Paper vs. Computer: Are Printed Thermodynamic Property Tables Still Important

John L. Krohn
Arkansas Tech University

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Abstract

With the advent of computerized thermodynamics tables, students no longer necessarily need to learn the use of printed tables and the difficulties of interpolation. However, the question arises, at least in the author's view, of whether full dependence on computerized tables removes the student further from a basic understanding of what the properties represent and what is a "reasonable" value for a particular property. As has been seen in other courses, the use of computerized thermodynamic property tables seems to lead to a "disconnect" between what the table values represent and the actual numbers obtained. In this extended abstract, observations from 20+ years of teaching thermodynamics using both paper and computerized property tables will be discussed and a possible framework for further investigation of the state question will be set forth.

For purposes of this study, the term "computerized" thermodynamic tables is meant to refer to a computer program available to students in which thermodynamics properties at any virtually any combination of temperature and pressure (or other property combinations) can easily be found simply by typing in the known values. In reality, computerized thermodynamics tables have been in use since the 1960's as the printed tables used in thermodynamics textbooks from that time forward have been based on a computer solution to a many variable fundamental thermodynamic function. As an example, when the author was an undergraduate student taking Thermodynamics I and II, along with the textbook, students were expected to obtain a copy of "Steam Tables" by Keenan, Keyes, Hill, and Moore[1]. A large part of the instruction in the use of such printed tables was always related to the act of interpolating between table entries to determine property values at temperature and/or pressure values between those presented in the table. As the use of computers advanced and with the advent of personal computers, it became possible and common practice to provide students with a computerized set of tables which performed all interpolations within the program. These computerized programs also allowed for easy inclusion of property tables of additional fluids beyond those typically included in the printed versions. Simply due to size constraints, printed tables were typically limited in the number of fluids included while this is not a concern with the computerized tables. Another large advantage to the use of these computerized tables is the much easier determination of state values when the known properties did not include both temperature and pressure (or one of these plus quality). Using printed tables, which were always arranged by temperature and pressure, it is more difficult to find state values when one of the known quantities is internal energy or enthalpy, but using the computerized tables, these are done in the same manner as for temperature and pressure being the two known quantities. Thus, from the student's point of view, computerized tables are much simpler to use than printed tables. However, does the exclusive use of computerized tables lead to poorer student understanding of the workings of the property tables and a loss of "feel" for typical values? In the author's opinion, it seems that it does. However, this is an opinion based entirely on anecdotal observations. These observations come from many semesters of teaching Thermodynamics II to students who experienced a range of exposure and use of computerized tables in Thermodynamics I ranging from using 100% paper tables to 100% computerized tables. In the author's observation, it appears that students who used computerized property tables exclusively in Thermodynamics I have a poorer understanding of the meaning of various properties and of the range of typical property values. In short, it seems that they simply accept whatever numbers the computer returns and do not have the judgement to realize when these values are unrealistic due to an undetected error in data entry, for example. This is not an unusual experience for engineering instructors in a number of subjects where it seems that blind acceptance of a result produced by a computer or calculator is common among students.

How, then, to try to more formally measure this supposed effect? One approach could be to do a normalized study of the grades of students in Thermodynamics II based on their level of use of computerized property tables, or lack thereof, in Thermodynamics I. However, this approach is likely overly simplified as overall course grades depend on much beyond the use of property tables. Clearly, such a study would be dependent on having available cohorts of students who had experienced a range in the level of use of printed tables. This may very well be not available at institutions which either do not have sufficient students for multiple sections of Thermodynamics I or where it is taught in a single, large lecture section. This approach would be even more difficult in those institutions that have only a single semester of thermodynamics. It would seem that some type of longitudinal study, even if the longitudinal nature of the study consists of the early versus later portions of the same semester, would be the obvious method for studying the effect of exposure to printed tables. The study would have to contain specific questions and problem statements aimed at not only measuring student's ability to find the correct property values, but also aimed at judging overall understanding of the thermodynamic tables. The author welcomes any suggestions or reference to other such studies.

References

[1] J. Keenan, F. Keyes, P. Hill, and J. Moore, *Steam Tables,* New York, John Wiley & Sons, 1969.

John L. Krohn

Dr. John L. Krohn is a Professor and currently serves as Interim Department Head in the Mechanical Engineering Department at Arkansas Tech University. Dr. Krohn earned his BSME and MSME degrees in Mechanical Engineering from the University of Arkansas and his Ph.D. in Nuclear Engineering from Texas A&M University. He has served as Department Head for the majority of his 30 years of service at ATU and his primary interest and research areas have been in nuclear materials interactions and energy production from both traditional and alternative fuel sources.