This work presents a theoretical study to take the heat transfer within the heated sample and out to the surroundings medium into account in time resolved thermal lens (TL) and thermal mirror (TM) experiments. We solve the diffusion equations with heat flux boundary conditions to obtain a semi-analytical solution for the temperature in the sample and in the surrounding fluid. In the low optical absorption case, the semi-analytical solution is used to model the thermal lens effects and the results are compared with the finite element analysis (FEA) software solution. Finite element analysis software provides numerical solutions to the heat transfer equations with realistic boundary conditions imposed by the experimental geometry. The FEA modeling results were found to be in excellent agreement with our solutions. The phase shift induced in the probe beam in a mode-mismatched TL configuration, in which a weak TEM$_{00}$ Gaussian beam, almost collinear arranged with the excitation laser beam, travels through the sample and probes the TL. The heat transferred to the air coupling fluid does not introduce any important effect in the sample phase shift when compared to the solution obtained without considering heat flux. The contribution from the thermal lens created in the air coupling fluid corresponds to approximately 2% of the sample’s TL effect. When water is used as fluid the heat coupling leads to a more significant effect in both sample and fluid phase shift. Our solution opens up the possibility of applying the TL and TM methods for accurate prediction of the heat transfer to the coupling fluid and subsequently to study the fluid media by using a known solid material.