vs. Yielding and, hence, premature failure

Works in Theory- What about in practice?

Construction of a prototype was necessary to prove the validity of the theory.

- Materials - Cheap and easily obtained

E.g. Mild steel, aluminium, brass, timber, resin

- Manufacture - Turning, milling, cutting

Make it anywhere in the world!

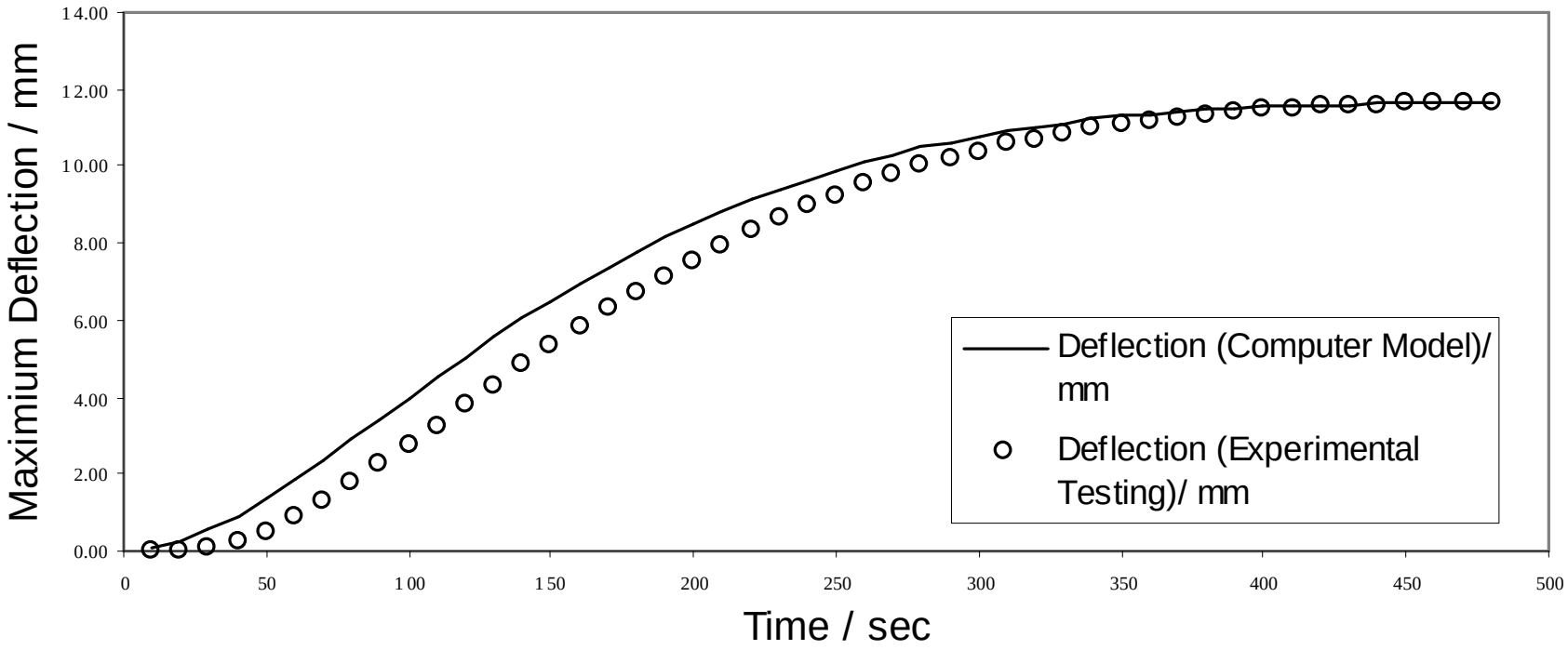
Completed prototype

Testing

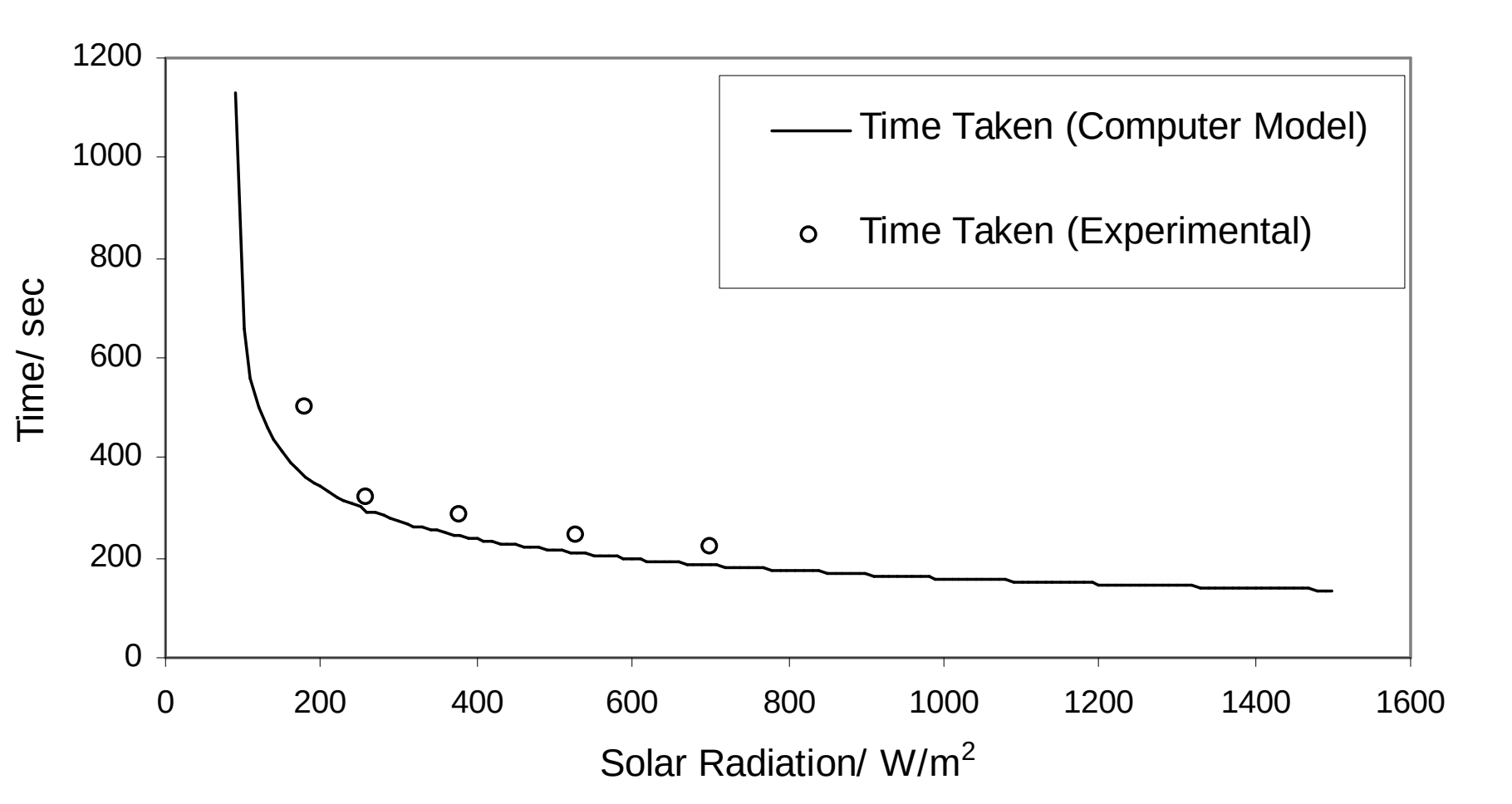
- Conducted in the School of the Built Environment.
- 500W halogen lamps used, hence conditions could be accurately measured and program altered to suit.
- However, testing set-up insufficient to model solar conditions for a full day.

i) Bimetallic Strip Testing

Comparision between experimental testing and computer model of bimetallic strip deflections



ii) Response Testing



Tracker In Action

Suggested improvements

Two main improvements considered:

- Night Return Mechanism
  - Sun sets in the West but rises in the East.
  - Reorientation during nightfall to anticipate sunrise.
  - Bimetallic strip again as a possible trigger, temperature drop at night produces differential contraction and hence bending.

Suggested improvements

- Tilted central axis system
  - Solar tracker currently only effective around equatorial regions.
  - Tilted axis would allow potential for use in other locations (of sufficient solar intensity).
  - Dual axis system more efficient but also more complex.

Conclusions

- Passive, low cost, low maintenance method of solar tracking presented.
- Materials and manufacturing processes available in developing world countries.
- Computer program boasts efficiencies of up to 23% extra.
- However, confined to areas receiving sufficient solar intensity.

Acknowledgements

- Dr. S. Pickering - Advice and consultation on bimetallic strip thermodynamics
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