ORAL HISTORY PROGRAM

Hardarshan Singh Valia: A Destiny Fulfilled - Exploring the Magical World of Coke

2022

PREFACE

The following oral history is the result of a recorded interview with Hardarshan Valia conducted by Amanda Blyth on May 15, 2022. This interview is part of the AIME Oral History Program.

ABSTRACT

Hardarshan Singh Valia is a geologist with the heart of a poet. He began his life in the small town of Chindwara in Central India, where he received a primary and middle school education. His parents moved seventy-eight miles south to a large city, Nagpur, where he completed high school and college education. He attended India's Government Science College, earning a Bachelor of Science and a Gold Medal in geology. After receiving a Master of Science and Technology in Applied Geology, he pursued further studies in the US at Bryn Mawr College and Boston University. After teaching for a brief time, he left academia for industry, becoming a research engineer for Inland Steel Company in East Chicago, Indiana.

Over the years, Dr. Valia became an expert in cokemaking technologies, working on a wide range of projects: improving blast furnace performance/operation by improving coke strength after reaction (CSR) with carbon dioxide (CO2), which resulted in the development of a CSR predictive model; coke behavior in the blast furnace utilizing blast furnace tuyere sampling; modification of Chinese beehive cokes for blast furnace usability; coal selection and blend design for heat recovery/non-recovery and slot oven cokemaking; research on carbonization behavior of coal in heat recovery/non-recovery and slot oven cokemaking; use of poor-quality (low-rank) coals in cokemaking; prediction of coking quality of coal reserves; effect of oxidation on coke quality; new cokemaking technologies; coal selection and coal behavior in blast furnace pulverized coal injection; and the use of additives in cokemaking, ironmaking, and steelmaking. His patents and awards attest to his impact on the steel industry. Dr. Valia retired from ArcelorMittal as a staff scientist in 2002 and started a consulting firm, Coal Science, Incorporated.

In addition to his research efforts, Dr. Valia also enjoys writing. He has contributed to a number of books and technical papers. He has also channeled his passion for science, geology, and steel making into poetry, as well as a children's book written in the Hindi language. He is a longtime member of AIST and attributes much of his success to his membership in the association.

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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PART 1

00:22 INTRODUCTION

Amanda Blyth:

I'm Amanda Blyth with the Association for Iron & Steel Technology. Today is Sunday, May 15th, 2022. We're here today at AISTech 2022 in Pittsburgh, Pennsylvania, with Dr. Hardarshan Valia, who is joining me for an AIME oral history interview. Thank you very much for joining us.

Hardarshan Valia:

Thank you, Amanda.

00:43 YES, DOROTHY, MIRACLES HAPPEN ALL OVER THE WORLD – A CHILDHOOD IN INDIA

Amanda Blyth:

Let's start with your childhood. Tell me about your childhood.

Hardarshan Valia:

Before I start that, I want to say a few words about destiny. Because, to me, it seems more like a magical phenomenon to be swept away from growing up in the central part of India, right in the center, and landing in a faraway land and following the pathway to the magical world of the steel industry. And, my apologies to the Wizard of Oz. Why? Because, yes, Dorothy, miracles happen all over the world, not only in Kansas.

So, with that, let me tell you about my childhood. I grew up in a town called Chhindwara. It is a very sleepy little town of the 1950s. Remember, that was my childhood. I fear now it is very, very different. So, this little town is surrounded by mountains and lush forests and rich in mineral deposits. There's a coal bed that runs through there, and very interestingly, there are two of India's famous tiger reserves very close to this place. One is about 30 to 40 miles south of Chindwara, which is where Rudyard Kipling, it is believed that he wrote his Jungle Book and the story of Mowgli while in that; it's called Pench, P-E-N-C-H, tiger reserve. So, my childhood is all from that area. It's just unbelievable when I think about it. I came from there. It's just unbelievable.

Anyhow, the next one is about 140 miles; that is also one of the most famous tiger reserves in India called Kanha, K-A-N-H-A. Although it's a little farther distance, it did not matter [because we traveled through that area quite often.] I did my geology mine training in a town nearby the reserve called Balaghat.] So, my whole childhood is from that area.

My father was a railway employee, so we could take the train, go anywhere, come back. And, there's another big thing, they don't go very fast. Just to go 70 miles, it would take the whole night. So, 10 o'clock in the night, we'd get ready, and seven o'clock in the morning, we'd reach the other place. So, I come from that. My mother was a housewife, and I was the only son in the family. I had three sisters in that Chhindwara town, but one sister was born later on when we moved to another city.

03:42 SIKHISM, PART OF A UNIQUE IDENTITY

Hardarshan Valia:

I really want to talk about my distinct identity. I belong to Sikhism, which is the fifth-largest religion in the world. People don't realize that. They are well known as saint soldiers. And why? Because when you look at them, and you see them, they have long hair. Long hair is the symbol of saintlihood. And then, they wear turbans. Turban is a symbol of, you know, you are a king of your own families and others [who depend upon you]. When there's a persecution, you stand up. So, we're known as a very martial race.

And, you'd be very surprised to hear that the largest numbers of Victoria Cross, besides British, anyone got are the Sikhs. Not many people know that. This was in a National Geographic article. So, we have tradition usually from family, [quite a few] are in the army. So, both my paternal grandfather and my maternal grandfather, they were both with the British Army Indian forces. So, my paternal grandfather was very proud. I didn't see him. He died before. So, in the Pakistan part, we were living in the Pakistan part, my father was transferred to the India part. [My paternal grandfather died in the Pakistan part.]

So, at that time, what I know from stories from my father, the heroic stories and all that, he went with British forces to countries and in ships from Karachi, Pakistan to Africa, different places and all that. He told me many stories about that what happened. But he survived. Many people died, and he came back to Punjab. But, the beauty of that, this picture of his with three medals and the engravings on the medals are amazing. One of the engravings is of Queen Victoria. Second one is an engraving of King George. Third is the engraving of King Edward. My maternal grandfather, he never went to the war front with British Indian forces. But I think he was an officer. And so he was assigned to the administrative services.

06:00 EARLY SCHOOLING & CHILDHOOD MEMORIES OF INDIA

Amanda Blyth:

So, let's talk about your early schooling and the role of the small township in your upbringing.

Hardarshan Valia:

Okay, so I have two phases there. One is a primary middle school, which is in a small town of Chindwara. Then, my father transferred to a big city, Nagpur, so I'll talk about both places.

So, in the primary schooling, our classes were all on the floor. We would sit on the floor, and at times it was cold. So, my middle school and primary school were all there in that [town, but in middle school, we had desks and chairs]. But, I had a wonderful teacher from primary school. His name was D.P. Shukla. I'm thankful to him. Because of him, he put all of us in training for knowledge. It's because of him I could be kept in line following a study path. You'll be surprised to hear that our house had no running water, no electricity. But, we had a well in the house. Later on, my father got the railway house. It's interesting, not in America, but in India, most railway employees in small places live in railroad colonies—houses, hospitals, schools, and all that. So, he was given a railway house, and in that, we had running water but no electricity.

Now, let me describe a little bit about the town, what we did besides studying. So, I had wonderful fond memories. We would take bicycles, all of our friends, especially four friends, and we would ride on Narsinghpur Naka Road. It was surrounded on both sides with the forests, and no fear, nothing, just go through the whole thing. I don't know how many miles. Then we would see this little hillock called Tekadi. We would climb there, leave our bicycles and run around. No fear of imaginary or real animals that might be lurking in the forest. After eating all the fruits — I don't even remember the names now in English — we'd come back. My friend's father had a big grain storage space. So, outside there'd be huge piles, mounds of peanuts. We'd climb on those and eat peanuts, sing songs, tell funny stories, and do things that children do.

Then, the other thing that was very interesting was that we would have monsoon rain sometimes for a whole week. Everything was flooded with water. Sewage would flow onto the streets. It wouldn't matter; we'd put our underwear on and run through the water. And, of course, hands in the mud. We'd leave our marks on some decaying walls, proclaiming that we were there. There was one small library, just one room. I think every book in that library has my fingerprints. So, that was a beautiful time that I spent there. My memories always go back to that when I'm tired, stressed here. That's the place where I take recluse.

Then my father was transferred to Nagpur, which is a very big city; it's about 70 miles south of Chindwara and in a different state. Here, we were given a very nice railway bungalow from British time, and running water and electricity was there. But, the beauty was very interesting. It was right across the railway station. So, the trains are going left and right. So, my life revolved around watching trains and seeing those different people coming, going. And Nagpur is a very interesting city. It's right in the center of India. So, that Delhi train would come all the way to Nagpur to Madras South. And then, Calcutta, all the trains would come and go to Mumbai or Bombay and cross here. So, trains are going left and right. Our house was right adjacent to the narrow gauge straight from Chhindwara Nagpur sub-station. That is where my heart was. A few of the people who would be coming from Nagpur to Chindwara, we would know. Sometimes they would come and stay at our home. We would have a good time. So then, I went to Model High School and did my high school in Hindi medium and then moved to, after that, Government Science College.

11:21 COLLEGE EDUCATION PART 1: INDIA

Amanda Blyth:

Yes. Let's skip ahead and talk about your education in college and any mentors you may have had along the way.

Hardarshan Valia:

Sure. So, I'll get into two parts because I had college education in India and in America. So, let's start with the India part first. In India, after high school, then I did my B.Sc. in the Government Science College. I received a Gold Medal in Geology; that was my field. That's where my love for science, arts, and teaching flourished. Then, at Nagpur University Geology Department, I did my Master of Science and Technology in Applied Geology for three years under scholarship from University Grant Commission. I had wonderful mentors, Professor Giri and Professor Kulkarni, who always encouraged me to go to America for higher studies because they had [been to America on educational programs].

At the same time, while I had been applying, I got a scholarship to do a Ph.D. program in Coal Geology at Nagpur University. My professor was Dr. Sappal from Australia; he had just returned. I know he's back now to Australia. While I felt bad about leaving him, I got a scholarship from Bryn Mawr College, one of the seven sister colleges in America. It's basically a women's college, but they were taking graduate students at graduate level, men. So, I got a scholarship in that program. And so, I went there. But, of course, money, how to travel? So, R.D. Tata Trust, which is the Tata Steel Company, they had a partial travel grant they gave to me. The Geology Department gave me a nice farewell. I came to America. So college in the USA, Bryn Mawr College first and then Boston University. So, there were two colleges.

When I left Nagpur, there's a picture at the airport before my departure because not too many people were coming to America. So, it used to be news if somebody's going; it would be in the newspapers. So, a lot of people showed up at the airport. My father's friend, my sister's friend, my friend, neighbor children, they all arrived at the airport with garlands, all that. So, there's a picture. And that picture, my parents always hung in their bedroom. That picture captures the joy, the tears, the agony, the waving hands, and all that. It always teaches me to discern what the emotions are that my parents must have gone through all these years during my absence because I was the only son. And so, I left for America, obviously young man with all the hopes and dreams and all that. And, landing in America, it was September 11th, 1969.

14:38 COLLEGE EDUCATION PART 2: AMERICA

Hardarshan Valia:

I was lucky enough that I went to Bryn Mawr because the faculty there was just unbelievable. They went out of their way to help me to settle down to go through the program. I'm eternally grateful to Dr. Watson, Dr. Dryden, Dr. Bruce Sanders, and Dr. William Crawford for guiding me through all the courses and the fieldwork; we had to go to a lot of field trips in different places. I achieved my Masters in Geology from Bryn Mawr College in 1971.

Let me share something about dorm life because this was out of this world, knowing how I came from Chhindwara and Nagpur. Suddenly, I come to a Victorian style; it looks like a Cambridge University kind of campus, you know? A beautiful campus and the dorm, both. And, this is, for those of you who may not know, it is called Main Line, Philadelphia. That's where Katherine Hepburn lived, there in that Main Line area. Okay? M. Night Shyamalan, the movie director, he lives in that area, too. So, the Bryn Mawr is on Main Line train station. So, the amazing thing about that not only the geology department was very helpful, but the dorm, that's where you live, that's your home. So, the friends there that I developed friendships with, they were amazing people. I have a picture there of the cook, Helen, and the staff there, and a custodian whom I lovingly called Johnny Chacha (Uncle Johnny). So, they took care of me, fed me, you know, make sure I'm just like their family member. So, that just made it very easy for me to adopt the American way of life and learn from them.

Then I moved to Boston City, and I received my Ph.D. in Geology in 1976. My mentor was Dr. Barry Cameron. Under his guidance, I reached the pinnacle of my academic career. He was unbelievable. Oh, my God. In one story I tell people sometimes, he used to call me Harshan. "Harshan, what time it is?" I said, “12 o'clock in the night.” "12 o'clock? Oh, let's eat.” [We’d go to a submarine place and eat hoagies]. While I'm coming back, I said, "Dr. Cameron," — I could never call him Barry. So, I said, "Dr. Cameron, I wish you were married." He said, "Why do you say so?" I said, "Because you should be

going home on time at five o'clock." So, he told me, "Remember this one thing: You can never be a successful scientist or a successful family man, okay? Unless you're fully devoted to that. You choose which one you want." I chose the middle road. [He was] a wonderful mentor. I'm [so lucky to have met] a person of his caliber. He taught me everything in the field that I owe to him. My thesis was "Miocene Sedimentation and Stratigraphy of the Delaware Coastal Plain."

18:43 MARRIAGE, PER SIKH CUSTOMS

Amanda Blyth:

So, we've learned about your upbringing and your education. Let's talk about your family. Tell me about your spouse.

Hardarshan Valia:

I went to India, like many Indian students do, less now, but more at my time. I got married to Bhupinder Kaur. She's a fellow Sikh from Punjab. I'm from the central part of India. She's from Punjab. Punjab is where most of the Sikhs live.

It was January 10th, 1982. She's a physician by profession. The marriage was performed by Sikh rites, and it was an elaborate one. I won't go into detail, but we went on a horse to the bride's home. And there, the bride's family, the groom's family, [were introduced], and then, the priest [recites hymns]. This is how the families join together. Then, in front of the holy book, we take four rounds, and each round has got a couplet for different phases of life, how to react to those situations. Then, marriage is done, followed by a reception. In old times, it used to be a two, three-day affair. But, nowadays, because of the lifestyle, it's one day or two days at the most. Then, my children, we have two children. Vikram Singh, he's my son. He is more interested in science and research; my daughter, Anu Kaur, she is a director in Hollywood.

Amanda Blyth:

That's very interesting. Thank you for sharing [details] about your family. It's always nice to hear about people's home lives and their families rather than just all their career because you're a whole person, and you have all those facets to you.

Hardarshan Valia:

You're so right.

20:45 A START IN ACADEMIA & AN INFLUENTIAL MENTOR

Amanda Blyth:

Let's talk about your entry into the profession.

Hardarshan Valia:

Okay. After Boston University, I spent one semester at Case Western University in Cleveland and

taught there. Then I joined Oberlin College as Assistant Professor of Geology in Oberlin, Ohio. And, that's where [there was a] very interesting turning point. I saw an ad for a [job posting in an] oil and gas journal. It was for a coal petrographer. Because, when you are exploring for oil and gas, you use the reflectance of light on [organic matters to figure out if] the sediment has a potential to have oil or gas or nothing at all. So, in the steel industry, coal petrographer plays a very important role. Not all coals are usable for making coke, only very select ones. One of the key ways we find what selectivity of those coals is by microscope, examining under the microscope. So, that's where they put the ad in that. At Boston University, I was a teaching assistant to world-renowned coal petrographer Dr. Norm Schapiro. He retired from U.S. Steel and came to Boston University to teach for a semester. I happened to be his teaching assistant because, in India, I had done one year [research work in] coal petrography. And, just to say about Norm Schapiro, all over the world, most industries they use one form or another form of his petrography prediction method for predicting the cooking quality of the coal. So, his diagram, [jointly created with Ralph Gray, is very famous [and is known as Schapiro & Gray Coke Stability Prediction method.] So then, after that, then I chose the new path.

23:08 A CAREER PATH GUIDED BY MEMORABLE MENTORS

Amanda Blyth:

It sounds like working with Norm Schapiro had a big impact on you. So, tell me about other mentors you've had along the way.

Hardarshan Valia:

Okay. I would describe that in two phases because my professional career has two phases. One is that of by-product cokemaking. [Because most of the batteries were old and expensive to maintain/comply with emission control, they were shut down in the 1990s. My first phase was devoted to by-product cokemaking research from the 1970s to 1990s.] Why by-product? Because while you're making coke from coking coal, there's a lot of by-products from that. Then the second phase was called heat recovery cokemaking. [Where by-products are burned and heat recovered is used for generating steam and electricity.] So, there were two different mentors during those periods. In by-product cokemaking, Dr. William DuBroff; he was an amazing person, Director of R&D at Inland Steel, which is now Arcelor Mittal. He nudged me to join Inland. Why? I was double-minded. At that time, I was fully a very academic-oriented person. To come to the steel industry, it was a big jump. I came to industry in 1979. He just provided me a completely free hand to follow research projects. Unbelievable. Wonderful mentor.

Then the steel industry went through a difficult time. During my second phase of heat recovery, I was lucky to have Dr. Gregory Ludkovsky. He was the Vice President of R&D. He gave all resources for plant trials to me. We went to Virginia, Vansant, and did a lot of trials, three weeks or so, to make sure that the coke quality we can produce that will fit our specifications. So, these are the two persons, very important in shaping my direction there.

I want to mention [the role of coal researchers] here. I looked up to these giants in my field, the industry, and they are as follows: Again, from Norm Schapiro's Shapiro and Gray, both from U. S. Steel, and I just looked up to them. And then, Dr. Harry Marsh: he is a professor at the University of New Castle Upon Tyne. He's a premier authority in the world on Mesophase and maceral (organic entities) interactions. When you melt the coal, in the absence of air, then, at a certain temperature, it starts

melting into plastic phase forming nematic-liquid crystals that coalesce and grow, and they give wonderful carbon form of different visual colors, [when the coke formed is examined under a microscope]. He was the expert in we call it Mesophase/nematic liquid crystal transformation. Then, Dr. T. Miyazu he's from the NKK Steel of Japan. What he did is that all over the world, he took coals and defined into a diagram based on reflectance of coal and fluidity of coal and [for assessing the coking abilities of coals from the world over.] So, Dr. Miyazu. Then, there is a team of two well-known scientists from Bethlehem Steel, Dr. Dick Thompson and Lou Benedict. [When coal is heated in coke ovens, the gases evolve and exert pressure on the oven walls. If pressure is high, it can damage the oven walls, and gases may escape via cracks or via doors causing leaks.] They both developed a model; it's called wall pressure prediction model.

My other mentor, who I looked up to, [Professor John Patrick of the University of Nottingham, U.K., and co-editor of Fuel], and he's all already known in the world for coke breakage behavior inside the blast furnace. There's one more [mentor, Dr. G. Nashan from Ruhrkohle, Germany, under whose tutelage Jumbo Coke Reactor was created, and he also was the editor of Cokemaking International. Those are the giants in my field who I am lucky to call mentors.]

28:53 A DEFINING CAREER MOVE - INLAND STEEL & BY-PRODUCT COKEMAKING

Amanda Blyth:

So, you've had these giants of industry, as you say, as your mentors. That must have helped you achieve many milestones in your career. So, let's talk about the by-product cokemaking milestones.

Hardarshan Valia:

When I joined Inland Steel, Dr. DuBroff, he gave me a project, and that project just defined my career. In 1980, we had one of the largest blast furnaces in the Western Hemisphere, the No. 7 blast furnace. But, after some time, we started having troubles with the blast furnace. [Nippon Steel informed us that the hot strength properties of coke used in the blast furnace were low.] They are the ones who came up with this parameter called CSR, coke strength after reaction with carbon dioxide gas. [So, that tells you coke behavior at high temperature inside the blast furnace.] As a result, we were having operational issues. [I was assigned to develop a] CSR prediction model. And, once you have developed that, now it's a huge project to make that kind of coke in the coke plant, then to try in the blast furnaces. [Progressing from low CSR to high CSR coke with time resulted in improvement in productivity and stability of the No. 7 blast furnace operation.] A lot of people got involved, from plant to research. They were Denise Kaegi, Marty Sorensen, and Valerie Addes from research, and the technicians who conducted tests in pilot oven and plant were Rick Kruse, Fritz Oberc, Bill Ference, Tom Coyle, and many more. Plant help was generously provided by Bill Ambry, Don Zuke, Wendall Carter, Bill Hooper, Joe Moore, and many more.

The next one is that, since we developed the CSR operation model, we went one step further [in applying CSR prediction to coal reserves from where we were procuring coking coal.] To my knowledge, nobody did it. So, what we'll do is that we, if we buy any coal from anywhere, we said, “No, we want to come to your reserve, look at the map, and predict the CSR, and then see if it'll be compatible with the coal that we're already using.” [Reserve evaluation for CSR was greatly helped by Charlie Harrison, William (Chip) Ostenberg, Joe Moore, and Jeff Wozek.]

The next thing is that, by this time, beginning of '92, we started working for PCI because we had shut down our coke plant. So, we had to use PCI. [When we adopted Pulverized Coal Injection, at times, we noted some unburnt char and unburnt coal in the flue dust. We monitored its content by microscopy and used it to evaluate a coal's combustion efficiency in the blast furnace. To my knowledge, we were the first to use this technique. All microscopic work was done by William (Chip) Ostenberg.]

The next one, it's a coke degradation behavior inside the blast furnace. [A coke core sampling device was developed at Ispat Inland Research by Dr. Pinakin Chaubal, Rich Kruse, and Tom Coyle. It was driven through a tuyere at No. 7 Blast Furnace, and it reached all the way to the center called Deadman's zone. The coke samples were also taken from the stock house screen and also raked at the tuyere. Additional plant and research personnel who participated in the project included Madhu Ranade, W. Carter, E. Knorr, D. Zuke, J. Moore, William Ostenberg, and Bill Ference. The reason on why we undertook this study at the particular time is as follows.]

The Chinese coke from Sanjia was being delivered at low cost to America. We were using US Steel coke, 100% in Number 7 blast furnace. So to reduce the cost, we started to try for that coke. But, we had a difficult time because this coke had very unusual properties. [It had very high cold and hot strength properties close to Super Strength Coke, and we needed to discern its degradation behavior compared to the domestic coke that were used to. We found that the Sanjia coke was distributed near tuyere and Deadman zones, while the other zones consisted of the mixture of the two cokes. The coke gasification studies in the Research laboratory showed that the thicker cell-walled Sanjia is indeed a reactive coke; however, at the tuyere level, the thickness of cell wall is still higher than the domestic coke. Tom Coyle and Bill Ference did the gasification experiments, while William Ostenberg did petrographic analysis.]

The last one, this is very interesting, induction heating of coal. [Dr. Harry Marsh published that the nucleation of nematic liquid crystals coalesces and grow resulting in increased anisotropic carbon form and is accelerated with fast heating rate. This led us to think applying induction heating on coal samples. We were able to show improvement in carbon form and in hot strength properties. This process could be used in developing a continuous cokemaking process. The research work was published in the journal FUEL. The petrographic work was done by Charlie Harrison, and the project was sanctioned by I.G. Saucedo and B. Dasgupta. In summary, those were my milestones in the By-Product cokemaking phase of my career.]

PART 2

00:16 HEAT RECOVERY COKEMAKING MILESTONES

Amanda Blyth:

How about the heat recovery cokemaking milestones that you were able to achieve? Let's talk about those.

Hardarshan Valia:

[Adopting environmental-friendly heat-recovery cokemaking technology at Indiana Harbor Works is the milestone that I am very proud of. In the early 1980s, Dr. DuBroff delegated Denis Kaegi from R&D to investigate new cokemaking technology. He and his team carried out research work at the only

non-recovery coke plant in Vansant, Virginia. It was not a heat recovery coke plant. The intent was to replace the aging slot oven coke plants with a heat recovery, environmentally compliant technology. Inland had announced that they would adopt the technology in the early 1990s, but the steel industry went through a severe downturn, and the project was terminated. In the mid/late 90s, the project was restarted under the leadership of Dr. Gregory Ludkovsky. I, along with a team of others from plant and purchasing, went to different parts of the world and evaluated new technologies and decided that for us, the heat recovery cokemaking would be most suitable. In order to test that such technology would produce high-quality coke for use at our large blast furnace, we did a series of tests at Vansant, VA. The technicians who helped me at Vansant were Rich Kruse, William Ference, Tom Coyle, William 'Chip' Ostenberg, and personnel from the Vansant Coke Plant. The test results proved that we could produce coke quality with superior hot and cold strength that would work well at Inland's No. 7 B.F. Now, a side note about why and how the non-recovery coke plant came into existence on the coal property of a company called Jewell Smokeless Coal Company, Vansant, VA.] So, the project basically was terminated.

It's a very interesting story. When there was the oil crisis, all these oil companies started buying coal. So, they bought this coal company, and they didn't know what they had to do with this coke plant that is sitting next to it. [The coke plant was built on the Jewell Smokeless coals because the owner had gone on a mine tour visit to Australia and saw there a coke plant built over a coal mine utilizing the coal from the mine. He realized that instead of shipping coal to steel companies, why not sell value-added product coke to steel companies? This is how Sun Oil came to possess the non-recovery coke plant and formed the Sun Coke Company. Since we had shut down our coke batteries, Sun Coke offered to build the heat recovery facility right next to our No. 7 B.F. Since the coke produced was superior in quality to the by-product coke that it was going to replace, many plant and R&D personnel were involved for a successful transition. They were Madhu Ranade, Pinakin Chaubal, Ismael Saucedo from Research, Eric Knorr, Wendall Carter, Mark Dutler, Joe Moore from No. 7 B.F. and Allen Ellis, Ken Schuett, and Joan Etter from Sun Coke. In a joint paper with Sun Coke, we pronounced the startup in 1998 as 'An Historic Event for the Steel Industry' that was published at the 1999 Ironmaking Conference. Our team from Ispat Inland B.F. and R&D presented successful transition results to new coke at the Paris Cokemaking Conference. The reason why it became a coke plant of choice is that the oven operates under negative pressure, unlike the by-product cokemaking, where oven operates under positive pressure. Here, gases are combusted inside with the air that is sucked into the oven in controlled fashion. The combusted gases move through a tunnel and are drawn into waste heat boilers, producing steam that is delivered to a steam turbine to generate electricity. Hence, no tar or other chemicals are produced except sulfur, that is removed at the scrubber with a lime spray.]

After that, all the steel companies, U.S. Steel, AK Steel, they all had that plant. And worldwide also, India started a plant, Brazil started a plant. Interestingly, when I went to China, [we noticed a stand-alone heat recovery coke plant but not in a steel complex that was similar in design to the Non-Recovery Jewell Smokeless coke batteries.]

The next milestone is the non-recovery coke quality work at the Shanxi Coke plant in China. [We had identified coke from this plant to possess the highest CSR and highest coke stability and availability at low delivered cost to our facility. This was done after visiting many coke plants in China and analyzing cokes and the respective coals that went into coke production at those facilities. High-quality coke and superior-quality Chinese coals from Shanxi Province made us look into a joint-venture possibility of a coke plant in China. Our team was comprised of myself, William Ambry, Eric Knor, Madhu Ranade, Tom Tsai, and Mike Tarkoff. However, the project did not reach success. But, we decided to buy super-

strength coke from Shanxi Sanjia Coke Plant, Jixiu, in Shanxi Province of China. Although the coke was of superior quality, when used at our B.F.s, its usage resulted in unstable blast furnace operation. Hence, Madhu Ranade and Pinakin Chaubal from Ironmaking asked cokemaking to initiate a project to modify coke properties at the Shanji Sanjia coke plant. William Ambry from the plant and myself from R&D, along with Song Weijie and Yang Jiying of Shanxi Sanjia, worked together and modified the process so that the apparent specific gravity and porosity of coke were closer to the domestic slot oven coke. Modified coke was subjected to a successful blast furnace trial at IHW. We received a U.S. patent on modifying the non-recovery beehive coke.]

[On a side note, I want to tell a humorous story that happened in Shanghai. Because we had worked so hard in one plant and had only seen Shanghai in the car going back and forth to the plant, I requested the hotel manager to get me a taxi early morning, 6 O'clock, and the taxi driver can take me on a two-hour sight-seeing tour of Shanghai downtown and bring me back to the hotel before our departure time of 9 am. The problem was that the taxi driver came on time but spoke no English. He is showing me more and more places, but I am begging him to take me back to the hotel. At the last stop, while we were walking in Pudong, it started raining, and the taxi driver disappeared. I was getting nervous, but there he showed up with an umbrella so I wouldn't get wet.] I'm sorry I'm digressing here and there, you know. So, that's a joint venture in cokemaking with China and in search of people's experiences.

01:55 HONORS & AWARDS

Amanda Blyth:

It sounds like you were able to achieve a lot in your career and were there for pioneering moments in the industry. So, what kind of awards have you been given throughout your career?

Hardarshan Valia:

The first award immediately, this one meant a lot to us in that when we developed a CSR prediction model and applied it to the plant and the plant could see the benefit. So, we got the AISI medal. And, this is very interesting, you know, the medal was given at the Waldorf Astoria Hotel during American Iron & Steel Institute's Annual Meeting. At the time, our management, full team, president, vice-president, you know, research director, we all went there with our families, full expenses borne by the company. Can you imagine that, to imagine that now?

Amanda Blyth:

No.

Hardarshan Valia:

We received the award for [the paper on Production and Use of High CSR Coke at Inland Steel Company, among stiff competition from steelmaking, casting, and other finished product areas.] Then, the next award, I was very humbled to my core. I think probably, maybe, I was the youngest person to receive the Iron and Steel Society's Joseph Becker Award, which is given for new technological developments in coal carbonization and coal technology. The next award is the AISTech Joseph Kapitan Cokemaking Award for the best paper entitled "Coal Cost Reduction Using Low-rank Coals."

We developed a procedure to use such coals without affecting quality and productivity. The other award is receiving a U.S. Patent in a collaborative work with Purdue University faculty R. Kramer, L. Pelter, H. Abramowitz, along with A. Ellis entitled Multipurpose Coke Plant for Synthetic Fuel Production. Then the last thing was an Eminent Visitor Program that was sponsored by the Council of Scientific and Industrial Research Organization from Australia. I was invited to visit various inner cities, coke plants, steel plants, coal mines, and labs. It was all arranged by Dr. Richard Sakurov from CSIRO in Australia.

04:04 LITERARY ACCOMPLISHMENTS - BOOKS, TECHNICAL PAPERS, LECTURES

Amanda Blyth:

Next, let's talk about books or any contributions to books that you've made throughout your career.

Hardarshan Valia:

AISI asked me to write a chapter at their website, www.steel.org. On the right-hand side, there's a chapter there called Learning Center, how to make steel, and, in that, how to make coke. So, that's one. Then, the second one, I wrote a book called "Indiana Coals and the Steel Industry" with Dr. Maria Mastalerz. This was published by the Indiana University and Indiana Geological Survey.
And then, I have contributed to some chapters in about nine books and course manuals. The three that I would like to talk about; the first one is "The Making, Shaping, and Treating of Steel" from AISTech. And then the second one is called "The Keystone Coal Manual." It has the names of every coal mine in America, their owners, their qualities, and then every state with coal deposits. It's a huge thing.
The last one is a book that came out in 2019. It's called "New Coal Conversion Technologies." [I contributed] a complete review of heat recovery, non-recovery in that. Besides those, I have contributed in books such as: Coke Reactivity and Its Effect on Blast Furnace Operation, 1990, Ed. Ralph Gray, Iron & Steel Society Publication; and, coauthored Carbonization Chapter in Coal Conversion Process, Kirk-Othmer Encyclopedia of Chemical Technology, John Wiley & Sons.

Besides that, there are manuals of courses that are taught in the USA, Canada, Brazil, Argentina, and India. And these manuals have chapters; so, for example, every alternate year from the mid-90s, I go to McMaster University and teach a one-hour lecture. Then, two-hour lectures I had from the Iron & Steel Society; they used to have continuing education in 1996 and 1997, two times. So, I have two-hour lectures in that. And then, one-hour to one-day lectures in various places, you know. But really, this one is important: Dr. Ronaldo Sampaio, he is such a fantastic teacher, and he loves to spread knowledge, and so many students of his are everywhere, you know? So, he arranged for a trip for me to come to Brazil and give a three-day lecture. So, I gave it on heat recovery. Everything you want to know about heat recovery, but you were afraid to ask.

06:45 AIME-BENEFITING FROM MEMBERSHIP & GIVING BACK

Amanda Blyth:

Let's switch gears and talk about AIME. I'd like to hear your thoughts on your involvement over the years, what you've gained from being involved, and why it would benefit new graduates to join.

Hardarshan Valia:

[After I joined Inland Steel, Dr. DuBroff asked me to join the Iron and Steel Society.] So, I joined that about 42 years ago. The biggest thing that happened there was networking with coke makers, steel makers, and they were amazing people. They shared their wisdom, and they shared with technological development that was happening in their plants and other plants. And, all this because we were new. Young guys. And then, they offered -- this is the most important thing — they offered problem-solving procedures that they adopted when they failed with a problem because we also would face this kind of problem. There were exchange of ideas freely. They genuinely were interested in the personal welfare of every member [and also worked tirelessly to support AIME, Iron & Steel Society, and AIST.]

And so, how am I giving back? I have regularly participated in the ironmaking and cokemaking program committees from the mid-90s all the way up to, like tomorrow, I am going for the committee meeting. Then, I regularly co-chaired sessions from the mid-90s all the way to 2016. Now, I'm not chairing because I want young people to. And then, I'm teaching short courses.

I have a request to the executives of the steel industry: I humbly request that they should [include in the orientation of new employees an introduction about AIST, and the benefits of joining AIST and benefits of attending AIST Conferences.]

Now, advice: I really want them to fall passionately in love with the pursuit of knowledge. The reason is very simple: that when you're passionate, it brings peace within. And, when you have peace within, it helps you to navigate through the storm that's always rolling around outside. And you're able to sleep peacefully. When you get up, it shows on your face. And then, it affects people around you, and you know what happens? Ultimately all good things follow your pathway. And, be humane, because what good it is to achieve all the success in the world and, in the process, you have lost the peace within?

Amanda Blyth:

That's very poetic.

10:10 REDUCING THE STEEL INDUSTRY'S CARBON FOOTPRINT-SHORT-TERM & LONG-TERM EFFORTS

Amanda Blyth:

You know, you're an expert in the use of coal to make steel. We've learned that in our discussion here today. You're an expert. So, I'd like you to share your thoughts on what's happening in the industry right now in terms of the industry's efforts to shift away from coal to reduce its carbon footprint.

Hardarshan Valia:

I would define the efforts in two parts: one is the short-term efforts, and one is the long-term efforts. Short-term efforts, a lot of focus is going on in all the blast furnace areas because that's where the biggest carbon footprint is there, okay? Everything is geared towards increasing efficiency, you know? So, increasing the hot blast temperature, reducing the charged moisture, you know? Actually, in the areas we live here with all this snow and rain. And then oxygen enrichment and reduction in heat losses. In many places, there's too much heat lost also, especially through improved factories. And

there are many other process variables that we're working on and projects in many areas pertinent to local plant conditions.

Then, the next big thing is also going on is the use of HBI, Hot Briquetted Iron, in the blast furnace, [which reduces the need for coke]. And then increasing the use of natural gas for PCI [thereby substituting hydrogen for carbon as a reducing agent].

Now, another thing interesting going on is the use of CO2-neutral biomass or biochar and charcoal; charcoal use in mini blast furnaces of Brazil; biochar can be used as injected fuel to replace PCI].
And then, in steel making, increasing the use of scrap so that the amount of hot metal coming from the blast furnace can be reduced.

And in the long-term efforts, there are two big efforts going on in different parts of the world. In the European Union is ultra-low CO2 steel making. There are 48 companies that are joined there together in that.

On the other hand, in Japan, there's a Japan Iron and Steel Federation project, it's called Course 50. So, 2050. And there are different approaches being investigated in the European Project. So, let me go through a few of them. So, the first one is a very important one: the hydrogen injection into the blast furnace. So, no coke, no coal. And, not even that, no gas. But, the problem is that it will require huge amounts of CO2-free hydrogen and CO2-free electricity.

The second thing that is [being pursued by European steel companies is converting CO in the blast furnace gas into CO2 and hydrogen via a water-gas shift reaction]. Now you will have two streams. One is the hydrogen stream coming, and another is the CO2 stream coming. Hydrogen stream, injected into blast furnace directly, and CO2 stream, we will have to think about storage or making chemicals from that.
Now, there's also an effort going on, especially by Tata and Corus in the Netherlands, and that is coal-based smelt reduction. So, basically, the idea is to take fine ore and take ground coal. Ground coal is of low-rank type because they are abundantly available, low cost, and chemically more reactive. You can remove the ground coal with the biochar, CO2 neutral.

Then, there's a gradual move towards replacement of [BF/BOF steelmaking route with hydrogen DRI/EAF steelmaking route]. You need to have high quality and large amounts of scrap and all that. The last one is how to capture CO2, so carbon capture, utilization, and storage. [One interesting example of this in operation is at Reykjavik Energy's power plant in Iceland. It takes CO2 from its power plant and feeds into basalt rocks underground where, with the passage of time, CO2 reacts with the calcium component in the minerals and forms Calcite (limestone)].

And, now let's talk about the Japanese Course 50. There are four steel companies that have joined that: Nippon Steel, Kobe Steel, [JEE Steel, and Nippon Engineering. The idea is to use SCOPE 21 coke plants, that are highly efficient, low-emission plants. However, the blast furnace will be using a hydrogen injectant. They are currently working on injecting hydrogen in an experimental blast furnace and, at the same time, developing high strength-high reactivity coke to hydrogen. This is to be followed up with capture-separate-recover CO2 and also store CO2 underground].

18:20 SHARING A PASSION FOR GEOLOGY, SCIENCE, & STEEL WITH THE WORLD

Amanda Blyth:

Steel plays a vital role in our everyday life, but I think people don't often realize that. They don't realize how ubiquitous steel is. So, how are you spreading this message to the citizens of the world?

Hardarshan Valia:

It's all related to coal-to-coke transformation under the microscope. I just go crazy looking [where one can see colorful carbon forms. To an untrained eye, coal and coke are dirty-looking materials, but optical microscopic studies reveal how the organic entities in coal melt to nematic liquid crystals that coalesce into colorful carbon forms, giving rise to coke that to the naked eye looks dark gray]. So, it's that intoxicating interaction with science that I want to tell everybody in the world. [I did not run shouting 'Eureka!" because the coal-to-coke carbonization phenomenon had been observed for years. I started to go to nearby schools to help children see the beauty of earth materials. I remind them, 'Be Grateful for these gifts from Mother Earth.' I accomplish my message by writing and through show-and-tell venues.]
In show and tell, when I do that, I carry a large piece of rock made of iron ore. I have a nice one with a magnet, so when the kids see that magnet attaching there, they're "Ahhh!" And then, coal, coke, iron pellets in a jar, and then a pig iron sample, and a tiny model car, a spoon, and a scissor. So, I go through the whole system: how this scissor that stitches your wounds, the spoon that brings food into your mouth, you know? This car that you have gone in everywhere, to school and to vacations with your parents.

So, all that came from this black material. Then, I go through the whole nice phase storytelling. And then, after that, I show them — I have a beautiful collection of rocks and minerals, unbelievable. I have a very large quartz crystal, just one crystal by itself. So, I give it to kids; they love holding it. I have many crystals of different minerals. Then I go through these and say, look, this is a beautiful crystal of fluorite to whiten their teeth [to prevent tooth decay. Then, I show a sulfur sample for use in antibiotics. In this way, I make them realize how minerals are taken from the earth and made into products for daily use. Hence, they appreciate the industries that produce these valuable materials.] After that, to keep their interest also and to tell them about the bigger picture, I tell them the evolution of life and the history of the geologic timescale.

And I have a wonderful collection of fossils. I have a fossil close to one billion years old, [and it's an impression of a colony of bacteria from Bitter Springs Formation of Australia. They are amazed to see it. In Minnesota, one finds similar ones of about 2 billion years old. Further North in Canada, in Gun Flint Chert of Ontario, one finds organic impressions of cytobacteria (blue-green algae) of about two billion years old. They are amazed to hear that these organisms thrived in CO_2 and noxious gas environments where iron could deposit, forming large iron ore ranges. They inhaled CO_2 from the air and exhaled oxygen, and gradually, with enough oxygen, allowed higher life to evolve. They listen with wide eyes to the miracles of earth. How life evolved.] So, we understand that two places, Bitter Springs in Australia and Gunflint Chert in Ontario, have the first organic impressions of cytobacteria. As if you are watching a play, in the middle, the curtain rolls, and you see life. But you have no idea what happened before, and that is what Geology and making iron from minerals, and the coal, 300 million years old, from Pennsylvania. Can you see how they combine and bring miracles like life? I tell these stories wherever I get a chance, whether it's a school, a park, a gallery, or retirement community, a building, or a sidewalk.

Besides show and tell, I have some literary work where I try to relate to Earth's resources, also. So, for example, on my first day of [work at Inland Steel, I, the novice car driver, drove over Ridge Road and marveled at the historical geology of the road, noticing that I was driving over the ancient shoreline of Lake Michigan while the glaciers were retreating in the last ice age. My story about my journey to Inland Steel was published in a book entitled 'Undeniable Indiana' published by Indiana University in celebration of the Indiana Bicentennial. Similarly, the Indiana Writer's Consortium asked me to write a blog for instilling a love of science in younger minds. I had done similar writing work in Hindi during my college days in India. One was a children's fiction book about Journey to Earth's Interior and also quite a few articles about Earth Resources for local city newspapers.]

Now, one of the things that my giving back to society is that Indiana had a bicentennial celebration in 2016. So, in commemoration, I wrote a poem, it's called "Volcanoes of Northwest Indiana." It's, basically, our blast furnaces. This was published and shared by the Indiana Bicentennial Commission in their newsletter. Also, thanks to Amanda, it was published in the Iron & Steel Technology in the January issue of 2015. It basically highlights the contributions of Indiana's steel industry in uplifting people's lives. And, steel here—it's produced by somebody with loving hands, and a person is behind every spoonful you eat. So, Mother Earth gives us the resources for the betterment of humankind. So, extract and process it wisely, in environmentally friendly ways. So, the poem is there. I'm not going to read it, but it's there, and one can find it. Now, besides celebrating Indiana's bicentennial, I was privileged to be part of the Inland Steel's Centennial celebration in 1990.

26:04 REFLECTIONS ON A CAREER IN THE STEEL INDUSTRY

Hardarshan Valia:

[I consider myself lucky to have undertaken a journey into the steel industry's magical world. It has bestowed me with a richness of life that is hard to describe in words. Let me talk about this in the context of Inland Steel's Centennial Celebration of 1990. To commemorate it,] Inland Steel produced a book in 1990, and in that book, it describes the evolution of steel. On the cover page, they have three pictures: one is the workforce during the early phase, middle workforce during the middle phase, and then the workforce in 1990. And I was one of the five people in that picture. Why me, a turbaned Sikh? Because we all five workers in the photo reflected the Inland's philosophy of what America is made of: richness of diversity, richness of family, all strengthening the delicate fabric of togetherness. The interesting thing is that the book ends with the same photo of us five workers completing a circle of joyous celebration of life in the steel industry.

Now, at the end, what is my oral history in the bigger picture of life? That is described in a poem; it's called "I Remember." I'm going to read this poem; it's a short poem.

"I remember sight of first monsoon planting a kiss on mud-cracked cheeks that instantaneously evaporated into sweet, misty vapors, spreading the scent, igniting the heart, diffusing into every cell of my body. Since the last three billion years, I am here. I am everywhere. Carrying the scent and heart of fire.

Thank you. Thanks to AIME, AIST for including me in the oral history project, and my gratefulness to Michele and the staff from AIME and Chris McKelvey and staff from AIST. And a bouquet of thanks to Amanda Blyth for conducting the interview. Thank you.

Amanda Blyth:

Well, thank you so much for that! It has been an absolute pleasure talking with you today, learning about your life, your love of the industry, and your love of poetry. And while, as I mentioned earlier, you are a coal expert, you are a poet at heart; we can see that clearly. So, thank you for sharing that poem. It was beautiful.

Hardarshan Valia:

Thank you, Amanda. Thank you, Michele.