3.4 Multi-Dimensions

In Chapter two it was indicated that a multi dimensional input vector can complicate the prediction process. In (Fig. 3.4-1) the results of a prediction using 81 equally spaced training samples that do not include any noise are shown. The prediction was performed for simultaneous changes of the mass flow rate and the inlet temperature of water.

The predictions in (Fig. 3.4-3) and the folowing figures in this section were performed for simultaneous changes of the mass flow and the water inlet temperature. That means that the temperature of the mass flow of *0.5kg/s* was *300K*, the temperature for *1.7kg/s* was *350K* and the temperature of the mass flow of *2.9kg/s* was *400K* respectively. The intermediate combinations of mass flow rate and temperature result from the above, the same proportional changes as before.

It was hoped that the results of these predictions were better. This makes the question 'why are the results for a sole prediction without a simple model so bad?' more than appropriate. The truth is that the use of four dimensions in the input vector influences the prediction including the selection of the smoothness parameter.

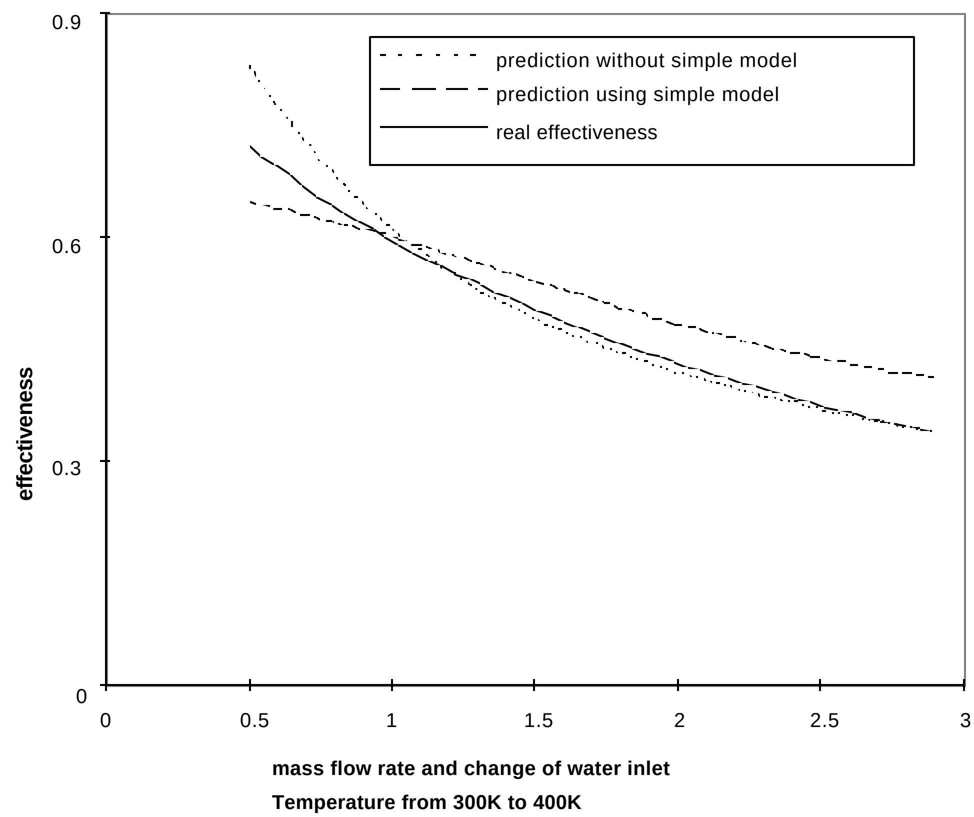

Fig. 3.4-1 Comparison of prediction using simple model or not, 81 equally spaced training samples, Tair=300K, velocity=25m/s

The temperatures of the water and the air have a rather small influence on the effectiveness of a heat exchanger. In other words changes in the effectiveness for changing temperatures are minor. It was therefore tested what change it would make if the temperature dependence would be ignored and the effectiveness would be regarded only as a function of mass flow rate and velocity.

Another approach was tested that was discussed in Chapter two. Under certain independence assumptions it is possible to predict the dependence of the effectiveness from the mass flow and the velocity and the dependence of the effectiveness from the temperatures independently. The necessary assumptions are that the influence of the temperatures on the effectiveness is independent from the mass flow rate and the velocity (Chapter 2). Or with an example, the error made for estimating the effectiveness for a mass flow of *0.5kg/s*, a velocity of *15m/s*, an inlet temperature of water of *350K* and an air temperature of *300K* is the same for a different mass flow and a different velocity, like a mass flow of *2.3kg/s* and a velocity of *30m/s* but still for the same temperatures. This is not absolutely true but it is a possible simplification.

The prediction method will be built up as follows. The simple model still gives the initial trend of the prediction. A first block of GRNN will predict a correction depending on the mass flow and the velocity, any temperature dependence is ignored. A second block of GRNN predicts a correction term for the temperature dependence. This term is independent from the mass flow and the velocity. The block using the mass flow rate and the velocities is independent from the temperatures respectively.

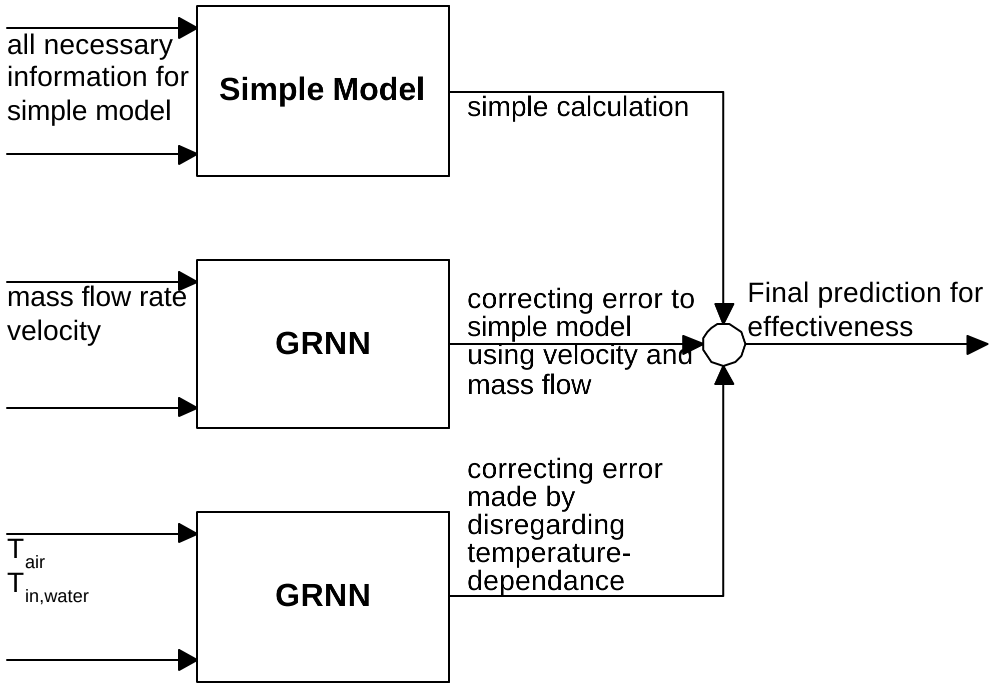

Fig. 3.4-2 Procedure to predict under the assumption of independence

For the approach that does not use a simple model as an underlying function the effectiveness will first be predicted using only the dependence on the velocity and the mass flow. The second block will still perform as before. The second block will predict a term to correct the temperature dependence.

The training samples for the prediction below were split into two sets. The first set included only information on the dependence of the effectiveness from the mass flow rate and the velocity for fixed air and water inlet temperatures. The second set included information only on the dependence of the temperatures for a fixed mass flow rate and velocity. The fixed variables were fixed at their design points. Each of the training sets included only 9 training samples. This reduced the amount of training samples by a factor of more than 4. For the prediction that is ignoring the temperature dependence only the first set of training samples was used. This means that only 9 training samples have been used, this is only a little more than a tenth of the amount of training samples that was used for the prediction in (Fig. 3.4-1).

The shape of the predicitons of the approaches are comparedly good. They do represent the real effectivenss closesly. The prediction for extreme values of the effectiveness still levels off but this leveling off is a lot more moderate than for the use of a four dimensional input vector, discussed in the previous sections.

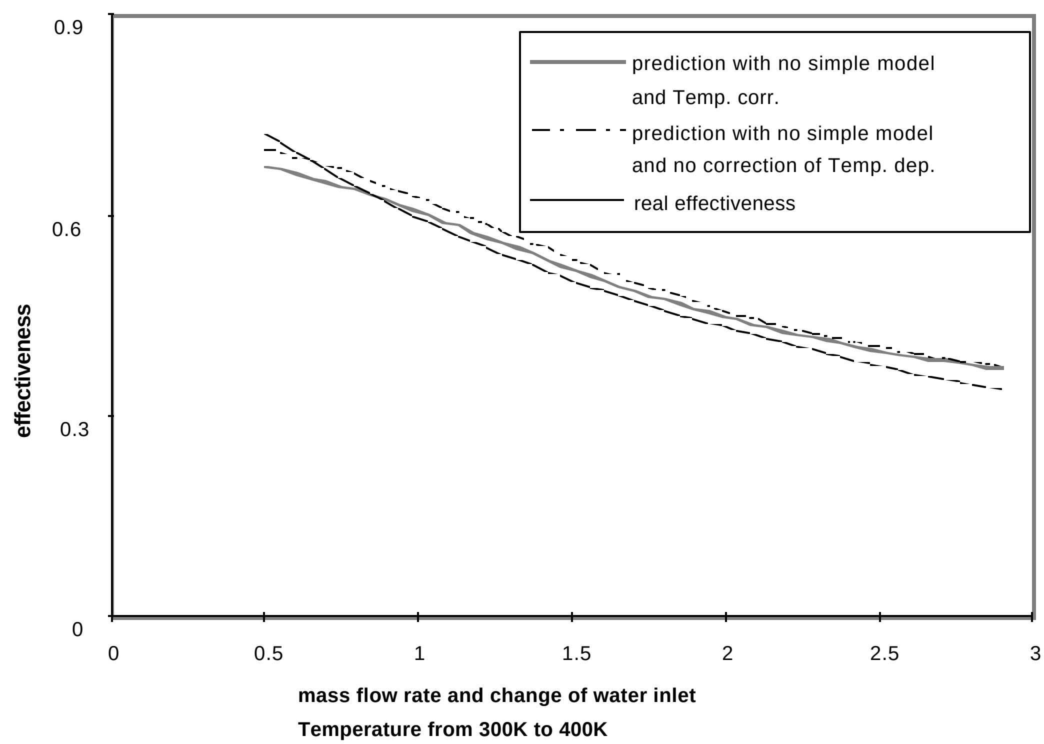

Fig. 3.4-3 Using no simple model and a temperature correction or not at T_{air}=300K, velocity=25m/s compared to the real effectivenss

The result for the use of an underlying function are satisfying. The shape of the curve of the predicted effectiveness is more pronounced than the real effectiveness.

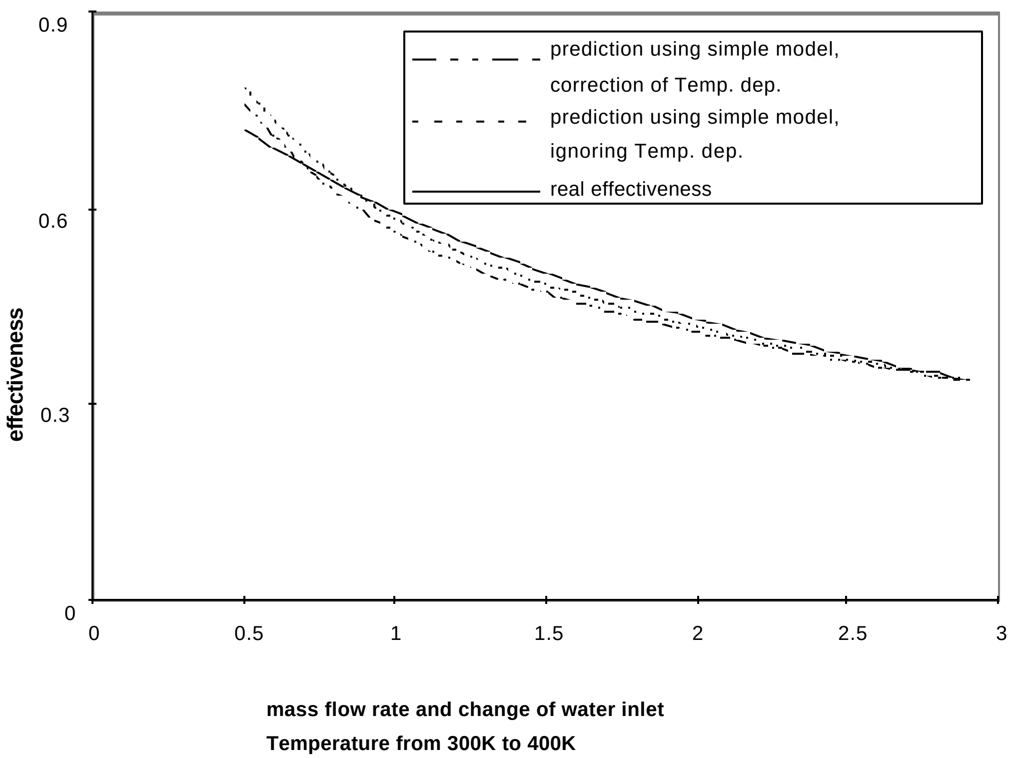

Fig. 3.4-4 Using simple model and a temperature correction or not at T_{air}=300K, velocity=25m/s compared to the real effectivenss

The prediction of the effectiveness for 999 points for the approach of correcting the temperature dependence are shown for the use of an underlying function in (Fig. 3.4-5) and for using no simple model to support the prediction in (Fig. 3.4-6). The results are shown again in a plot of predicted effectiveness versus the effectiveness calculated with the detailed model.

The precision of the prediction is not improved. The assumption of independence between the mass flow rate, the velocity and the temperatures of the air and the water is not valid and therefore the predicted efectiveness and the real effectiveness deviate from each other. The Sum of Squares devided by the calculated predictions of the approach using two independent sets of training samples yields a more than twice as big of a number that for using one entire set of samples. The number of training samples for the two independent training sets is just one nineth of the number of training samples for the the apporach using no assumption of independence.

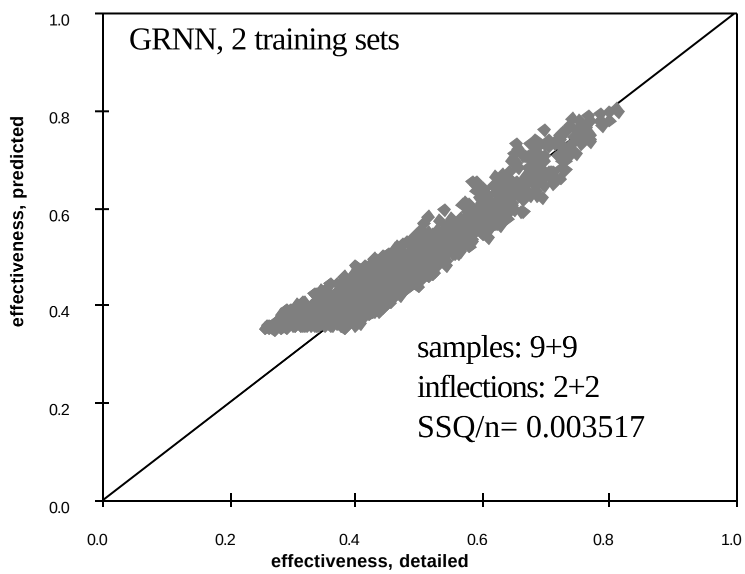

Fig. 3.4-5 Predicted effectiveness versus effectiveness, calculated with the detailed model for 999 randomly picked points for approach correcting the Temperature dependence for 9 and 9 equally spaced training samples, using the approach to correct simple model

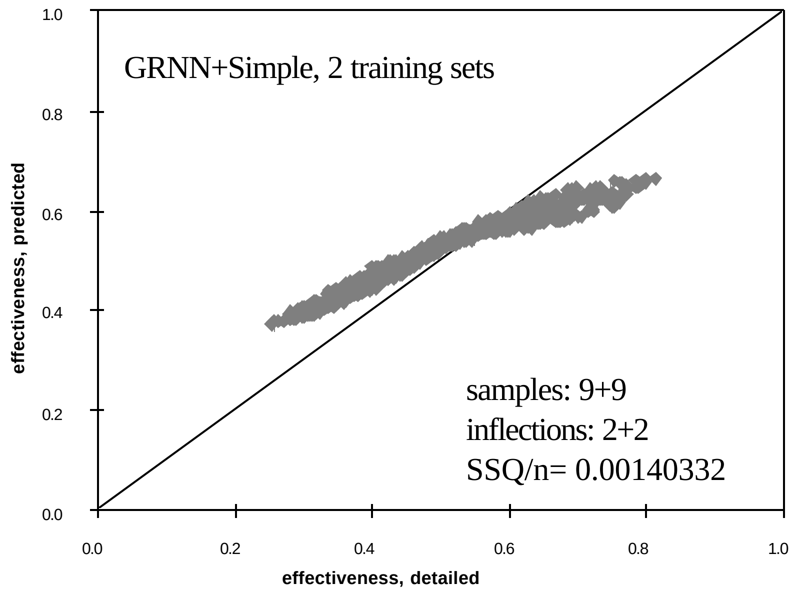

Fig. 3.4-6 Predicted effectiveness versus effectiveness, calculated with the detailed model for 999 randomly picked points for the approach correcting Temperature Dependence with 9 and 9 equally spaced training samples, using the approach without additional knowledge