Web Based Interactive Thermodynamic Property Evaluation

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I. Introduction

With the tremendous growth of the Internet and the world wide web, many engineering courses now have some components that are web based. At its simplest, this may involve posting course materials, such as syllabus and homework assignments, on the web, while in its more complex form includes full-fledged web based courses. To fully accomplish a completely web based course in thermodynamics, some provisions must be made for interactive problem solving and, as the focus of this paper, interactive property evaluation. Two JAVA applets have been developed that provide an interactive, web based approach to the evaluation of thermodynamic properties for steam and ideal gases.

This paper continues with a brief description of the software development. This is followed by a description and demonstration of the JAVA applets. Finally, conclusions are provided concerning this work.

II. Code Development

In developing these applets several different JAVA compilers were considered. Borland JBuilder was chosen to be used for this purpose. One of JBuilder's strengths was its drag and drop feature for building the graphical user interface. As shown in Table 1, two other JAVA compilers were given serious consideration. JBuilder was found to be more desirable than the other compilers because it has extensive code-browsing facilities, as well as facilities for creating and modifying Java Bean components. It also provides features for component-based program, so building an interface is accomplished by dragging and dropping GUI components, such as a push button, into the designer window. Finally, the software was readily available at the MSU Student Bookstore and was reasonably priced at $99.98.

The property calculation component of the applets were handled by taking existing MATLAB or FORTRAN codes and translating them into JAVA code. For the ideal gas applet, the ideal gas law was used for the relationship among temperature, pressure, and specific volume. The enthalpy, entropy, and internal energy were calculated from integrating the specific heats. That is,

$$s - s_o = \int_{T_o}^{T} \frac{c_P}{T'} dT' + R \cdot \ln\left\{\frac{P}{P_o}\right\} \qquad (1)$$

Table 1. Compiler Choice Decision Matrix

Decision Criteria	Software Packages			
	Weighting Factor	Java Development Kit	Visual Café	Borland JBuilder
Cost	2	10	4	7
User-friendliness	5	1	8	7
Speed	4	8	4	5
Use of System Resources	5	5	4	7
Design Panel	4	1	9	8
Total		86	120	136

The specific heats are evaluated using the polynomial expressions provided by Van Wylen and Sontag [1]. The base state for the properties were taken to be 298 K and 1 kPa. For the steam applet, the steam table subroutine of RANKINE [2] was used.

Because of JBuilder's extensive use of Borland Java Beans several difficulties were encountered in deploying the applets. It was found that by adding each individual dependency to the project folder and compiling into a single file these problems could overcome .

II. Code Description and Demonstration

The ideal gas applet supports property determination for eight different ideal gasses:

N_2, O_2, H_2, CO, OH, NO, H_2O, CO_2

The properties that are determined by the applets are:

Temperature (K)	Pressure (kPa)	Entropy (kJ/kg·K)
Enthalpy (kJ/kg)	Internal Energy (kJ/kg)	Specific Volume (m^3/kg)

Specific Heat at Constant Pressure (kJ/kg·K)
Specific Heat at Constant Volume (kJ/kg·K)

It also allows for ten different combinations of two properties that fix the state of the system. As shown in Figure 1, the choice of known properties is made from a web page hyperlink. Upon clicking on the appropriate hyperlink, a second applet, see Fig. 2, comes up that is customized for this choice. The user then identifies the ideal gas, inputs the values of the two known properties, and clicks on the "calculate" button. The values for the remaining properties are then calculated and displayed. The calculations of the applets have been tested extensively and comparison with standard ideal gas tables indicates an error leas than 0.5%.

The steam applet provides five different scenarios for property evaluation. The user indicates of the following situations:

Temperature and Pressure known
Temperature and Fluid Phase (or Quality) known
Pressure and Fluid Phase (or Quality) known
Pressure and Entropy known
Pressure and Enthalpy known

The choice of known properties is made from a list box on the applet. After values of the known properties are entered, a calculate button is pressed and the remaining properties are calculated and displayed. An example of the steam applet is shown in Fig. 3.

Figure 1. Initial Web Page for Ideal Gas Evaluation

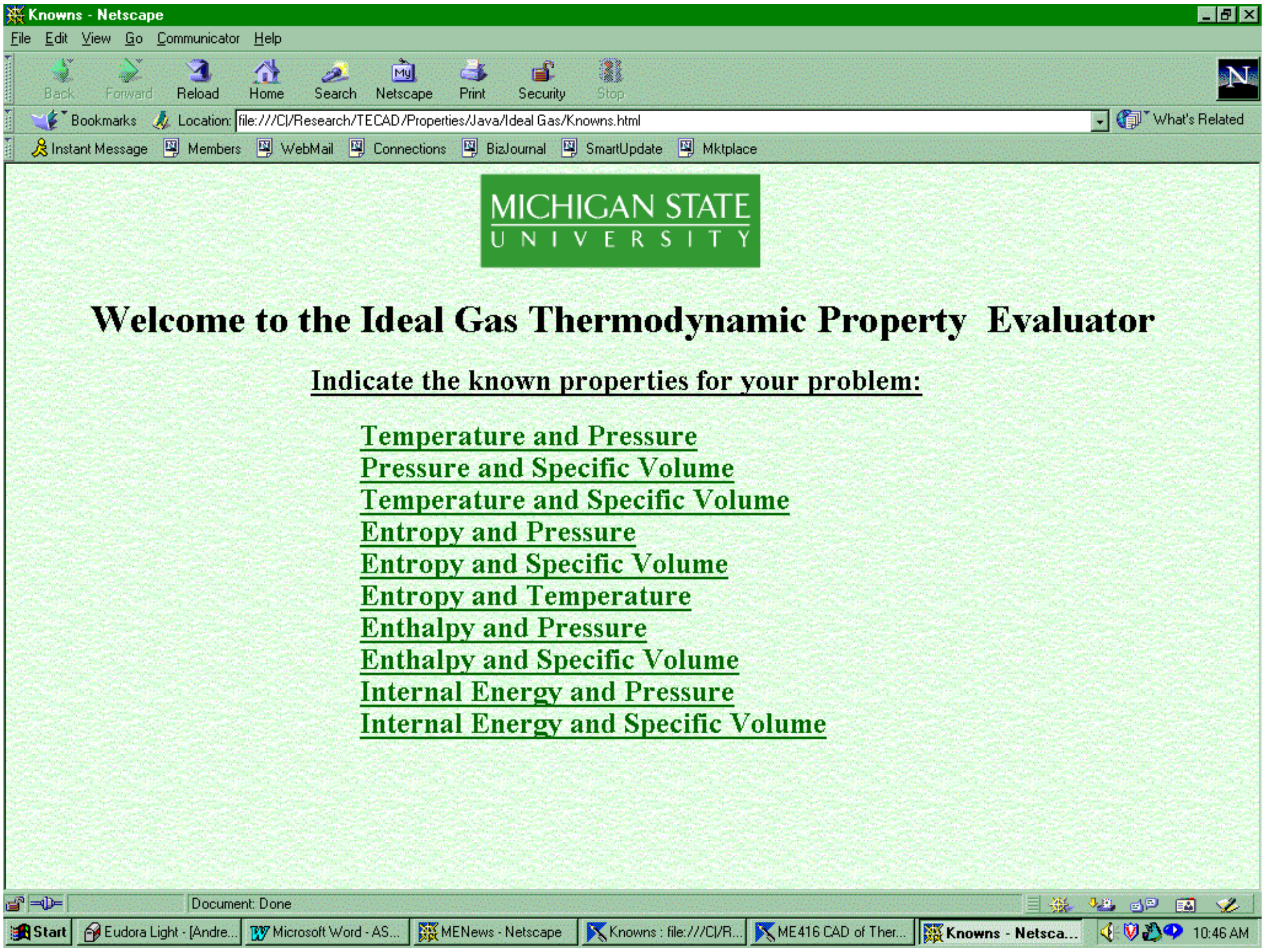


Figure 2. Applet for Ideal Gas Evaluation

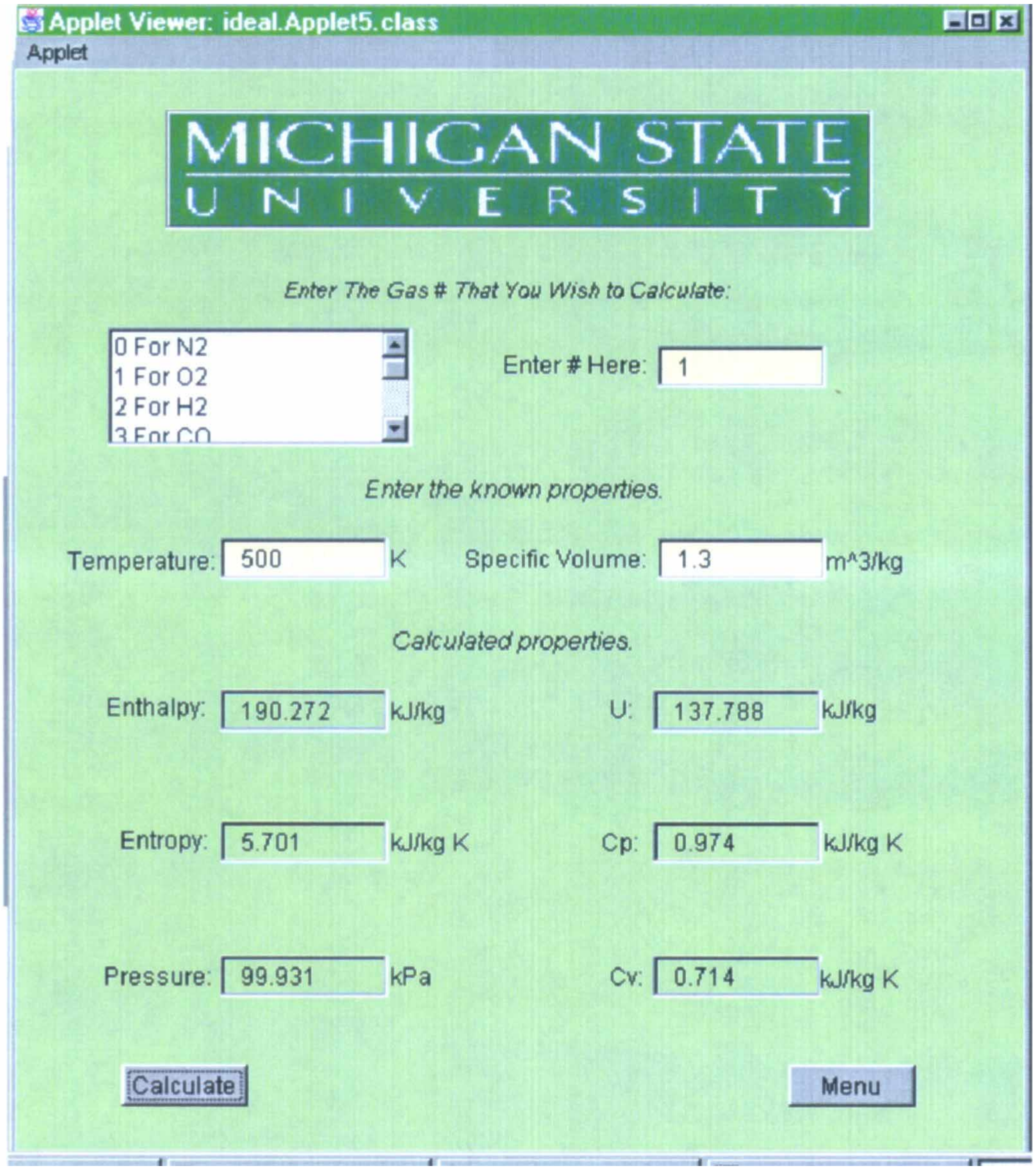
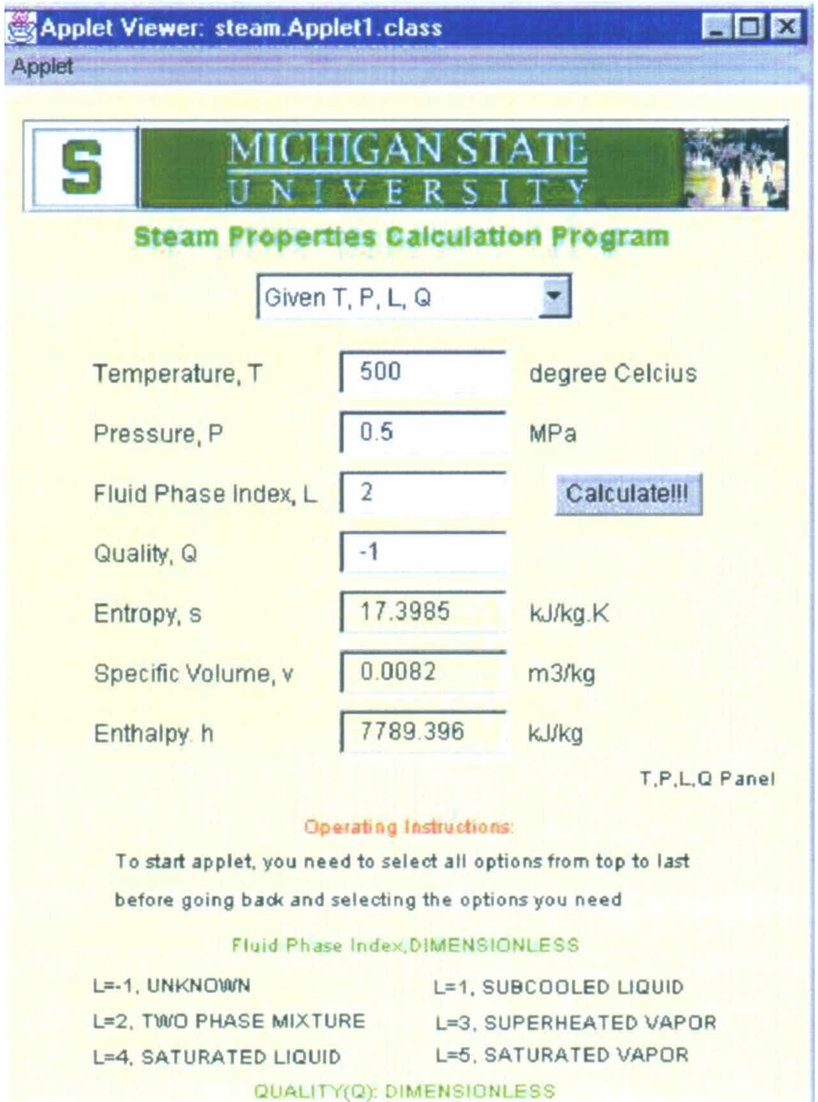


Figure 3. Applet for Steam Evaluation



Both applets are available for access at the Thermal Engineering Computer Aided Design (TECAD) homepage in the Department of Mechanical Engineering at Michigan State University. The URL address is

http://www.egr.msu.edu/~somerton/TECAD

III. Conclusions

Two JAVA applets have been developed for the thermodynamics property evaluation for ideal gases or steam. With the thermodynamic properties for ideal gases and steam available in a web based form, it will be possible to develop additional thermodynamic software for the web that could include first law analysis, second law analysis, and simulation of per and refrigeration systems. Calculation tutorials can also be developed.

Bibliography
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2. Thelen, W. and Somerton, C.W., "Rankine 3.0: A Steam Power Plant Computer Simulation", ASME International Congress, November 1994.

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