Timoshenko and His Books

K R Y Simha

Timoshenko has authored some of the most extraordinary books in the history of technical literature. First hand experience of life in a rustic setting initiated Timoshenko's bold and critical appraisal of engineering education. His restlessness and discontent with the educational system extant in Russia at that time motivated the young Timoshenko to venture out to explore, examine and assimitate diverse pedagogical views and cultures of France, Germany and England. Thanks to his tormented spirit and his early appointment as an instructor at the Kiev Polytechnic Institute, Timoshenko took the plunge to writing his maiden Russian classic, *Strength of Materials* in 1908 (Part I) and 1910 (Part II).

This book made history after Timoshenko emigrated to America and published the English version in 1930. The impact of this publication was so dramatic and immediate that it was simultaneously translated into Czech, French, Japanese, Portugese, Spanish and many more languages. Interestingly, the updated English version was also translated into Russian!

A similar story repeated with his book for a course on elastic theory published in Kiev and Petersburg between 1909-1916. The English version with J M Lessels appeared in 1925 while they worked at Westinghouse.

Publishing history repeated again with his second English book, *Vibration Problems in Engineering* with Young. This book was translated into many languages. The genesis for this book perhaps came from Timoshenko's first American job of balancing machines for the U S Navy.

This missionary zeal of Timoshenko for writing books for improving teaching and for guiding practical engineers has played a key role in uplifting technical education worldwide, but more em-

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phatically in America. A sublime feature of Timoshenko's books is the generous citation of papers, books and reports published all over the world sometimes suppressing references to his own work. In fact, most of his books emanate a raw energy of original writing virtually extinct today. Timoshenko tackled difficult problems in his own characteristically eminent teachable and learnable style. The best way to explain Timoshenko's obsession with teaching and writing is to quote the master himself (*Box* 1).

Obviously, writing books like Timoshenko did requires great amount of time and energy but above all an ascetic attitude without any consequent attachment to fame and fortune. Writing like Timoshenko also means enormous reading in different languages, interacting with teachers, students and colleagues; and, travelling to meet and discuss with eminent scientists. Finally, and perhaps more intriguingly alien to the increasingly western world, Timoshenko revived the ancient eastern wisdom of disassociating himself with his own books and associating the names of his students! Today it is somewhat disconcerting to see the legendary name of Timoshenko appear second!

Returning to Timoshenko's prolific writing, the year 1934 marked the launch of a quartet of classics that appeared annually. The first and the greatest with Goodier was a huge hit with critics, students and teachers alike. This book translated into many languages continues to sell steadily all over the world to this day. Many readers may indeed recognize the names of Timoshenko and Goodier as the famous authors of this evergreen classic: *The Theory of Elasticity*.

The following three years 1935-37, Timoshenko teamed up with Gere and Young to publish three more books: a condensed version of strength of materials, elastic stability and engineering mechanics. This unique quartet of texts explores intricate mathematical techniques to explain some subtle aspects underlying elasticity and stability to give new insight into the behaviour of solids and structures for engineering design.

Box 1. Teaching and Writing

In the initial period, the spring semester of 1907, I gave a short elementary course on the strength of materials, the students using Kirpichev's book for the examinations. In the fall of 1907 I started giving a fuller course, which encompassed two semesters. The fall-semester portion was required for all students; the second semester, in which more complicated problems were dealt with, was required only for students in the structural-engineering and mechanics departments. There being no suitable books for such a course, I decided to write one. I wrote it as I prepared my lectures, so that in the fall of 1908 my lectures were published in lithographed form. The final version was printed in 1911 and enjoyed great success, was adopted as a textbook in most Russian engineering schools, and sold some tens of thousands of copies. In America I revised this book and published it in two parts, in which form it still exists. It has been translated into a number of foreign languages and continues to be studied by many future engineers.

My teaching duties and the preparation of my lectures for publication took up a great deal of time. During the school year it was difficult to engage in scientific work. To this I devoted the summer vacation. In the winter of 1906-1907 my earlier work on the buckling of plates had been published in the *Proceedings of the Kiev Polytechnic*. This work promptly found wide application in shipbuilding. Such eminent marine engineers as A N Krylov and I G Bubnov were engaged at the time in preparing designs for construction of the Russian navy's first dreadnaughts, and the compressed steel plating of those ships was stability-tested in accordance with my formulae.

I found Foppl's book more suitable for engineers. It contained Kirsch's solution for the distribution of stresses around a circular hole in a flat strip subjected to uniform tension or compression. I did not like the explanation, for Foppl had taken a ready-made solution and merely showed that it was valid because it satisfied all the equations of elasticity theory. That is no way to explain a problem's solution to students. One must show them how such a solution can be directly arrived at. I succeeded in doing this by employing a special device. With a concentric circular section of large radius I cut out from the plate a circular ring, applying to this ring the well-known solution in the form of Fourier series. While I did not obtain here a new solution, I did arrive at the known solution by a direct logical route. I was subsequently able to use this method to solve new problems and did solve in this way the problem of the compression of a circular ring by two equal and opposite forces applied at the ends of the diameter. I investigated also the influence exerted on the stresses in a ring by reinforcing the rim of the opening with a special stiffening ring.

In 1907-1908 I gave a full course in strength of materials, the course designed by me, then published it in lithographed form. In that same year I investigated a number of new problems involving the stability of compressed bars. In connection with the Quebec bridge disaster in Canada I started working on the theory of the stability of composite beams, and found a simpler method of solving the problem than F Engesser had done. I studied in greater detail the special case of the stability of two bars connected solely by unbraced crosspieces, and conducted in the laboratory a number of experiments, which confirmed my theoretical formula. I published all this research at that same time, in 1908. I also published my work on the compression of a ring.

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Three years after the quartet, Timoshenko teamed up with Woinowsky–Krieger to publish the first English book, *Theory of Plates and Shells*. Around that time, Flugge, a student of Prandtl, had published a book on shells in German. It is interesting to mention that Flugge and Timoshenko became colleagues decades later at Stanford University. The theory of plates and shells also entails formidable theory of differential equations and these pioneering authors devised their own ingenious mathematical schemes to enable better understanding. These days, of course, engineering books exploit numerical routines and softwares marketed widely.

Finally, Timoshenko wrote two more books with Young, *Theory of Structures* and *Advanced Dynamics* formally winding up writing texts for teaching technical courses. By this time Timoshenko's books had already become classroom classics all over the world; and, Timoshenko had formally begun teaching a course on something dear to his heart, *The History of Strength of Materials and Elasticity*. He set out writing bits and pieces of technical and anecdotal history during his tours to Europe.

The year 1953 saw the great Timoshenko epic, *The History of Strength of Materials* with a brief account of the history of the theory of elasticity and structural mechanics. Tracing the history all the way back to Archimedes, he carries the reader through the period of Leonardo da Vinci, Galileo, Hooke, Newton, Mariotte, Bernoulli, Euler, Lagrange and Coloumb reaching the end of the 18th century. He divides the 19th century into three 33 year periods to describe the early masters like Maxwell, Mohr, Navier, Kirchoff, Saint-Venant, Stokes, Kelvin, Lamb, Love, Rayleigh, Foppl, Boussinesq, Neumann, Klein, Prandtl and others. He stopped at 1950 just when the subject was ready to take on the study of fracture, contact and impact phenomena. Even if he had not written any of his wonderful texts, this sweeping magnum opus on the history of strength of materials would have ensured eternal fame for this professor author par excellence. Even Truesdell (1919-2000), one of the most irreverent and acerbic of all twentieth century American critics, wrote

mellowingly: "*It is evident that this book is a result of a great love and understanding for mechanics with many years of study and criticism*".

The final climax was his autobiography, *As I Remember*. Timoshenko's character is revealed in his autobiography. Like all great writers, he led a generally solitary life avoiding commercial, political and social trifles. He chose to be rich by making his wants few, and dedicated his genius entirely to writing educational material. He roamed freely through the centuries old sprawling forests of mechanics knowledge in Russia, Germany, France and England tapping the engineering essence and eschewing the esoteric mathematical mumbo-jumbo devoid of engineering significance. This unique and rather uncanny engineering savvy typical of Timoshenko is perhaps an outgrowth of his idyllic childhood experience in a rustic farmhouse that honed his engineering skills as well as survival instincts while he studied far away in Petersburg, or when he took temporary refuge in Yugoslavia during the Russian revolution before emigrating to America. It has to be also admitted that there was a misanthropic shade to his nature for he had set exalted and exacting standards of professional competence and conduct particularly for scientists and professors. Thus, his autobiography seems harsh at first sight. Soderberg and Den Hartog provided partial explanation in a tribute to Timoshenko after his death in 1972 though somewhat wistfully. A few excerpts from this tribute follow (*Box* 2). [http://books.nap.edu/books/0309032873/htm/323-349]

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In summary, Timoshenko perhaps is the only technical writer to have written nearly a dozen original books used widely as texts all over the world. Many great scientists, engineers and academicians before him have written great books. Here we may cite such classics as Newton's *Opticks,* Rayleigh's *Theory of Sound*, and other works of Euler, Lagrange, Raman, Chandrasekhar, Prandtl, and many more. But Timoshenko leaves them all behind by the sheer effort of organising engineering education through his books. Both Timoshenko and Chandrasekhar provide copious historical references in several European languages

Box 2.

Only gradually did we come to appreciate the turmoil and anxiety that had been his lot during the preceding years. Under the charming exterior there was a deep-seated disappointment in American culture, which to Timoshenko and his wife seemed crude and uncouth in comparison with their experiences in the Ukrainian countryside and the cultural circles of Europe. He was still smarting under the effects of the cataclysm of his homeland, which prevented him from reunion with his aged father. Out of these experiences grew a strange love-hate relationship in his feelings toward America, which never left him and sometimes stood in the way of full utilization of his talents. In reading *As I Remember*, one is astonished at the absence of a single word in grateful recognition of his debt to America, which had awarded him such a rare opportunity. (Also noted in the review of *As I Remember* by J P Den Hartog, *Science*, 160, 1968).

Americans were accustomed to immigrants who developed an uncritical admiration for their new homeland, often accompanied by bitter hostility toward their place of birth. But to many of us, who also were immigrants with strong cultural roots in the homeland, Timoshenko's attitude was at least understandable. Through the years of turmoil – the late twenties, the depression, and the years just prior to World War II – this attitude of Timoshenko's did not appear to soften. These feelings culminated during his trip to Russia in 1958, when he became, so to speak, reunited with his homeland. But it was largely a reunion with the homeland of his dreams and with the successors to the old institutions. It is significant, as observed earlier, that his accounts of his life following this trip were written in Russian, this from the author of dozens of successful textbooks in English. It is also worth observing that circumstances prevented him from fully sharing in the wave of scientific revival that was part of the World War II scene. The experience of the first epoch of American superiority in scientific and technological developments was somehow denied him.

While Timoshenko was well known in professional circles all over the world, the number of people admitted to his innermost sphere of affection was not large. His former students had a special position; so did a small group of his early acquaintances in the United States. One has the impression, however, that real intimacy was reserved for his own family and his Russian speaking friends (he was a member of a remarkable family, which contributed much to his worldwide views and connections. Of his two younger brothers, Serhij (an architect) was Secretary of Transportation in the Ukrainian government in the early 1920's, while Vladimir (an economist) was Secretary of Commerce of the Ukraine and later Chief of Statistics of the AAA under President Franklin D Roosevelt in Washington and at Stanford University). Among those who might be mentioned are G B Karelitz, who passed away in 1940, and Vladimir Zworrykin. Professor Leonid M Tichvinsky, in a personal communication, observed that "Timoshenko was the last person who knew my parents; he was my best man when I married my first wife, coming from Ann Arbor to Pittsburgh for this occasion in 1935". In a later communication Professor Tichvinsky observed that Timoshenko, while leading a comfortable life in the United States, did not accumulate any substantial wealth. He left a modest legacy to be divided among his children. The royalties from all his books were assigned to Stanford University.

Box 2. continued...

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In the perspective of more than a half century, Timoshenko's great influence upon applied science and technology in America resulted less from his original, creative discoveries than from his ideals of engineering education, his superb skill as a teacher, and his highly developed pragmatic skill in using fragments of exact solutions for a variety of approximate solutions to difficult problems in applied mechanics. Examples of this are his skillful use of the solutions for beams on elastic foundations to problems such as railroad rails and to details of machinery such as highly stresses dovetail joints. Another example is his frequent use of the Boussinesq solutions to a variety of intractable problems in machine structures. He also clarified the premises of the Rayleigh–Ritz iteration method, extending it to a variety of problems in elasticity and dynamics. Throughout his work there is a pragmatic attitude toward mathematics, and even to theoretical mechanics, which was regarded as one of his great sources of strength.

This charming pragmatism was new to most of us and seemed of immense value to the practising engineers. It is well to remember that even elementary computer aids, which we now take for granted, were then many years distant in the future. Iteration procedures had to be worked out with brute strength and untold man-hours. With the development of modern computers and new methods such as the finite-element method, many problems once beyond our reach have now become routine. The pragmatic approach may now seem less essential, but I believe this is only a temporary phase. In any case, the effectiveness and charm of Timoshenko's teaching will always be a treasured memory to his students.

During his long and productive life, Timoshenko received many honours, meticulously listed by Eugene A Vetchorine in his foreword to *As I Remember*. He was elected a member of the Ukrainian Academy of Sciences, Kiev (1918); Russian Academy of Sciences, Leningrad-Petersburg (1928); Polish Academy of Technical Sciences, Warsaw (1935); French Academy of Sciences, Paris (1939); National Academy of Sciences, Washington, DC (1940); Royal Society, London (1944); and Italian Academy of Sciences, Rome (1949). Honorary doctoral degrees were conferred upon him by Lehigh University, DSc (1936); University of Michigan, DEng (1938); Zurich Technical Institute, DEng. (1947); Munich Technical Institute, DEng. (1949); Glasgow University, DLaws (1951); University of Bologna, ScD (1954); Zagreb Polytechnic, D Eng (1956); and Turin Polytechnic, ScD (1960).

to stimulate readers internationally, and then attempt to unify the subject. This rare ability of highlighting oneness while admiring regional, cultural, historical and geographical differences forms a salient characteristic of their books.

It is, therefore, somewhat annoying that modern authors possess so little acquaintance with engineering literature and professional trends outside of their own narrow experience. Consequently, different teaching and research traditions are not given

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due importance. There is perhaps also a suspicious feeling that modern research is not as varied and original due to increasing global competition and marketing. Marketing education, information and knowledge on a global scale with internet medium has shifted the focus from individual discoveries to institutional initiatives. Further confusion about protecting and trading intellectual property can be depressing for truly international icons like Timoshenko or Einstein.

Ironically, on the other hand the mighty merchants of technology have lured the best of physics, chemistry, biology and mathematics professors into developing packages, patents and products for rolling the velvet carpet of globalization. This innocuous new form of intellectual colonization has seriously undermined academic ideals while greatly promoting academic affluence. Another impact of intellectual globalization is the declining scope for publishing in local languages creating a subtle form of linguistic colonization. In this context, it is important to recall here that the great American ascendance in the 20th century owes largely to genuinely brilliant immigrants like Einstein, Fermi, Chandrasekhar, Timo-shenko, von Karman and many others who ignited the imagination of young Americans. What is even more significant is that they came from different countries speaking different languages. Timoshenko thought about these aspects of society and education deeply and wisely in his sensational autobiography.

On the balcony at Merligen in 1932

Today, intellectual celebrities seem to be unprepared for taking on major book writing projects like most of their predecessors in the 19th century and a few number in the first half of the 20th century. Critics like Arnold (1822-1888) and Eliot (1888-1965) battled bravely for over a century to degloss and deride the decadence in literature, and now this contagion has spread to scientific and technical

Box 3. Timoshenko's Books in English

1. *Applied Elasticity*, (with J M Lessells), D Van Nostrand Co., Inc., New York, 1925.
2. *Vibration Problems in Engineering*, D Van Nostrand Co., Inc., New York, 1st Ed., 1928, 2nd Ed., 1937, 3rd Ed., 1955, (with D H Young).
3. *Strength of Materials*, Part I, Elementary Theory and Problems, D Van Nostrand Co., Inc., Princeton, New Jersey, 1st Ed., 1930, 2nd Ed., 1940, 3rd Ed., 1955.
4. Strength of Materials, Part II, *Advanced Theory and Problems*, D Van Nostrand Co., Inc., Princeton, New Jersey, 1st Ed., 1930, 2nd Ed., 1941, 3rd Ed., 1956.
5. *Theory of Elasticity*, McGraw-Hill Book Co., Inc., Princeton, New York, 1st Ed., 1934, 2nd Ed., 1951 (with J.N. Goodier).
6. *Elements of Strength of Materials*, D Van Nostrand Co., Inc., Princeton, New Jersey, 1st Ed., 1935, 2nd Ed., 1940, 3rd Ed., 1949 (all with G H MacCullough), 4th Ed., 1962 (with D H Young).
7. *Theory of Elastic Stability*, McGraw-Hill Book Co., Inc., New York, 1st Ed., 1936, 2nd Ed., 1961 (with J.M. Gere).
8. *Engineering Mechanics*, (with D H Young), McGraw-Hill Book Co., Inc., New York, 1st Ed., 1937, 2nd Ed., 1940, 3rd Ed., 1951, 4th Ed., 1956.
9. *Theory of Plates and Shells*, McGraw-Hill Co., Inc., New York, 1st Ed., 190, 2nd Ed., 1959 (with S Woinowsky-Krieger).
10. *Theory of Structures*, (with D H Young), McGraw-Hill Book Co., Inc., New York, 1st Ed., 1945, 2nd Ed., 1965.
11. *Advanced Dynamics*, (with D H Young), McGraw-Hill Book Co., Inc., New York, 1948.
12. *History of Strength of Materials*, McGraw-Hill Book Co., Inc., New York, 1953.
13. *Engineering Education in Russia*, McGraw-Hill Book Co., Inc., New York, 1959.
14. *As I Remember*, Van Nostrand, 1968.

literature. The alarmingly low number of books published today by eminent scientists undermines their claim to fame in young minds today. It is even more odd to note that, in the past 50 years, only a few Nobel laureates have contributed to educating students and the general public through texts, popular books and articles. Consequently, the vast majority of intellectual celebrities fade out of sight while the great theories of Newton and Einstein or the elegant experiments of Raman and Curies continue to inspire young minds. Indeed Timoshenko answered the great Roman philosopher Cicero (106-43 BC): *What greater or better gift can we offer our republic than to teach and instruct the youth?*

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