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ABOUT UNFORGETTABLE SAMSON SEMENOVICH KUTATELADZE

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I remember my first encounter with S.S. Kutateladze; this was at the All-Union Conference on Self-similarity Theory in the conference hall of the Krzhizhanovsky's Power Engineering Institute of the USSR Academy of Sciences. This was the place where I started my academic career as a junior researcher after graduating from the Moscow Aviation Institute (Engine Design Department). In this Institute, I was engaged in the research of the cooling processes for liquid propellant rocket engines. That is why I knew the Samson's publications in the heat transfer theory well. These days the Institute's conference hall was overcrowded. The young generation of researchers occupied the balcony places. From this place, we watched the presentations of the "luminaries" in the science of heat transfer: academicians M.V. Kirpichev, M.A. Mikheev, A.N. Kolmogorov, L.I. Sedov, I.S. Brook, and A.S. Predvoditelev. I remember a bright lecture of young S.S. Kutateladze, who became our "cult figure" from this moment on.

The next time I had listened to the talk presented by S.S. Kutateladze at the All-Union Conference (Kiev, 1955), when he managed to argue boldly with recognized incontestable authorities of the turbulent heat-and-mass transfer science like L.E. Kalikhman, M.F. Shirokov, V.M. Ievlev, G.N. Kruzhilin, and V.V. Uvarov. It was very interesting to observe this discussion, since I considered myself as a well-shaped scientist in this area and I admired Samson's intellectual audacity and original thinking on the subjects even remote from his direct scope of interest. Samson S. Kutateladze had undisputable authority in the field of heat transfer for boiling liquid; he was the author of a well-known hydrodynamic theory of boiling crisis. It was amazing to see how bravely he competes with well-known experts in turbulent flow science, who already had many years of experience in studying the turbulent boundary layer in a compressible gas flow.

In 1957, the "Pravda" newspaper published an article signed by academicians M.A. Lavrentyev, S.A. Khristianovich, and S.L. Sobolev about the government's plan to establish the Siberian Branch of the Academy of Sciences. This paper summoned the young men of science to support this plan and go to Siberia. I discussed this news with our family counsel, and the next day I brought my application to the would-be director of the Institute of Thermophysics of the Siberian Branch. This was I.I. Novikov, the rector of MEPI and the head of thermophysics chair at the same institute. Ivan Novikov was very kind while interviewing me. When I explained to him that my scope of interests was heat transfer for cooling of liquid propellant engines, he told me: "You better take this application to S.S. Kutateladze, my deputy, who hires extra personnel for heat transfer study."

However, events developed by an unexpected scenario. I remember in detail my first meeting with S.S. Kutateladze, the leader of Russian thermal physics school. He invited me for a job interview at his office, where an old gentleman was sitting on a sofa (it appeared later that this "old gentleman" was slightly above forty).

Samson asked me about my scientific achievements and I retold him with enthusiasm the key points of my PhD thesis, but he interrupted me with a question. "How did you spend the previous working day?" I responded that I focused my time on reading Berman's paper from the "Thermal Energy" journal. The paper was about vapor condensation from vapor-gas mixtures. I expressed my perplexity about how it could happen that this sort of rubbish had been published in a serious journal. Then I jumped to explanations of errors made by Berman in writing the system of differential equations. Suddenly I see that Samson Kutateladze summons me to occupy his place at the desk and asks me, "Why do you tell me all these arguments? Here is sitting Berman himself – tell this directly to him, and I'm going to listen to that." That was a confusing moment…

However, I read on my application list the words "Offered for a position of the head for the Thermal gas dynamics lab at the Institute of Thermophysics of the Siberian Branch of Academy of Sciences of USSR" with the bold signature "Samson Kutateladze." This was the beginning of my Siberian years that linked me for many years with this amazing scientist and, as life has proved, a very faithful and kind friend. I returned to Moscow inspired, full of energy: my future looked romantic and unclouded.

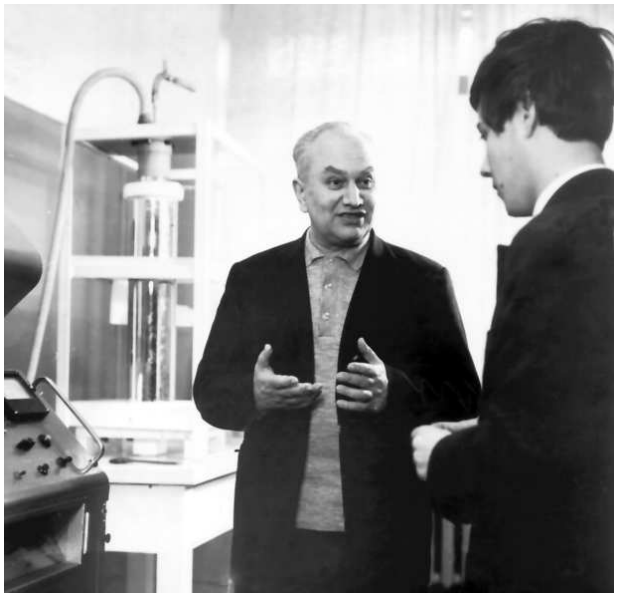
The plan to build a scientific center in Academgorodok, in the vicinity of Novosibirsk, was a mighty project. To accomplish this in a few years it would need the support of a powerful socialist state. The Soviet state provided the conditions for creative scientific work that were unique for that epoch. The directors' positions were offered for rather young and ambitious scientists. They have recourses to create a team from young specialists, zealous for inventions and scientific glory. From the very beginning, my relations with Samson were very friendly and confiding. The first year of our cooperation was very fruitful. In Siberia, he lived with his handsome son Semen, but I was alone (my family stayed for a while in Moscow). I visited the Kutateladze's house almost every evening. Samson Semenovich explained to me the rules of the nards game. Between the sets, we would get used to discussing the daily results: this was the most interesting part of our evening chat.

Samson S. Kutateladze had astonishing intuition; available experimental results provoked him to develop very original and creative ideas. Most of the ideas were screened out by the end of the day, but those remained after selection became the nuclei of new research directions in the field of heat transfer theory. The bright example of this

"A nice smile gives away a nice person" (F. Dostoevsky).

creative approach was the hydrodynamic theory of boiling crisis developed by S.S. Kutateladze. His ability to focus on primary things and discard the secondary things was the key feature of the Samson's scientific method. Kutateladze offered a very simple and clear analogy between liquid repulsion from porous surface by gas blowing and liquid repulsion by vapor from a heated surface while liquid was boiling. This analogy and method of dimensionality analysis gave a single self-similarity criterion comprising the heat load and several other parameters describing the boiling crisis. The hydrodynamic theory of the boiling crisis found a wide international recognition. This is considered as one of the important contributions of Soviet science into heat transfer theory. This hydrodynamic theory of heat transfer crisis introduced Samson S. Kutateladze as one of the well-recognized Soviet scientist for the international academic community. For this achievement, we were honored by a highly ranked international award in the field of heat transfer theory called the Max Jacob's medal.

Samson Kutateladze often participated in our lab seminars, where all men appreciated not only the scientific results alone, but humor and bright mind as well. His witty retorts and remarks created the festive mood on our seminars; besides, this was an unforgettable school for young scientists. In these years, many efforts of researchers were focused on the effect of nonisothermity and compressibility of a stream on the friction coefficient and heat transfer process. Following the Prof. Eckert example, many researchers decided to solve the problem of these effects by introducing a "governing" temperature imbedded into regular criterial equations of heat transfer for incompressible fluid. These days almost every active researcher followed this fashion by introducing his own variant of "governing" temperature and believed that his finding was the best (the author of these lines was not an exception at all). The idea promoted by S. Kutateladze about relative laws of friction and heat transfer appeared to be very fruitful and demonstrated many advantages in comparison with the "governing temperature" concept. First of all, Kutateladze demonstrated that we have a simple limiting law of friction for infinite Reynolds numbers: this law depends only on the temperature factor. Samson offered to me to expand this idea to the case of compressible gas flow, and it was an easy task. This is the history how the limiting relative laws for friction, heat transfer, and mass transfer were developed with account for nonisothermal and compressible properties of



Scientific discussion

the gas. An amazing thing happened, all formulas for limiting conditions had found confirmations from numerous experimental data for finite Reynolds numbers. Later I tried to extrapolate this idea to the case of a turbulent boundary layer upon a permeable surface. I showed comparison of my calculations by the limiting formula with the experiment, and Kutateladze's response was prompt: "This is a good material for your future doctorate thesis, let us go, and consult with Prof. Loitsyansky."

It was remarkable that the critical parameter for blow-off of turbulent boundary layer (obtained by Kutateladze on paper) almost coincided with the only available experimental data from Prof. Hacker (US). I remember the workshop under the guidance of L.G. Loitsyansky, who initially had critical perspective to our new approach, but at the end of this workshop he had to admit that although he spent many years in studying the boundary layer problem, he missed this interesting physical fact. Later L.G. Loitsyansky republished his famous book "Mechanics of Liquid and Gas" and reproduced in this book our limiting-case formulas without referencing the authors. I was indignant and ran to Samson, but he calmed me down by these wise words: "What is the point for your indignation? We should feel joy!" "Why?", I asked. "We have become classical scholars alive! Have you ever met a physicist who references Newton's work while writing the equations of motion?"

After that, it took me several months to write my doctorate thesis; this material became the basis for writing our co-authored book "Turbulent Boundary Layer of a Compressible Gas" (published in 1962 in Novosibirsk). Prof. Spalding translated this book into English and after that, the international academic community became familiar with our achievements. Other five editions of this monograph included new extensive information: mainly the results of Kutateladze's followers from the Institute of Thermophysics.

The most interesting portion of our results was about the critical injection of gas. This gave us the idea to spread the hydrodynamic theory of boiling crisis to the case of forced fluid flow. This extrapolation produced the general formula for critical heat load (this formula takes into account the subheating and flow velocity). It was an unexpected success in using the calculated critical injection parameter in estimating the startup of erosive entrainment in the flow zone of a solid-propellant rocket motor (SPR motor). The theory for gas dynamics within the flow part of a SPR motor operates with the Pobedonostsev criterion (it generalizes numerous experimental facts on mechanical erosion). It was enough to assume that mechanical erosion starts from the cross section where the gas friction on the channel wall takes place, and the outline of a simple physical model arises − this model gives the position of a cross section where mechanical erosion initiates. While fuel combustion goes on in a cylindrical channel of the SPR motor, the longitudinal gas velocity increases along the length. At a critical velocity, the gas friction on the channel wall develops, and mechanical erosion is on. This Kutateladze's approach was like a flash of light in the realm of empiric knowledge of those years, and S.S. Kutateladze was the inexhaustible generator of this "light".

Kutateladze's working style had revealed itself in the story of creation, the formula for gas cooling efficiency, which, probably, became one of the best known of our formulas. I took the integral relation for energy with an assumption that the energy loss thickness in the gas cooling area is the same as the momentum loss thickness − this gave me a rough formula for the gas cooling efficiency. Although this formula was simple and had clear physical background, the theoretical efficiency was by one order higher than that in experiment. Actually, it was possible to fix the situation by introducing artificial correction coefficients, but in this case, the formula's ideology would be out of the general style of the set of our well-confirmed relative limiting laws. I remember the evening when Samson called me and invited me saying, "Drop in, I've hit the point for your theory of gas cooling." He took the behavior of gas cooling for infinitely high Reynolds numbers, i.e., at high distances from the injection of cooling gas. Kutateladze demonstrated that for this zone the energy loss thickness is by one order higher than the

momentum loss thickness, so the gas cooling efficiency drops considerably. I objected that anyway in this zone the cooling efficiency is so low that this low magnitude cannot be interesting for practice. However, he offered, “Just compare this formula with the experiment and then we will be ready to discuss this.” I followed his recommendation the same evening: coincidence of the new limiting formula with the experiment was so amazing, that I immediately called him back. And his comment on this situation was wise he said, ”As I have told you, the idea is more important than the fact.” On a later occasion, he remarked that our limiting formulas would be widely used not due to correctness, but also because they were simple ones. As a poet and philosopher, Skovoroda said, “All simple things belong to truth and complicated things that build up the lie.”

Later Edward P. Volchkov, the researcher from the laboratory of thermal gas dynamics, developed this direction. Now he is a corresponding member of RAS. He became the author of several excellent monographs. He also was a scientific advisor in the writing of many PhD and Doctorate thesis, but this is a subject for a separate story.

I recall one vivid example of serendipity of Samson’s way of thinking. Scrutinizing the photos of water-alcohol mixture boiling patterns, Kutateladze noticed two things. Firstly, it was curious that the maximal heat load for a mixture (exceeding the sum of boiling components) takes place exactly at the alcohol concentration in the water equal to 40 %. This induced some thoughts about side effects and some doubts about experimental purity. “It would be nice to ask an abstainer to reproduce these experiments,” muttered Samson, but it was difficult to find a proper man in the Institute of Thermophysics. Another set of pictures were the images of foam for fire-fighting devices (results of S. Druzhinin, the oldest researcher of the thermal gas dynamics lab). The problem was foam stability as a function of composition. Kutateladze noticed that there was a resemblance between the pictures of most of the stable variant of foam and the pattern for vapor bubbles at the condition of maximal critical load. He immediately applied the dimensionality method of analysis for these two cases, obtained the criterion for foam stability, and extrapolated this criterion for the liquid boiling process. After he had performed this generalization of experimental data about the boiling crisis and foam stability, anyone could admit that this was very simple. Nevertheless, this was a remarkable characteristic of Samson Kutateladze. The gift to obtain very simple formulas for extremely complex phenomena, and this feature puts the person of Samson aside from other classical scholars of the heat transfer theory. This is why the scientific community has not accepted all of S.S. Kutateladzes’ ideas but nobody was indifferent to his ideas.

I remember asking Prof. Hartnett, a coryphaeus in heat transfer physics, what was interesting at the last conference. He answered, “It was a schism on the conference; one part of the participants supported the Kutetaladze’s hydrodynamic theory of boiling crisis, and another part objected to it. All days were filled with discussion about this subject.” It was no wonder that the name of Samson S. Kutaleladze was very popular among experts in thermophysics worldwide. Hardly ever, you could find a thermo physicist who did not know this name.

The place is chosen for workshops of The International Center for Heat and Mass Transfer in the city of Dubrovnik.

S.S. Kutateladze had publications and even a monograph dated years before WWII, when he was a young man without a university education. It was in the 1960s, when academician A.V. Lykov put many efforts in opening the Soviet school to the European academic community. Usually foreign visitors on their first meeting with Samson S. Kutateladze were amazed to see a mid-age scientist. They had an image in their minds of a very old or even late person. I should admit that it was a pleasure for me to be in the gleam of fame belonging to S.S. Kutateladze, since I was his close disciple.

I should emphasize this even more deeply. Moving in his wake, I stepped into the international community of thermo physicists. In 1999, I received the Max Jacob medal (the second one going to Russia). I received the medal at the Congress of American Mechanic Society, when Samson was no longer with us. However, I know that this award also honored our joint works performed during our Siberian years, so distant and so close for me now.

Actually, it is very difficult for me to stay objective while speaking about Samson's personal features. Sometimes I saw him as a kind and bold person, and I admired him. His friendship was an honor for me. Other times he seemed to be impolite with employees, too harsh in his personal estimates, very steady and irreconcilable in his beliefs (especially political ones). This side of life brought some disappointments to me. However, he never was vindictive and always remained open for reconciliation. This is my personal experience.

One of Samson's remarkable features was his amazing accuracy in appointments. In those years, we often exchanged home visits, celebrated holidays and events with our families, and he was a welcome guest anytime. Usually the parties started at 6 p.m., but most of the guests reached my home at 7 p.m. All of them were late, except Samson. I am usually slicing bread for the dinner table, when my wife asks me, "Alexander, get the door, it must be Samson arriving!" At 6 p.m. sharp, we see our dear Kutateladze at the doorstep, handsome and with flowers in his hand.

Samson was not only a highly gifted talent, but also a very brave man. I recall one of our trips to a slalom mountain. Kuteteladze suggested to me to climb the hilltop. The mountain-skiers occupied the slope practicing their braking technique. Samson reached the top of the hill, took a glance around, and said, "Off we go!" He immediately dashed downhill. I even failed to beg him to be careful. I was watching him speeding down the slope. Then he fell on the snow bank going full speed, toppling over and sprawling on the snow near the group of mountain-skiers. He stood up, shaking the snow off, and said to the coach, "Watch the effective way of braking!"

Usually Samson never minded to drink a few shots of brandy, especially in good company. I remember our first days in Academgorodok; one of the Institute's workers

Skiing trip.

invited Samson and me to a house warming party. This was my first experience of a feast with Samson. I noticed that he did not restrict himself with drinks, telling jokes, dancing, etc. I followed his example. The next morning I felt uncomfortable and made a call to him saying, “This is an inappropriate situation, we have recently arrived to Academgorodok, and suddenly exposed ourselves as drunken and noisy guests. We should make our apologies to the host; else he would take it wrong.” Nevertheless, Kutateladze responded, “Take it easy. We misbehaved slightly yesterday, now we become good boys. We behave and they will consider this fact.”

There was one peculiar feature of Samson’s personality, known only to his family and friends. Kutatelazde could be very open and unhindered by his emotions with his close friends. This could result in tactless actions and offences. Later he always regretted his outbursts and asked for forgiveness. However, he was always extremely polite with an unfamiliar person. The less sympathy he felt for an opponent, the more impeccable he was in his manners. Therefore, we knew for certain: if Samson is over-polite, there is something wrong with his opponent. Kutateladze had a unique talent of unmistakable judgment about any person from the first sight. I remember that one professor asked me to introduce him to Samson Kurateladze in order to present his current work. Since I knew only of a low level of his scientific papers and his insufficient qualification, I was reluctant to organize this meeting, dreading the outcome. He insisted and finally the meeting took place. I saw that the professor was very satisfied by the conversation, but Kutateladze was furious after the meeting asking, “How did you manage to work so close to such an idiot for so many years?”

Samson Semenovich Kutateladze absolutely was not a type of cabinet scientist, although his productivity, especially in writing books on science, was amazing. His secret was simple. He possessed universal knowledge, the result of intensive and steady self-education. Kutataladze got used to writing several monographs in parallel. He followed a strict rule to write at least 10 pages a day. This makes about 300 pages per year, making the volume of a standard-size monograph. An interesting observation was that Samson wrote every line of his books himself, even in co-authored books. Usually I brought a ready chapter for a new book, but he processed the content in his mind and, as a result, the whole book became written in a single uniform style. That is why it is difficult to say now who had written a specific part in each of our co-authored books. All was written by Kutateladze’s hand, and the books were printed from his manuscript only.

Samson had wonderful erudition in various fields of human activity. Besides professional knowledge in mathematics and physics, he was a connoisseur in history. When he lived in a mid-size apartment, one room was reserved entirely for a personal library. He liked to collect and read books in different areas such as fairy-tales, detective novels, science fiction, books on politics, and history of military science. I can recall only one person who had the same level of erudition and versatile knowledge in different areas. This was his friend and co-author, academician Michail A. Styrikovich. Once I was a witness of their hot discussion. The topic was the number and types of cannons on military ships during the marine battle between Russian and Turkish navel fleets near the Kaliakria cape!

Once we were discussing the trends in science fiction. Samson told me that it was almost impossible to find a fresh plot for a novel that had not been used already by writers of science fiction. I challenged this idea and we had a bet. The point of the bet was that I had to invent three plots for stories and if at least one of them turned out to be new, I win the bet. I invented a simple plot, and Kutateladze dashed to his personal library and quickly found a book with a similar plot. I lost that bet.

Many of my memories were about Kutateladze in episodes of international conferences and workshops held in Dubrovnik (Yugoslavia) at the seashore of the Adriatic Sea, sponsored by the International Center for Heat and Mass Transfer. Classical scholars of

At international workshop

this science such as, E.R.G. Eckert, V. Rosenau, B. Spalding, J. Hartnett, M.A. Styrikovich, and B.S. Petukhov set the pace. Although, Kutateladze's presentations were the most vivid and provoking for discussions, his lectures, deep and clear, gathered a wide audience, and even those who never engaged in the study of boiling liquid heat transfer. He always found interesting answers to the audience's questions. Discussions with participation of Kutatelazde, Rosenau, and Zuber were very interesting to observe, and they stimulated development of heat transfer theory for boiling liquid.

There was a memorable and very nice party honoring the 70th anniversary of Samson S. Kutateladze. I was working in Moscow that year, but I took a flight to Novosibirsk to attend the party, and to give a toast. Our friends from Georgia sent us a disk with a record of songs devoted to Samson and performed by Georgian singer Vahtang Kikabidze. I remember a few lines from this song:

I wish that with the new glory
would begin to sparkle Samsons' triumphs
so that the conclusions would be bright
so that the formulas would be simple.

The Siberian Branch's president, academician V.A. Koptug, finished his speech with news about awarding S.S. Kutateladze the Star 'The Hero of Socialist Labor," these words were later followed by thunders of applause and cheers.

I had many joint publications with Samson Kutateladze, including four books. During the last years of his life, he planned to write one big book aimed to include the generalization of interesting results of our disciples and followers. I remember that we discussed the outline of this book at a resort. We screened new results on development of the asymptotic theory of a boundary layer published in Russian and foreign journals. Samson was in a good mood and promoted the idea of publishing a handbook with a collection of limiting-case formulas for engineering needs. A nurse interrupted us calling him for a procedure. His last words addressed to me were, "Wait for me here, I will get an injection and this must improve my mind. Maybe you better come tomorrow because the morning is a time for wise thoughts." Unfortunately, there was no tomorrow for him, and for the rest of my life I have in my mind the image of a creative scientist, a wise mentor and teacher, and a wonderful man and friend.