Correct Use of Thermodynamics

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Abstract:
Correct use of Thermodynamics starts with correct teaching of Thermodynamics. Unfortunately the word teaching is not well respected by people as experienced when technical papers that deal with teaching are rejected no matter what the content. As academicians, we have committed ourselves to teaching. Since Thermodynamics is such a fundamental topic, it must be taught precisely and practiced correctly.

Keywords:
Education, Precision, Teaching, Thermodynamics.

1. Education

Education in engineering requires many courses that end in –ics such as mathematics, physics, chemical kinetics, and mechanics – solid, fluid and thermodynamics. Of course economics and ethics are just as important, one from a monetary point of view and the other from a character point of view. As such we must make sure that instruction must follow some very rigid protocols. To be a Professor the only current protocol is that you must have a doctoral degree. Very few, if any, institutions require pedagogy experience or education/training. As such we all become teachers and thus Professors by default. To educate engineers of the future, we must be able to know how to teach and teach the subject matter precisely and correctly. The current situation can no longer be tolerated. This situation must somehow be remedied. Thus Education is number one issue and we must take it very seriously.

2. Precision in Teaching

Precision in teaching is a most important issue, as is mentioned in the introductory pages of [1]. To be effective and efficient on this issue, the textbooks must be very precise and correct in the subject matter that they cover. It is seen more and more that textbooks in the fields of mechanical engineering that concern issues on energy are getting away from precision in spite of the fact that their size increase with each edition. Students who consider the textbook the only way to learn the material is getting away from correct coverage in their learning. In due time when they become instructors and Professors on their own, unfortunately the material that was not learned precisely will be taught incorrectly thus producing a generation of engineers who do not understand the material and the important issues of the day well enough to find correct solutions. As the problems that deal with energy get to be more and more intricate and difficult, the incorrect understanding of the fundamentals will not help solve these issues.

During the last sixty years that I have been exposed to the material in my own professional life, I have seen ups and downs, unfortunately very few ups. I have seen the attitude that “anybody can teach” is indeed unacceptable. Unfortunately, engineering departments put in persons who not only do not have the necessary knowledge in the subject matter area but do not have the interest in teaching the subject matter that they face. Thus people who do not know how to teach are faced with teaching a subject matter that they did not study or have an interest in causing damage to the future generation. Thus education, precision and teaching are all very important topics for the future of the world and must be so recognized by us all. We must take steps immediately to remedy this very unfortunate situation that exists in most parts of the world.
3. Thermodynamics

Thermodynamics is one of the fundamental courses in mechanical engineering; in my opinion should be taken by all engineers. It is a subject matter that affects many problems that we are facing in relation to energy, its use, pollution, sustainability and quality of life for all particularly the future generations. Thus fundamentally it must be taught precisely by people who have studied it in graduate school and practiced it in academia, research or industry. Unfortunately, education in Thermodynamics has deteriorated during the last fifty years and it has been experienced first-hand by those who were involved in learning and teaching the subject matter at the undergraduate and graduate levels over the years. The books of the past, such as [1], have been replaced by “easy reading” and over one thousand pages of not very precise material but which is very popular, [2]. Upon this unfortunate situation comes the fact that no new teachers of thermodynamics are prepared for this task in graduate schools. It was a fact that in mechanical engineering there used to be three graduate level courses in Thermodynamics: Classical, Statistical and Non-Equilibrium. This used to be the norm sixty years ago. About forty years ago, it dropped to just one because there were fewer teachers who knew how to do this in such a detail; luckily there was a book that did an outstanding job [3], although not too many engineers knew about is since it was written by a physicist! However, the depth of understanding diminished as well as research in the fundamentals dropped also due to the lack of financial support for research in applied thermodynamics because of the decrease of funding for and from the space program in the United States.

As for teaching at the undergraduate level, no matter which book is used, the general consensus is that “anyone” can teach the undergraduate Thermodynamics course. Such an attitude is not uncommon since there are many who take the course; in the United States, the Fundamentals of Engineering examination requires it for all engineers though they are starting to relax this requirement. Therefore, there are many sections to be taught and not enough faculty who are “thermodynamics” faculty! Thus “any” faculty is pushed into teaching it since they have a doctoral degree! As a result the quality, precision and the outcomes are compromised. Thermodynamics being a co- or pre-requisite to other courses in mechanical engineering such as Fluid Mechanics, Heat Transfer and Energy Conversion, they also suffer because of lack of precise learning. These students then design engineering systems that deal with Thermodynamics for mechanical engineering as well as those that are most needed in energy applications. Such a situation does not exist for teaching of dynamics, vibrations or control!

One of the very first mistakes made deals with the sign convention, whether it is in relation to Thermodynamics or Heat Transfer, [4-6]. In [2], a “relaxed” sign convention is used, whatever that may mean! Callen uses the fact that any energy in is positive and any that goes out is negative; however, it is done consistently and correctly, [3]. The wrong usage carries over to textbooks in Heat Transfer, [7]. Although this text is probably the better one in existence, the thermodynamic mistakes are not acceptable and perpetuates what is discussed above. When Energy Conversion Systems course is taught, luckily the instructor usually is one who is “more” of an expert in Thermodynamics and some of these mistakes are alleviated.

There are other examples in literature; however, they will not be discussed here in writing. The point to be made is that this situation cannot and should not be permitted to perpetuate.

4. Looking Forward

What is needed is better preparation of students of thermodynamics by subject matter experts and making sure that they have the same passion as those who are concerned with the current situation. Among other issues we speak of sustainability very often without understanding how it relates to exergy and “taxation of nature”. The politicians are not aware of these issues since they are not
engineers; however, they make the laws. We need to encourage engineers to be politicians so that more meaningful discussions can take place and laws passed. These are all one point of view. We must discuss these amongst those who are concerned about teaching of Thermodynamics and who does that. The background of teachers is most important as well as the pedagogical preparation of those. Hopefully the future is brighter than depicted above; maybe we should be more hopeful and less hopeless!

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References