SCO4 SolTrace

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1 Introduction

In an attempt to study the optical behaviour of the SCO4 system and validate COMSOL's results, SolTrace software was revisited. Previous attempts with the software for SCO1 and SCO3 were not successful, due to a software bug in deep parabolic shapes.

SolTrace does not include automatic tracker modules, so each mirror's aiming point has to be set manually. An equation was developed in order to calculate each mirror's aiming point so that the reflected rays hit the absorber.

2 Mirrors arrangement

Flat 18.7x14mm mirrors were used for the test case using the geometry settings shown in figure 1.

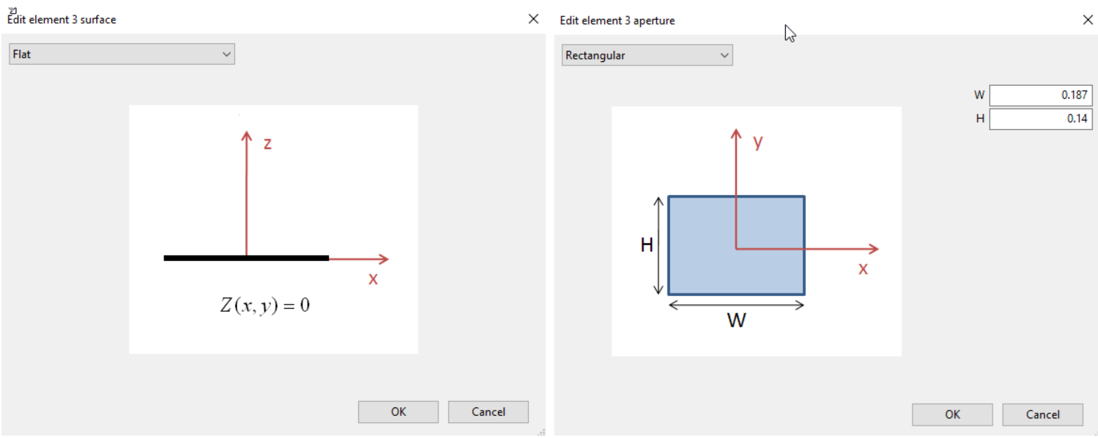

Figure 1: Surface and aperture settings in Geometry tab

The longest dimension of the mirror facet is set at the x axis (labelled W in figure 1) so that the longest dimension of the mirror array lies on x axis. The resulting arrangement is that of 2. The concentrating system does not have a built-in axis, so as a convention, the axis of the longest dimension is considered the longitudinal one and the shortest one the transversal one as indicated in figure 2.

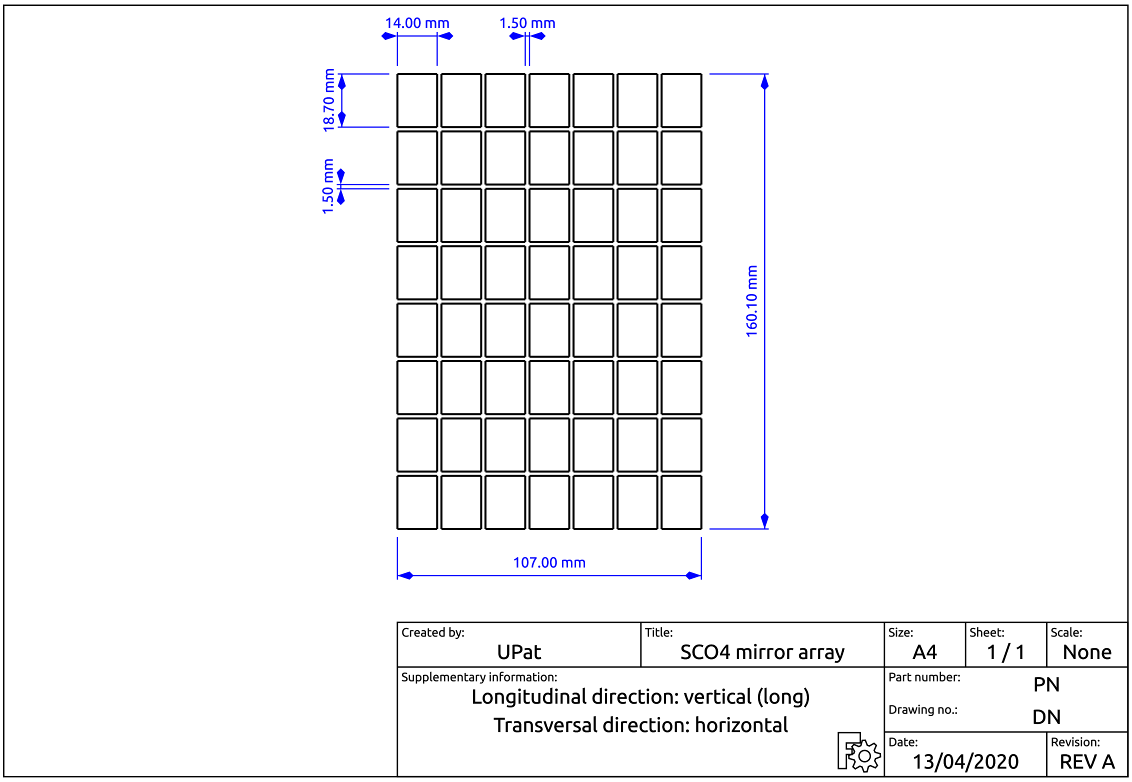

Figure 2: Mirror array

3 Aim point calculation

The center of the mirror array is set at $(0, 0)$ and he absorber is set $1,5m$ above the array's center $(0, 0, 1.5)$. The 3-dimensional coordinates for each surface created in SolTrace correspond to the surface center. The aiming point of each facet is defined using the facet's plane vector. The $x - z$ plane of the setup for normal incidence is shown in figure 3, where O is SolTrace's reference point $(0, 0)$, S represents the sun, A the absorber, DE the mirror facet with middle M and P the facet's aiming point. The solar elevation angle for the simplest case shown in 3 is $\alpha = 90°$.

$$\omega = \frac{\alpha - \phi}{2} \tag{1}$$

Let $OM = x$ and $OA = z_a$, then

$$\phi = \arctan\left(\frac{z}{x}\right) \tag{2}$$

Let $OP = z_p$:

$$\tan(\phi + \omega) = \frac{z_p}{x}$$

$$z_p = x\tan(\phi + \omega) \tag{3}$$

Replacing (1) in (3) we get

$$z_p = x\tan\left(\frac{\phi + \alpha}{2}\right) \tag{4}$$

Replacing (2) in (4) we get

$$z_p = x\tan\left(\frac{\phi + \alpha}{2}\right) \tag{5}$$

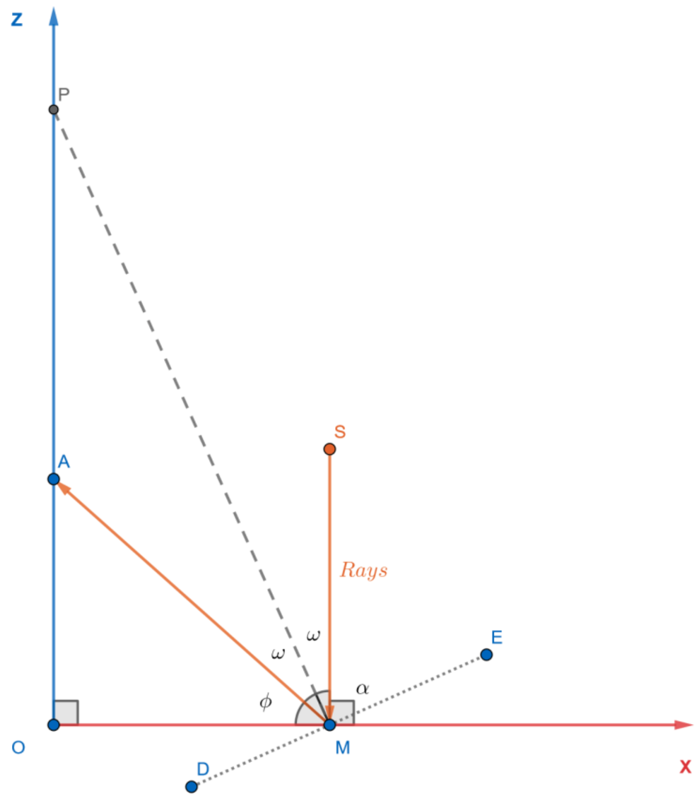

Figure 3: Mirror facet aiming point

$$z_p = x \tan\left(\frac{\arctan\left(\frac{z_a}{x}\right) + \alpha}{2}\right) \tag{6}$$

Considering that the mirror array lies on the $x-y$ plane, the distance of the facet from the reference point is $\sqrt{x^2+y^2}$, so equation (6) becomes

$$z_p = \sqrt{x^2+y^2} \tan\left(\frac{\arctan\left(\frac{z_a}{\sqrt{x^2+y^2}}\right) + \alpha}{2}\right) \tag{7}$$

The solar elevation is $\alpha = 90^\circ - \theta_z$, so the facet's aim point on z-axis is

$$z_p = \sqrt{x^2+y^2} \tan\left(\frac{\arctan\left(\frac{z_a}{\sqrt{x^2+y^2}}\right) + 90^\circ - \theta_z}{2}\right) \tag{8}$$