Prediction of thermal performance of crossflow economiser in transient mode using Transient Analysis Program (TAP)

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Abstract: This paper describes the work done in order to make the prediction of performance by thermal analysis of horizontal cross flow type of economiser in transient mode. It is rather simple to predict the performance of steady state due to less input data required and the fact that many more simulation software are available for steady state simulation than for transient process. The work aims at modeling the program of prediction of thermal performance of cross flow economiser in transient mode which will be applicable to any type of horizontal cross flow economiser. This economiser which is a bundle of tubes and the method used here treats each tube bundle in a similar way, replacing each tube bundle with an equivalent heat exchanger connected in series.

IndexTerms **- Performance prediction, Transient Analysis Program (TAP), Cross Flow Economiser, Transient Mode, Economiser.**

I. INTRODUCTION

Economiser is the energy improving device which saves the fuel and helps to reduce the cost of operation. Economiser tends to make the more energy efficient system. A common application of economiser in system is to capture the waste heat from flue gases and transfer it to the feedwater. This raises the temperature of feedwater, lowering the required energy input.

Normal Cold Start was considered for transient event, there is no diverter damper at the gas turbine exhaust, the economiser accepts the exhaust gas directly from gas turbine. Therefore, the conditions of exhaust gas follow the gas turbine start-up schedule, where base load is achieved in 20 to 25 minutes.

Transient Analysis Program (TAP) performs a heat balance for each section of economiser at time increment of one second to capture transient behavior. Each row of tubes is incorporated in the program. The input conditions are the combustion turbine mass flow rate and exhaust gas temperature. Process Conditions on the cooling side vary during the start-up sequence and the program includes these effects. Some basic properties are calculated using a datasheet analysis. A number of parametric calculations were run and adjustment factors were derived. The type of economiser used for analysis is Horizontal counter-current to cross flow type of Economiser of capacity 10 MW.

II.PROCESS CONDITIONS OF ECONOMISER

To perform transient analysis process data from datasheet, is given as input to the Transient Analysis Program (TAP). Some basic system properties calculated using a datasheet analysis. The data sheet conditions of economiser are given in Table 1. Initially This data is input manually to program.

Table 1 Data Sheet Conditions of Economiser

Parameter	Value	Unit
Gas inlet temperature	493.88	^{0}c
Gas outlet temperature	379.29	^{0}c
Water inlet temperature	120	^{0}c
Water outlet temperature	160	^{0}c
Gas inlet mass flow rate	77.319	kg/s
Water inlet mass flow rate	59.746	kg/s
Mass of water in tube row	868	kg
Number of tube rows	8	
Tube bundle weight	10522	kg
Heat transfer capacity	10.25	MW
Time to achieve base load	18	min

Analysis of transient state is done for normal cold start condition where economiser follow gas turbine start-up schedule and transient state of 18 min. Inlet mass flow rate and Temperature of gas at every minute in transient state are given in fig.1.

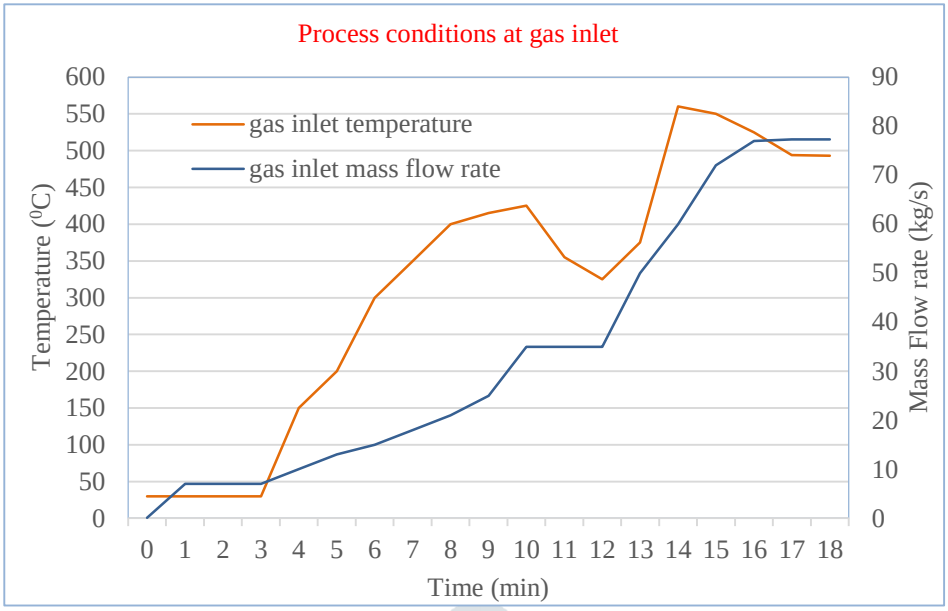

Figure 1 Change in Gas inlet Temperature and mass flow rate to economiser with respect to time

Also, temperature conditions on the water side vary during the start-up sequence these effects are included in the calculations. change in Inlet temperature of water (t_1) with respect to time is given in fig.2. Water mass flow rate is same as that of data sheet condition. i.e., (W_c = 59.746 kg/s).

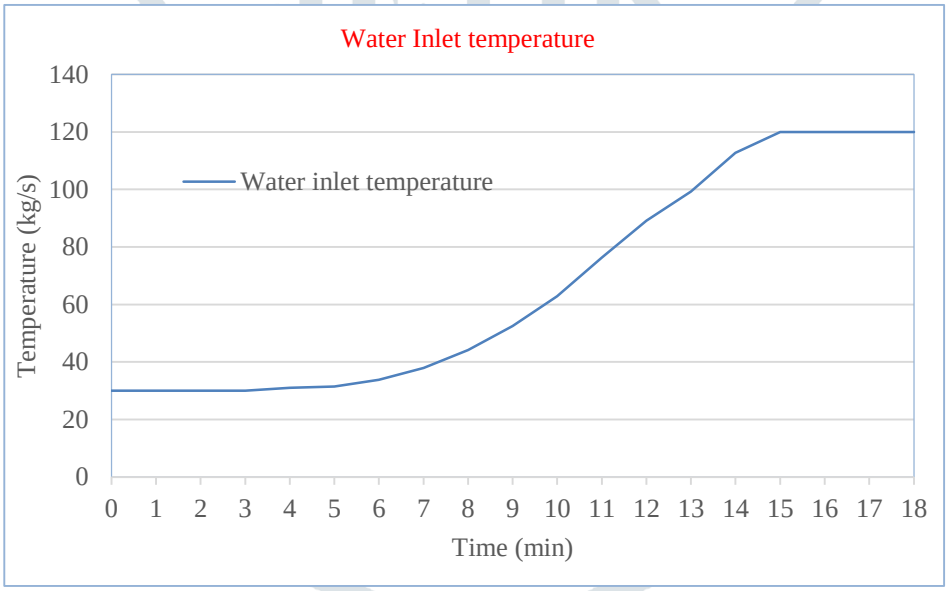

Figure 2 Water Inlet temperature to economiser with respect to time

III. PERFORMANCE ANALYSIS BY TRANSIENT ANALYSIS PROGRAM (TAP)

Transient Analysis Program (TAP) performs a heat balance for each section of economiser at time increment of one second to capture transient behaviour. Each row of tubes is incorporated in the program. Program divides Economiser module into that number sections equal to number of passes of tube bundle. All these sections work as separate heat exchangers which are connected in the series where the output of one section will be the input to the next section. Input of the economiser will be the input to the first section of economiser and output from the last section will be the output from economiser.

In this economiser the number of rows is eight and which is also equals to the number of passes. So that number of sections will be equals to eight. There are 21 number of tubes in each tube row but here it is assumed the total mass flow from all the tubes which is mass flow at the outlet of the tube header. The steps followed in Transient Analysis Program (TAP) are explained in flowchart given in fig 3. The results of previous section and previous time interval are saved for calculations of next section as well as next time interval. All calculations on gas side are done and results are saved for first time interval. Hence the results of gas side calculations can be called for water side calculations for that section in same time interval. Time interval is of one second and performance at every second is obtained over total time interval of 18 min.

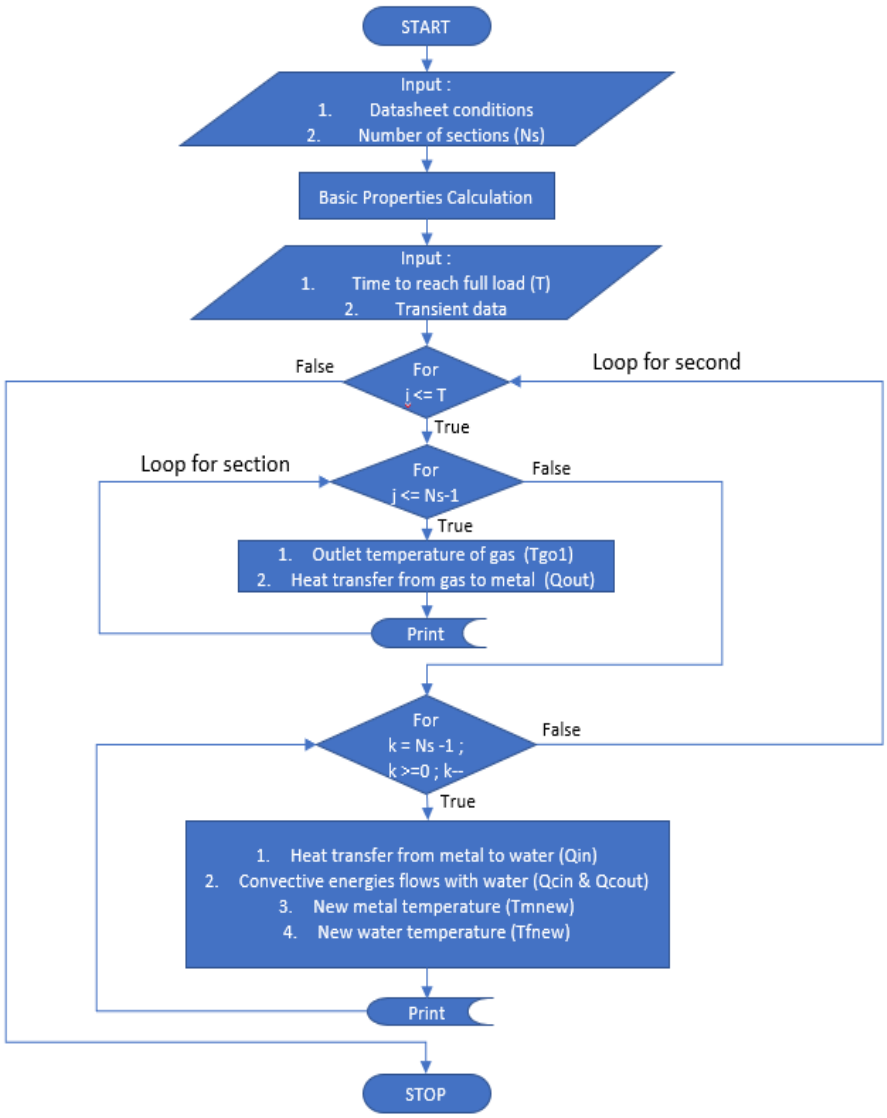

Figure 3 Flowchart for Transient Analysis Program (TAP)

IV. RESULTS AND DISCUSSION

Results of every time step are shown in output file. Columns in the output files are labelled with various results (Mass flow rate of gas, Water Outlet temperature, Gas outlet temperature, Minimum Metal temperature, Maximum metal temperature) corresponding to the time in second. These files can be imported into Excel spreadsheet format and used to produce graphs or whatever results format the user wants.

The change in outlet temperature of water and gas in transient state is obtained from Transient Analysis Program (TAP) is shown in fig.4. and fig.5.

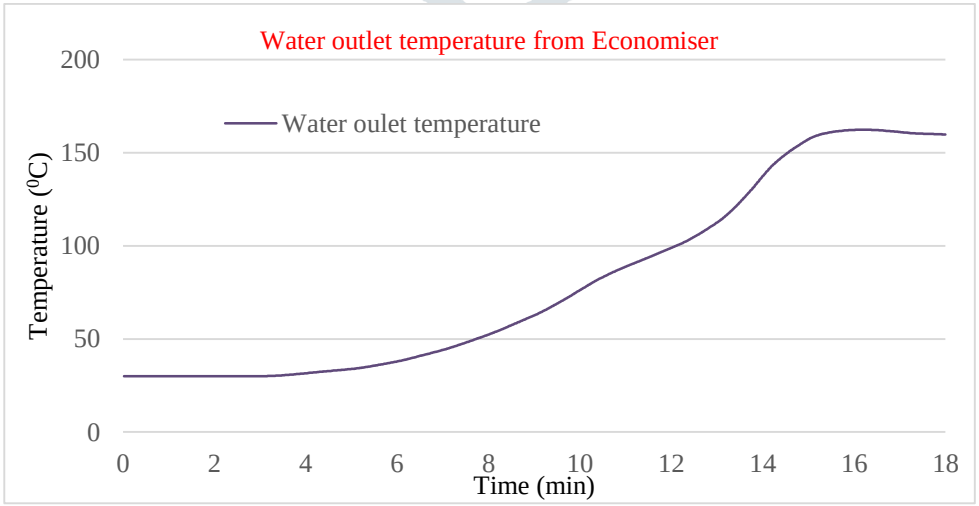

Figure 4 Change in outlet temperature of water with respect to time obtained from TAP

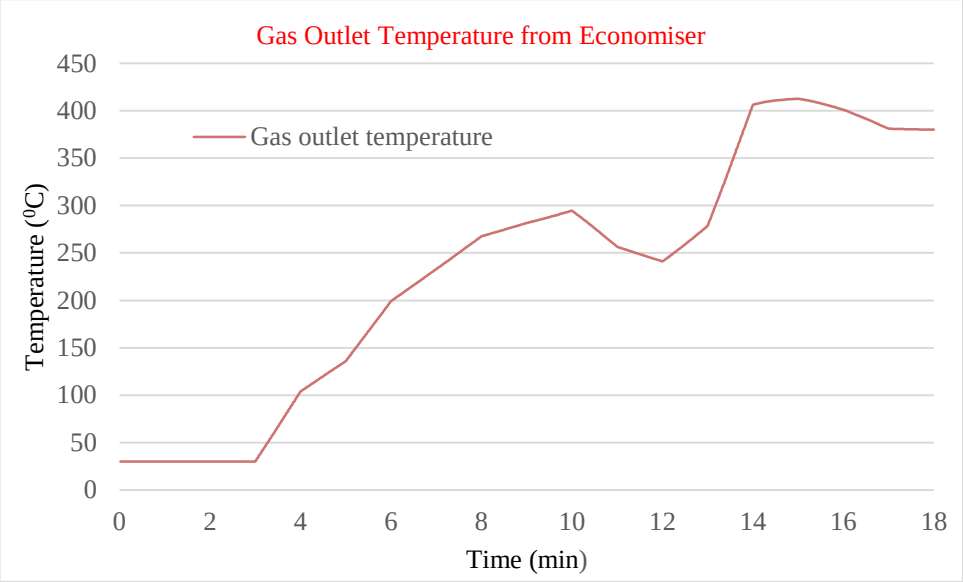

Figure 5 Change in outlet temperature of gas with respect to time obtained from TAP

Result show that outlet temperature of water approaches 160 deg C and outlet temperature of gas approaches 380 deg C. Also, we have the Minimum metal temperature and Maximum metal temperature corresponding to every time interval in output. Result can be seen in the required format by the user.

V. CONCLUSION

i. Transient Analysis Program (TAP) can do precisely the particular anticipated demands that are placed on it and is suited to specific conditions encountered in economiser.
ii. Transient Analysis Program (TAP) will be in general applicable to any countercurrent to cross flow type of economiser.
iii. Calculations require reasonable computing time.
iv. Comparison show that higher the number of sections and smaller the time increment results into more accuracy..

VI. REFERENCES

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