Evaluation on Transmittance of a Cylindrical Fresnel lens and Its Application on Solar Steam Generation

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Abstract: This work presents a cylindrical Fresnel lens which was designed based on the optimal transmittance condition. A method to evaluate the real transmittance is given. It has been calculated that the real transmittance of the cylindrical Fresnel lens is 81.6%. Then a solar steam generation system by using the cylindrical Fresnel lens has been tested.

1. Cylindrical Fresnel lens
The optimal transmittance condition illustrates that how light goes through a prism can get maximum transmittance. Prisms in the cylindrical Fresnel lens are most close to the optimal transmittance condition, which makes cylindrical Fresnel lens has high transmittance.

Table 1. Parameters of the design Fresnel lens

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
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<tbody>
<tr>
<td>Aperture width (m)</td>
<td>1300</td>
</tr>
<tr>
<td>Focal length (m)</td>
<td>1250</td>
</tr>
<tr>
<td>Thickness Max/Min (mm)</td>
<td>7/2</td>
</tr>
<tr>
<td>Material</td>
<td>Polycarbonate</td>
</tr>
<tr>
<td>Geometrical concentration ratio</td>
<td>32</td>
</tr>
<tr>
<td>Theoretical transmittance</td>
<td>87.7%</td>
</tr>
</tbody>
</table>

2. Evaluation on real transmittance
A comparative method for transmittance evaluation is proposed, which compares the energy distribution of focus in simulation to the experimental focus. It can be calculated by eq.1.

\[
e = \frac{E}{E_{\text{sim}}} \times 100\%	ag{eq.1}
\]

3. Test on solar steam generation system
A solar steam generation system has been set up and tested. Cylindrical Fresnel lens was used to build the solar concentrator. It has a self-tracking mechanism with tracking precision of 0.5°. The pressure of steam generator was kept within 0.5 ± 0.02MPa when releasing steam.

![Fig. 4 Photos of solar concentrator and steam generation system](image)

The cylindrical Fresnel lens solar concentrator can steadily provide heat above 170°C when DNI is around 650W/m\textsuperscript{2}. The system can generate steam 7kg/h on average. The effective working time is from 9:45 to 14:00, in which the collection efficiency is about 0.5 and solar-steam efficiency is 0.34.

![Fig. 5 Testing results of solar concentrator and steam generator](image)

4. Conclusions
1) This work proposed a comparative method for evaluating Fresnel lens real transmittance, by which the evaluation of the cylindrical Fresnel lens is 81.6%.
2) The Fresnel lens solar concentrator can work more 4 hours per day with collection efficiency at 0.5.
3) The Fresnel lens solar concentrator can provide higher than 170°C heat (DNI=650W/m\textsuperscript{2}) so that the steam generator can surely produce 150°C steam 7kg/h, keeping solar-steam efficiency about 0.34.

Acknowledge
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