



ORAL HISTORY PROGRAM

Robert G. H. Lee: Forging Innovation - A Life and Legacy in Metallurgical Engineering

PREFACE

The following oral history is the result of recorded interviews with Robert G. H. Lee conducted by William Hearn on February 17, 2016. This interview is part of the AIME Oral History Program.

ABSTRACT

This oral history interview with Dr. Robert Lee, a retired metallurgical engineer and technical advisor, chronicles his journey from a humble upbringing in Montreal to his distinguished career at Air Liquide and his significant contributions to metallurgical engineering. Dr. Lee recounts the challenges of growing up in a poor immigrant family, the importance his parents placed on education, and his early fascination with mathematics and industry. He details his academic path at McGill University, the mentorship and camaraderie he found there, and his pioneering work in the use of industrial gases for steelmaking—most notably, the development of the porous plug and submerged oxygen injection processes, which revolutionized steel production globally. The interview also highlights Dr. Lee's role in interdisciplinary innovations, such as advances in cryobiology and wastewater treatment, and his philosophy of lifelong learning and adaptability in research and industry. Dr. Lee's story is a testament to perseverance, ingenuity, and the transformative power of applied science in industrial practice.

Readers are asked to bear in mind that they are reading a transcript of the spoken word, rather than written prose. The following transcript has been reviewed, edited, and approved by the narrator.

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00:00 Introduction

William:

Today is Wednesday, February 17, 2016. This is an interview with Dr. Robert Lee, who is a retired metallurgical engineer who served as a technical advisor for Air Liquide as well as a special advisor to the Hydrogenics Corporation. The interviewer is William Hearn. This interview is being conducted as part of the American Institute of Mining, Metallurgical and Petroleum Engineers Oral History Project. We are sitting at Dr. Lee's house in Calgary, Canada and are going to discuss his experience in the metallurgical engineering industry as well as his contributions to the field. Welcome, Dr. Lee.

Dr. Lee:

I am so glad to be able to be here to help you to answer some of your questions.

00:32 From Montreal's Heart to Family Hustle: Early Life and Hard Lessons

William:

Thank you so much. Let's get started right away. So, tell me about where you grew up.

Dr. Lee:

I grew up around 200 feet from the Montreal Chinatown on Saint Urbain Street. And in an old house where it was built when they did not have electricity. But the pipes for the gaslights were still functioning, and it was a fantastic building. The foundation walls were around two feet thick, and I'm awfully sorry to see that being torn down because for heat in the old days, we had a fireplace in every room. This was how I grew up.

William:

That's very interesting. And so, then what did your parents do for a living?

Dr. Lee:

My father was a merchant who imported goods from Mainland China. And at that time, he imported the preserved salted fish. To an occidental, it smells like hell, but to an oriental, it smells great. So, this was one of the products that he imported, and it was greatly appreciated by the Chinese community in Montreal. Well, eventually he managed to maneuver himself to be the accountant of that firm, and he eventually owned that business. So, this is the start of my history in Montreal. I grew up with a family of six boys and one girl. My father and mother and my sister came to Canada in 1914, and they came at a very, very bad time, where the Depression was very, very much in my mind right at the present time. Sometimes we did not have enough food to eat, and my mother would tell us, "Sit down and lean over to press your stomach so you don't feel too hungry." And that was my start in life. I know what hunger is, which a lot of you people do not understand.

William:

Absolutely not, definitely not.

03:20 Chasing Opportunity: First Jobs, Big Dreams, and Academic Ambitions

Dr. Lee:

So, that is the start of the beginning. And my father says the most important thing for us is to have an education. And at that time, his aim was to make sure we all graduated in high school. But then the start of the Second World War, I was able to have a job in one of the aircraft plants in Montreal, and I started off making 25 cents per hour. But then the manager of my department realized that I knew geometry and trigonometry, and he made sure that I can design the jigs which he needs to check the parts which come from production, to make sure the holes are in the right places for the other assembly line of aircrafts. And that was how I got my start in industry, which was simple, because I knew trigonometry and geometry, which he did not know.

William:

That's very effective. And so, building off of that, so that's how you got into industry, but then what pushed you towards going from industry into engineering?

Dr. Lee:

Well, it was a hard thing to decide. But my father said -- after grade 10 in high school, he said that if I can get my matriculation in high school to go to university, he has enough money to support me for one year in university. So, I strived very, very hard to make sure that I get all the courses which gave me matriculation. But my father's goal was to make sure we all go and at least have a high school education. And I was slated to go into taking courses in bookkeeping, accounting, so that I can have a job in an office. But my dream was accomplished when he told me he can support me for one year at university. And I took three courses, which one of the teachers in high school made sure that I would do well in these three courses to get my matriculation to continue. This must be very boring for you.

William:

No, no. It's actually interesting because it's much different for us now relative to what it was before, because for the same thing, for my grandfather, him going through, the big thing was getting high school and then university was something kind of after the fact. But nowadays, it's much more where you absolutely need a university degree for a lot of positions. With engineering, thankfully it's one of the few professional undergraduate degrees where you can still get work with that undergraduate degree. But with many others, it's just not possible.

Dr. Lee:

Yeah, for one thing, it is not too well known, but my wife is the first Canadian Chinese to have graduated as a chemical engineer from university.

William:

Really?

Dr. Lee:

She graduated in 1950. And on her sheepskin—in the old days it's not parchment, it was a sheepskin—they mentioned - it's printed "in chemical engineering," and it was a "he." Just to show you how advanced she was during the older days. There were no female engineers at all. And I think she was the first or second engineer female who graduated at McGill 1950.

William:

Wow, that's amazing. Maybe we'll hear to interview her after as well.

Dr. Lee:

But there it goes. So, the next question you're going to come up with is what?

07:44 Experimenting, Scheming, and Surviving at McGill

William:

So, that brought you into university. And then you had done stuff before with accounting. But what moved you directly from accounting into saying, "I want to take metallurgy, I want to work in chemical and metallurgy"?

Dr. Lee:

Yes, I took metallurgical engineering by elimination. In chemical, in metallurgical engineering, we had two professors, and it was in the sub-basement of the chemical engineering building. And one of the great things that has transpired was that in chemical engineering, they use lots of mercury, and the kids didn't care. When they were through with the mercury, they poured it down their drain, and we gathered all the mercury and sold the thing. And we used it to celebrate our Christmas by producing a drink that we call Purple Jesus, grape juice and ethyl alcohol. We sold the mercury to get pure ethyl alcohol and combine it with grape juice for our Christmas party, Purple Jesus.

William:

That's very funny. Oh, that's awesome.

Dr. Lee:

Yeah. And we had two professors, and we were so poor in metallurgical engineering -- now you call it materials engineering. We had to develop the pictures the pictures/micrograph ourselves. We didn't

have a stopwatch. The professor says, "Count your post when you start to develop the films, *and so on and so forth*, says, "Count your post." *That's our stopwatch. You never have heard of that before?*

William:

No. Again, that's one of those things where a lot of the techniques that are used now to characterize materials we use a lot of computer programs for them now. But back before, it was all hand. It would be kind of just tinning, intuition, and stuff like that.

Dr. Lee:

I may have mentioned that before it gets lost in history, not to brag about it but to show you how poor we were when we started off. And now, well.

William:

That's fantastic. And that was kind of there and then. What influenced you to go to McGill?

Dr. Lee:

The reason why I had a possibility of going to university, McGill was the only university that I can go to in Montreal. I can't afford to go to the U of T or UBC because I will be living out of town. So, McGill was the only choice, and I am glad that choice was made.

William:

Yeah, it's a fantastic school.

Dr. Lee:

Yeah.

William:

During your time at McGill, were there -- these professors who you worked with, did you feel like any of them mentored you in a particular way?

Dr. Lee:

Yes, they made sure that what we learned is something that we take with us for the rest of our life. They said, "What you learn here is just a start, and you have to continue to read and improve your knowledge in the field," that we were involved with because it's evolving very fast. This is one thing that we learnt, that our education at McGill is just a start; it has to continue. This is one of the basic lessons that we learnt that we kept all our lives. I think that's the most important thing that we learnt is to keep on learning. It doesn't stop when you graduate.

William:

Absolutely. You have to always keep changing and moving towards something larger. And beyond professors, were there any classmates who kind of really not necessarily mentored you but helped you as you moved through university or made a huge impact on you?

Dr. Lee:

At that time, when I was going through the first year in metallurgical engineering, which they call materials engineering now, we had three boys, which came from metallurgical engineering, from grade one and grade two, and grade three and then graduation. In grade one, we had three boys. In grade two, we had six, three of them coming back from the war, the vets. And on our graduation year, we had nine. So, we had three young kids and six boys from the war, and that made us mature very fast, because they have the knowledge, they have the background. They knew why they came back to university, and that was a great help to us.

William:

Well, I can imagine you would be very, very focused. That's fantastic. And I guess beyond that, did you take any jobs or internship whiles you were at university or mainly just focused on studies?

Dr. Lee:

While we were there, in the summertime, we have four months to look for work. And I started off my first job being a student at one of the cast steel foundries in Montreal East called Canadian Car and Foundry. And that was where I learnt how to make sand castings and how to melt steel so that they can be approved for producing sand casting to get rid of dissolved gasses so you can make sand casting which are not full of porosity.

William:

Absolutely. That's a problem that's persisted for quite a long time. How fantastic.

Dr. Lee:

Yeah. And I found metallurgy extremely interesting because I learnt something new which was not practiced at these steel plants.

William:

That's also something that I'm dealing with as well.

14:37 Determined Spirits: Family Sacrifice, Perseverance, and a Foot in the Door at Air Liquide

William:

We're going to visit some steel plants now and talk about our research and how it can be used to improve their process and their production. That's kind of wrapping up the whole kind of childhood interest in engineering. Is there anything else you would like to that that we might have missed about that period?

Dr. Lee:

I would like to emphasize even though my father barely had enough money to buy toilet paper for us, he emphasized that we will not stop our education if at all possible until we graduate from university. And he made sure that all of us went to high school and graduated in high school. I have to say we came from a very, very poor family. One good daughter who graduated in high school, she was the first Chinese to work for the Sun Life -- they call it insurance company. And she would bring home the old punch cards that they used, and we use that as a toy to make airplanes and so on, with these punch cards. That was our first introduction to industry.

William:

That's very funny.

Dr. Lee:

It's true. We had six boys. Everyone knew how to eat but no one knew how to work, and my sister really supported us. She made enough money to buy our first refrigerator; she made enough money to buy us one of the machines to iron sheets and blankets. And she was really dedicated to the family of six boys who did not know how to earn a cent. And unfortunately, she passed away quite a few years ago. Well, of our six boys, we only have two left, me and my younger brother, who is in Toronto.

William:

Okay. Well, thank you so much. If you don't mind, can we just take a quick break and then we'll continue on in about five minutes?

Dr. Lee:

Sure.

William:

Okay, fantastic. So, Dr. Lee, moving from your childhood and university experiences, how did you get your first professional job in the industry?

Dr. Lee:

During the time that I graduated in 1947, we have to remember that Air Liquide was devastated by World War II. And since Quebec was a French-speaking province, they decided to send three of their

professionals to Montreal to start something up which eventually can go back to France, because as far as France was concerned, they had nothing there. So, they sent three of their people—one in developing gas production plants, one in welding, and one in metallurgy. And I happened to have graduated in metallurgy, so they hired me as part of the team to develop metallurgical processing there.

So, that's how I started off with Air Liquide, because they had nothing in France but they wanted to start something in the French-speaking Canada. And we all spoke English. And at that time, once or twice a year, I had to go to France to make a presentation on the work that I did. And at that time, I had to make the presentations in French. And eventually, Air Liquide became international. They were in 25, 30 countries throughout the world, and all the technologies, had to learn English. So, one year, I went back to Paris to make my presentation in French and they said to me, "Dr. Lee, we would prefer you to make your presentation in English now. We will understand you a little bit more," and from then on, it was all in English.

William:

That must have made it much easier.

Dr. Lee:

So, I thought I'd just inject that for fun.

William:

No, absolutely, absolutely.

19:09 Reinventing Steel: Wild Ideas and Oxygen Breakthroughs

William:

So, you mentioned you did these presentations, but what were your specific duties in this position when you first started off?

Dr. Lee:

To develop technologies using industrial gases that Air Liquide manufacture for steel, for iron, for non-ferrous.

William:

Okay.

Dr. Lee:

And as far as I was concerned, it was the greatest part of my career; to start the use of industrial gases for production of metals. My forerunner to all of this is a fellow by the name of, what is his name, Frank G. Kerry, K-E-R-R-Y. He had a joint patent with Stelco. And a joint patent with Kerry and Bailey was granted in 1945, two years before I graduated in university, and the patent was basically using oxygen to improve the production of the open-hearth steel-making process.

William:

So, is that focused on improving kind of heat flow within it or removing inclusions?

Dr. Lee:

No, improving the flame, to have a hotter flame so that the steel refining process can be faster. And then this crazy guy like me who came along and says, "The open-hearth furnace is not the way to make steel when you want to use oxygen." So, I said, "Let us start making steel with oxygen through the porous plug." But maybe I have to explain what the porous plug is before I can go ahead.

William:

Yeah, you know what, that'd probably be a good idea. So please explain the porous plug.

Dr. Lee:

Yes. Well, the porous plug -- here, that's the GAZAL process that you talked about.

William:

Okay, perfect, yeah.

Dr. Lee:

Read the next page. It's all there. I don't have to explain it.

William:

Okay, yeah. I know, fantastic. Okay, yeah. So, moving on from there, you had those. And...

Dr. Lee:

Well, I tried to -- that's yours. I had tried to use the porous plug, which is with oxygen to refine steel. But the porous plug disintegrated as soon as we put oxygen in there. So, then we said there must be a better way of submerging injection of oxygen to refine iron into steel. And that's where we started and we said, "If we use the high-pressure oxygen to cool the submerged injector, we would be able to refine the steel using oxygen in the bottom of molten bath. But the pressure has to be so high, say over 60 bars, to make the process possible." And the steel coal company would say, "I'm glad you have succeeded, but

you won't try that in my shop. So therefore, we have to develop another submerged injection technology to do this. So, that's when we went to the submerged injection of oxygen with the central plate for oxygen and an annular pipe with a hydrocarbon. And we were successful in submerged injection of oxygen for refining the iron into steel.

William:

So, specifically with that, what was the development process behind that, to actually find that that was the successful technique?

Dr. Lee:

We first did this with a non-reactive gas, like nitrogen and argon, as a shroud gas of oxygen. But the quantities that we had to use to protect the submerged injector, the quantity used was very high, you know, 15 to 20 percent by weight of the oxygen going through. And then we said, "If we use a hydrocarbon under the high temperature, the hydrocarbon would disintegrate. And when it decomposes, it absorbs heat, so therefore we can use a lot less hydrocarbon as our shroud gas. Like methane, where we use 7/8 percent, and propane, we can use maybe 3 to 5 percent by weight of the oxygen going through. We are doing something that no one believed.

William:

Yeah? Was everyone doubting it as you were working through it?

Dr. Lee:

Everyone doubted it. So, we have to test the thing out. And we did all this in a friend's foundry in Cap de la Madeleine. His name is Horace Freeman, F-R-E-E-M-A-N, and we tested all these out in a little group converter that our department built where we can treat around both 500 pounds of iron with submerged injection of oxygen, and we proved that we can do it.

William:

That's pretty fantastic.

25:04 Beyond the Lab: Cryobiology, Gases, and Impacting the World

Dr. Lee:

Well, while we were doing all this work with our company, Air Liquide Canada -- in the old days they used to be called Canadian Liquid Air, okay? But now it's called Air Liquide Canada, we're Air Liquide USA, Air Liquide Brazil, Air Liquide wherever you are. And our research department did not only work on the metallurgy, we worked on cryobiology.

And in the old days, there was a cryobiology group in the USA where we tried to freeze-preserve canine kidneys and so on for future transplant. So, we joined the society for cryobiology in the USA and we did some very interesting work down there with the helium gas to profuse the kidney, to expand the tubules. So, that it will not crush when you freeze it. And we found that there are holes in the cortex of the kidney which nobody ever knew of because we profuse a helium gas, which is very, very active in finding the little tubules...

William:

Yes, it always finds a path of least resistance.

Dr. Lee:

Yeah, we found a path to the cortex of the kidney which the people did not know of. So therefore, we improved their knowledge for the society of cryobiology.

William:

Wow!

Dr. Lee:

That we were in involved in.

William:

Do you mind if I...

Dr. Lee:

Sure, that's all for you.

William:

Oh, fantastic.

Dr. Lee:

Just background information.

William:

That's perfect. So, that was kind of unintentional?

Dr. Lee:

That was unintentional, but we did it for a reason, and we found something that the cryobiologists never knew of.

William:

That's pretty amazing. Yeah, so sorry to switch back, but going back to the GAZAL process, how did that process that you developed affect industry, in your opinion?

Dr. Lee:

Well, the GAZAL process, okay -- but I gave you that sheet there, the second sheet.

William:

No, absolutely. It's just that I wanted to feel as someone who -- you helped developed it and made it. What was the impact you felt?

Dr. Lee:

The reason why our thoughts went to the GAZAL process, we were going into an industrial steel plant. And when they poured the steel from the steel refining furnace into a transfer vessel, they knew that the transfer vessel will take heat from the steel that you just poured in. So, they use an ingot to plunge into this steel vessel, to stir it up to make sure the steel temperature would be as uniform as possible. And I said gee, that's a cumbersome way of doing it, there must be a better way. So, the story is right in there.

William:

Perfect.

Dr. Lee:

And how I tried to develop a porous plug, where I can have a -- not only pores and a plug but connecting pores where argon gas can be sent through to homogenize a ladle full of steel. The story is in there.

William:

Last thing on the subject, when you were developing it and when you finished it, did you expect that it would become so widespread? Because that is now a staple of the steelmaking process.

Dr. Lee:

It is used worldwide now, in ferrous and non-ferrous, even in the non-ferrous piercing of converter, they're using some of these porous plugs to stir up the bath. And there it's been used in steel-making plants throughout the world.

William:

No, absolutely. It's for me, in school, when I learned about steel, that is a fundamental part now, which is I guess really exciting for me because I get to meet one of the people who developed probably one of the most revolutionary products in steel for the last 60 years.

Dr. Lee:

Anytime where you have very high temperature, you will want something to homogenize the temperature and therefore homogenizing the bath.

William:

Absolutely, and gas blowing is the most effective. I didn't realize that before, that you just sent in a plunger to go up and down and mix it...

Dr. Lee:

To stir up the bath.

William:

That does seem quite archaic in its ability, because you're splashing it up and down but not necessarily -- yeah, that's quite fantastic.

Dr. Lee:

And that the story on the heartaches on the developing this porous plug, you will learn it there. We will go to a refractory manufacturer to say, "We want porous plug where we can send argon gas through." And asking for pores in a plug is sacrilege. But when you want connecting pores where you can send a gas through, they showed us the door. They said, "We make refractory as dense as possible to make sure that there is no gas, no porosities in it." But the Department of Mines, Canadian Department of Mines, they had a lab where they would say, "We think we have the capability of producing a porous plug for you." So, the Department of Mines of Canada had a ceramic department produce the first porous plug for me. And well, using the porous plugs in this industry by this time is known. But I said, I'd like to introduce oxygen through a bottom of a molten bath, and we tried to first with the porous refractory plug, and porous refractory plug disintegrated as soon as we put oxygen in. So, that's where we decided we had to find out a better way of submerging injection of oxygen. That's how we got started.

William:

Thank you. Yeah, no. Absolutely, it's very interesting how the whole process just kind of snowballs and you start off in one area then it kind of takes you in a whole different direction. No, thank you for that.

31:48 A Small Team, Big Risks: Patents, Autonomy, and Growth at Air Liquide

William:

So, it's very interesting, your career as, a lot of people, as they move through their career, they bounce from different company to different company, but you became a staple at Air Liquide and worked your way for pretty much your entire professional career. And so, could you please talk about how your career advanced within one company, and then was there a specific strategy you had or you kind of just went with how the projects came?

Dr. Lee:

Well, our research department, research and development department, was very, very small. At the max, we had around less than 20 people in our research department. And our capability of using industrial gases spread into just about every industry that you can think of. We were involved with the food industry, we were involved in the metallurgical industry, the chemical industry. And we were responsible for selling enough industrial gases to keep our research going in our new department to the point where the head of Canadian Liquide Air, a fellow by the name of, Pierre Salbaing, said, "Since your department makes more income than you spend, you have my carte blanc to do anything that you like. He was responsible for us taking chances in activities which never has taken part before. So, we had carte blanche.

William:

For research and development, that's kind of what you wish for.

Dr. Lee:

Yeah, we had a field day.

William:

Absolutely.

Dr. Lee:

Yeah.

William:

So, if you don't mind me asking, how did your career at Air Liquide develop from when you first started as a student who came in and was doing these once-a-year presentations in France to where you were by the end of it? How did that develop? How did the path go with research and development for you?

Dr. Lee:

Yes, we developed, I would say, the porous plug. And just about then around that same time, France had the possibility of starting up a huge research department. And they took the first thing in metallurgy was they took our development in porous plug back to France, and they developed it to a point where it became their technology and sold the porous plug in France, which I'm very proud of.

William:

I would be too.

Dr. Lee:

They spent lots of money to develop the porous plug because we don't have much money here to do any development work in steel companies. It's only where there is a need and we go out to help. But in France they can promote the plug by itself.

William:

Well, that's very exciting.

Dr. Lee:

So, I was very proud to see them using part of our development project to commercialize it there.

William:

Absolutely, it must feel very exciting because you spent so much time going through the development, all those struggles and all those kind of failures. But you learned from them and then you were able to develop something that not only helps where you are but changes globally, pretty much. Absolutely. And so, you worked in Air Liquide for quite a while, and it says here you're credited with more than two dozen inventions or for 200 patents. I know there's a huge range of them and they're all, you talked about the cryogenics with biology and you talked about the porous plug, but are there any maybe let's say lesser known patents you feel really proud of or you're really happy that you developed them?

Dr. Lee:

Oh gee, you embarrass me. That was such a long time ago.

William:

I'm trying to make it very difficult for you.

Dr. Lee:

Let me see now, I can look into this. Well, I did develop expertise in metallurgy in pulp and paper, where we would use oxygen for a certain part of the pulp and paper industry in energy, in combustion, in environment, entomology, and cryobiology. This is where we spent our time to try to develop technology using our industrial gases not only in metallurgy, which made me feel I'm indispensable.

William:

I would agree with that.

Dr. Lee:

You see here, there is a section on metallurgy. There's a section on pulp and paper, which I can let you read, and gases, in energy, in combustion.

William:

Well, fantastic.

Dr. Lee:

In wastewater treatment. Rather than going through all of these, you can explain what they're saying here. And here you've got all of the awards which I got. The awards, it's too long.

William:

No, no, absolutely. So, to avoid going through all that, I will go through that myself and kind of explain that. But for you, because I guess we -- say somewhat for me, I know a lot about the GAZAL process because it's such a huge part of the steel industry and a lot of people know a lot about that, and the kidney one was also very interesting. But is one other specific patent or technology you find that was sort of underappreciated that you developed but you really felt it made a difference?

Dr. Lee:

No, you have to give me back that sheet there.

William:

Absolutely, no worries.

Dr. Lee:

That was such a long time ago. Do you know, I have one more research project which I'm going to hold and not say a damn thing about it until the oil prices come back.

38:01 Cleaner Futures: Environmental Innovation and an Evolving Research Culture

William:

Or even -- you were mentioning to me before about the treatment in Pickering of the water, and you created that compact...

Dr. Lee:

Yes.

William:

Okay. Yeah, would you mind explaining that again briefly?

Dr. Lee:

In the wastewater treatment plant, they would use the first stage to get rid of the boots and log and so on, which goes into the sewer. And then they would have another wastewater treatment plant where they would get rid of some of the solids, fine solids, and then they would send it to another one, where they would use air to treat the biological waste, and then they would send it to a clarifier. But my technique was to use the clarifier using pure oxygen gas to go in to treat the biological waste so you can -- without the nitrogen and oxygen to stir up the bath. To use it as a clarifier and also a biological reactor because we can do it in such a way where there is no waste gas coming out of the clarifier. So, we use the biological reactor with oxygen gas and then use the top part of it as the clarifier. Because the only gas that we might generate there would be CO₂, which can be controlled.

William:

Well, okay.

Dr. Lee:

So, using the two stage into one reactor.

William:

Okay. Fantastic.

Dr. Lee:

So there, the process successful development did.

William:

Yeah absolutely, yeah exactly. That's very true. And at Air Liquide, you started off more kind of as like a research and development associate, and as you moved forward you became more a head of that department. What was the changing mindset that you had from working as someone who did associate tasks to someone who was more the head of research and development?

Dr. Lee:

The reason for it is, as I mentioned to you before, we were involved in so many activities which the people ourselves were involved in. Anytime they have a problem on using gases that we manufacture and sell, if they have a problem, they rely on the research department to go out to the field, they'll help them to resolve it, and we take that as a clue to say, "Ah, here's where more development work is required, where we can supply them with the technology we already know so that he can go to a process using our gases." And it was not developed. We developed it for them. And so, that is a tremendous thing. But one thing which I stopped at was to use our oxygen enrichment of air for cremation. I said I know how they're doing, but someone else will have to do it for me. So, that is real.

William:

That's absolutely fair. Yeah. Yeah, no absolutely, I believe you.

Dr. Lee:

And I also will be able to develop the rate -- the cremation process will take less time and where there's less pollution. But I would give them the know-how to do it, but someone else will I have to carry that out.

William:

Yeah, for implementation, yeah. Oh, definitely. And speaking of the research culture, did you feel that there were specific changes in that as you went from -- like between decades. So was the focus different between the '50s and the '60s and the '70s and the '80s. Was there ever, you find, like a shift?

Dr. Lee:

Yes. We made it possible for people to think of industrial gases, to do what they have to do rather than just air. And we produced many technology where they would use argon gas, technology where they would use nitrogen gas. Because they would be using air, but there's twenty-one percentage oxygen in the air. But they prefer not using air if they prefer to use nitrogen gas for what they want to achieve. We supply them with nitrogen gas and show them how to use it efficiently. And this gave us carte blanche, gave us absolutely carte blanche. So, we developed the technology, and we became expert just in many fields.

William:

Oh, I can imagine.

43:01 The Long Arc of Innovation: Milestones, Partnerships, and Global Influence

William:

Well, you had a very long career in the industry, and other than your own contributions, what milestones would you say had the biggest impact on metallurgy in the work you were with?

Dr. Lee:

The biggest impact, I would say, is in the development of cryogenic plants to supply the nitrogen, to supply the oxygen in tonnage quantities to use for the metallurgical processing. We developed oxygen production plants for metallurgical processing and for chemical processing plants to produce 25,000 tons of oxygen a day. It's for example, the largest use of industrial gas, oxygen is with the Sasol Company in South Africa. I don't know too much about that, but they use 25,000 tons of oxygen a day.

William:

So, if you don't mind me asking, so that's what they moved to. What were they doing before that? Was it just they weren't able to produce that quantity?

Dr. Lee:

They couldn't do it.

William:

Just couldn't do it?

Dr. Lee:

They couldn't do it.

William:

And then I guess affecting you directly, did that give you, I guess, more opportunity to implement your kind of technologies?

Dr. Lee:

Well, that is an incentive for us to develop technologies that we ourselves can take care of, and that is where we use, as I said, to use the porous plug with the oxygen, but the porous plug disintegrated. So therefore, we used a submerged injection of oxygen at a high pressure to start off with, 80 bar pressure, and it worked. And we would produce a mushroom of frozen iron at the tip of the injector, and we

showed that we can do that 80 bar pressure. We're going through a steel company, and they say you are successful, but you're not going to use 80 bar oxygen in our plant, so they will show us the door. So, that's when we started to say, "How can we lower the pressure to industrial available pressure?" That's why we used the concentric lances.

William:

Yeah.

Dr. Lee:

And I had a manager who is -- he should have been in the sales department. He's proficient in French and proficient in English by the name of Guy Savard. He did all my promotional work in France and most of my professional work in Canada, because he has command of English and French. And his name is Guy Savard.

William:

Yes. Oh, perfect.

Dr. Lee:

Guy Savard.

William:

Fantastic. Thank you.

Dr. Lee:

And if I came up with, say, we can make a profit on selling pencils if you go out and promote the thing, he would be successful in doing it.

William:

Absolutely. And so, this greater production of the gases, it allowed you to implement more of the technologies you made, right? Because if you increase the pressure, you're going to need more gas to come in. So, did it make it easier when you were designing, you were actually coming up with research and development? Or was it easier when you actually wanted to implement it?

Dr. Lee:

When we know we can use a gas at 80 bar pressure, the technology is already done, but no one would want to use our gas at 80 bar pressure. So, that's why we went back and did the Savard I'd say, "What

must we do to lower the gas pressure to commercially acceptable level?" That's when we came with the dual pipe of the oxygen going in the center and then annular pipe for our hydrocarbon gas.

William:

Thank you so much. And before we go to closing kind of questions, is there anything else you would like add about your professional career and anything like that?

Dr. Lee:

Well, that made our career, the whole world. Look at our submerged injection process for O₂ gas. And it was used again in ferrous and non-ferrous industry. To make these pyrometallurgical processes more efficient, they know they have to go to as pure oxygen as possible, and the only way to get it to using as high possible oxygen gas is to use our concentric injector. So, they're using the piercing converter in the non-ferrous. They're using in the steel-making process, which most people know about. But they're using it in the non-ferrous industry also, like in Inco and Falcon Bridge and so on.

William:

Thank you so much.

48:44 Looking Back with Pride: Reflections, Gratitude, and Legacy

William:

And to kind of wrap up our whole interview, I wanted to ask you, what has made working in the industry meaningful for you?

Dr. Lee:

When I started in this industry, the use of industrial gases for that was zero. And now I would say the metallurgical industry cannot do without this gas. And it started off with Frank Kerrey using oxygen for flame in [Richmond] in the open hearth. And I said if it can be used there, it can be used elsewhere. And I have to thank Frank Kerrey for giving me this incentive. Yeah. Unfortunately, he did not live long enough to appreciate what incentive he imparted on me to continue.

[CROSSTALK]

William:

And the impact of that whole concept yeah. Well, thank you so much. We really appreciated your time it was great to hear about how you went through your life and all of the work you've done. Oh, thank you for that. We'd just like to say, on behalf of myself, and AIME, we're grateful for this opportunity to have talked with you.

Dr. Lee:

I wish we had more time to dwell on this subject, but we cannot go into details. That there, no, that there is just a little bit more information that you might dwell on.

William:

Okay, thank you so much. Sorry. And that's the end of our interview. Thank you again, Doctor Lee.

Dr. Lee:

I wish we had a lot more time to just talk about the crazy things that I did.

William:

Yeah, absolutely. Thank you so much.

Dr. Lee:

And I thank you for your time.