ORAL HISTORY PROGRAM

Ronaldo Santos Sampaio: An Inexhaustible Influence on the Future of Engineering

2024

PREFACE

The following oral history is the result of recorded interviews with Ronaldo Santos Sampaio conducted by Thiago Oliveira on May 16th, 2022. This interview is part of the AIME Oral History Program.

ABSTRACT

Growing up in a poor family in Brazil, Ronaldo Santos Sampaio was no stranger to hard work. His youth was spent getting an education and assisting his father at the family grocery store in his free time. In college, his eagerness to succeed earned him the number one spot in his class and the opportunity to teach. As a professor, Santos Sampaio finished his master's Mathematical Model of the Reduction of Hematite by Hydrogen in an Isothermal Fixed Bed, published books on essential industry topics, and won eleven awards for his work with Ferrous Alloys and Iron and steelmaking subjects. He then went to the United States and earned his PhD at Carnegie Mellon. Over the course of his decades-long career as an engineer and consultant, Santos Sampaio made countless advancements to the steel industry in Brazil. His work with blast furnace reactors, ore-selling systems, zero-emissions mills, and the pelletizing process changed the industry forever. However, what he is most proud of is the work he has done with his students and interns. Under his guidance, Santos Sampaio's protégés have become good engineers and managers with major companies across the globe. Learn more about his outstanding career and his predictions for the future of engineering in his oral history.

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PART 1

00:13 INTRODUCTION

Oliveira:

Hi everyone, my name is Thiago Oliveira. I am here with Dr. Ronaldo Santos Sampaio for the AIME Oral History Program, where we are going to know more about his life and his career. I am a graduate student at Carnegie Mellon University, a former technical manager of the steel plant at Vallourec, Brazil, and most important, today, I'm a former student of Ronaldo.

So, Ronaldo, thank you very much for inviting me to be part of your oral history. I would like to start by asking you about your early age and about your interest in engineering. Could you tell us about where you grew up, about your family, and in particular your parents and what did they do for a living?

01:03 GROWING UP AS A GROCER'S SON IN BRAZIL

Sampaio:

Well, first, I'm very honored to have you as my interviewer because among many students, some of them, we get really close together. I came from a [low middle class] family in the interior of Brazil [Uberlandia], and you are going to see in one of my pictures that I was able to find, my mother and father [Graciema & Luiz Sampaio]. One of my pictures, like one years old, and the most special thing I have today, which is my daughter, Luiza, with her two years old, and today she is 19 years old and doing law school.

I had to work after eight years old of age in the pharmacy with my father. Taking lunch for him, bringing the empty lunch—empty dish back home. After that, he changed the business to a small grocery, and that place was tough for me because I was around 11 years old. I had my whole teenager's period, 11 to 16 years, working at the grocery. I had to work all Saturdays and Sundays until noon. I used to work go to school, and it was a public school far from where I was [living], and I used a bicycle at that time. To go was easy because most was downhill and then uphill in the return. [I spent a lot of energy.] One of the dreams I have up to date is to have an electric bike. I didn't buy it yet, but for sure I will have it. Then my family, my mother arranged for me to go to Belo Horizonte city, it is a big city, the capital of my state, for me to start to work in a company as designer like I used to like, and I studied in a kind of pre-college classes three years.

03:13 FROM FAILING GRADES TO A GOLD MEDAL – FIRST YEARS IN A PRE-COLLEGE

Sampaio:

I was placed in a fraternity house, which had very hard-working students. They were very good persons; they were professors of the pre-college students, even though they were college students. They were really good. Now, when I started [living] there, I was not studying like they did; the first grades in the exams I got was bad like it used to be. [The fraternity seniors] said, okay, we never saw you study, man. Come here; we are going to help you. You must spend a lot of time. Sit here, do all those exercises, and try to solve it as much as you can, as long as you can. If you really can't do it, call us for help. So, [after a few days], I changed from the weakest and became the first [in the class grades] since then. [In the

college admissions exams, I was the second for the engineering school, and] I graduated a metallurgical engineer — you can change now — as the number one in my [class] team. As a gold medal, and that was very good for me to show my father and mother that the bad student they had before became the best one. But man, days and nights, Saturdays, Sundays, and holidays, always working, and that kept up [all my life] until a few years ago. Then I can go [slower now].

Oliveira:

So, thanks, Ronaldo, for sharing those deep memories. Getting to your professional life, how was your first position after graduating, and what were the main areas you got to be involved with?

Sampaio:

Man, this is another thing that happens in our life. I was the number one in my class, only A's and things like that, a metallurgical engineer, but my dream was to be a floor worker; an engineer on the plant floor. But I couldn't get it because all the companies I went to, "No, you have to go to research. You have too good grades; you are not going to work on the floor." So, I went to three mills; they always offered me places in the research and said, "You are going to do master's, you are going to do PhD, and so on and so on." So then, at that same moment, the university where I had graduated opened a tenure for professor in my own department. So, I and ten others applied for it, and I got also the first place and that challenge, and I start to be a professor [“Professor Colaborador.”]

05:56 BECOMING A PROFESSOR - COMPLETING MY MASTER’S THESYS “MATHEMATICAL MODEL OF THE REDUCTION OF HEMATITE BY HYDROGEN IN AN ISOTHERMAL FIXED BED (1981-UFMG)”

Sampaio:

I got the full professorship title a few years later. I started as a professor [colaborador]. I was happy because that was the [best] metallurgical department [in Brazil and] that brought recently [highly qualified] PhDs professors from [USA Schools like] Colorado School of Mines, Pennsylvania State University, the State College from PA, Utah University, British Colombia, [UBC, among others from France and Germany]. So those guys [professors] were really trying to move the Brazilian mining and processing [ores industry to produce] goods such as steel [and ferrous alloys]. And they were good, and I became part of that [team]. So, they put us to write books for all kinds of needs to bring to the industry in those areas. For example, the ferrous alloys industry, the ones that produce silicon metal, that is a material today that you use to produce solar panels; also, you refine it more to make it silicon chips and so on. And all the other ferrous alloys: ferro-silicon, ferro-nickel, [ferro-manganese], and ferro-chromium.

By the way, in the first four years, we published [teaching books] related to this [ferrous alloys area]. We won four awards from the Brazilian Metallurgical Society, ABM Award that's called “Prêmio Morro do Niquel” [the Brazilian company] that produces nickel at that time. Also, during those times, we had to study a lot [to prepare lectures] in training, teaching, steel refining, thermodynamics, and physical chemistry. I had to prepare and give lectures in all those subjects. This forced me to learn from the professors some abilities that became easier for the students to understand, and the same happens to the people in the industry. When they went to see what we wrote, we made it very nice in the sense of we write a lot of [schematic drawings], figures, [flowcharts] that make it easier to understand physical chemistry, thermodynamics, and a huge amount [practical] exercises. For example, Direct Reduction of

Iron Ore Practical Exercises, I have a full book only of exercises for the people to learn it. And in that same period, I did a master's at my university in "*Mathematical Model of the Reduction of Hematite by Hydrogen in an Isothermal Fixed Bed*".

08:38 SUSTAINABLE FORESTS AND CHARCOAL PRODUCTION – "THE BEST THING THAT HAPPENS IN THE FARMLAND AREA OF MY STATE"

Sampaio:

So, in 1981, I defended my M.Sc. [thesis]. Today it's [subject] is a "fashion thing." Hydrogen use to reduce CO2 emissions [in Ironmaking]. The things from my past became very fashionable today. You are going to see many things that are going on now [that were the subjects of our University R&D of that time. Technical publications and research we participate before.] And parallel to this in the center in Brazil, we had the independent pig iron producers. We call here merchant pig iron. They had a bad image because they are supposed to use native forest to produce charcoal, and that is environmentally harmful and things like that. Some could use child labor to produce charcoal and things like that. I don't like this, but nobody likes it, [and it was all unlawful in Brazil].

[My team of professors and some students started] to give support to this sector, transferring knowledge and fundamentals and showing to them that by planting forests in a very biodiverse way, they could get much more money than they were doing. And we succeeded [partially on] that. I can see something in the presentations that you are going to see how the progress happens that today, zero native forests, all sustainable forests with biodiversity inside, is the best in farmland areas in Brazil for those sectors. So, it is a good thing that happens in the farmland area of my state, for example. [Where small and medium farmers start to produce, together with their traditional farmer activities, another one that was Eucalyptus plantations in small areas of their farmers, adding extra revenues to their business as well as biodiversity.]

10:18 LEARNING FROM APPLICATION – LESSONS FROM " GURUS" OF INDUSTRY

Santos Sampaio:

I [must] remember a lot of professors in those teams that really were my "gurus" in a lot of things. For example, the father of thermodynamics [and metallurgical] physical chemistry is in Brazil. Professor Alvaro Lucio. He's still alive. He's going to be 99 years old this year. I replaced him when he retired in early 80s. He's still producing and very active, but in mineralogy area, and he's a close friend of mine. We have meetings with certain frequency. And, [another professor] that died four years ago, Professor Rubens Corrêa da Silveira. [He was very practical in industry matters and strong in fundamentals.] He was what I wished to become at that time; strong industry expertise and presence, [excellent lecturer, and also good in putting practice and fundamentals in only "one dish"]. Both things together, he was also a very funny person.

And I used to drink at that time, and we drank a lot together; we got drunk, but he was the major responsible for those [good lecture and practical] books we wrote together [to the industry]. And I learned with him that industry is necessary for you to really apply the knowledge you have, and if you don't do that, being only a professor, you are lost. So then, since the beginning, I start to use my students to go with me to the industry. Every challenge the industry gave to me, I had my students together, so they didn't know what was going on, but they were always able, to listen the professor´s

[industry advices and see what was going on at the industry plant floor, and they could understand]: "No, this is because this, this is because that."

Some of those students were sons of the owners of the small metallurgical plants, like pig iron producers and so on. And they were helpful for me because I needed them to invest money to get more information for the process. For example, pressure meters to know the blast [rate] inside the blast furnace; how much you are pumping [air] inside the reactor. Chemical analysis, sampling apparatus, screening [devices], and they believe in me, and they invested because I said. [They asked]: "Daddy, we need money for this. Dad, we need money for that." And we were able to bring a lot of sensors, measurement apparatus, techniques, especially screen equipment's, simple things [with strong practical results in the Blast Furnace reactors]. But then the mini blast furnace productivity [increased], and fuel consumption went down fast.

13:26 THE HIDDEN BEAUTY BEHIND THE BLAST FURNACE REACTOR

[Our consulting services] started to spread through all the [ironmaking] sectors. All of a sudden, the government noticed that, and they established a program with this professor, and we, I, as part of it, to give a [technical audit] service to [the independent ironmaking sector]. More than 100 small blast furnaces at that time—and we took some years to do that. We went in each one of the plants to see how good they were, how bad really they were, and which actions we should do to help them to come back fast to a state-of-the-art knowledge for the blast furnace reactor. This really worked. And, during that period or after some years later, I'm getting confused, but I start to publish about that [sector] and showing the beauty behind the [biomass-based ironmaking that helps to modify the negative saying] they used to say about that sector.

And the beauty is really the beauty because when I realized, man, those people are utilizing photosynthesis, grabbing CO2 from the thermosphere, transform it into energy, energetic material, which is a carbohydrate, which is the [product of photosynthesis]. By doing so, they're feeding back to the atmosphere oxygen, and they had to [use] more labor to do that; [take care of plantations] that are living creatures (trees). And a living creature, it's not a machine like this glass. It needs permanent presence of another human taking care of it. So, this fact makes me very excited. I say, okay, if I manage every day to improve this sector in such a way that we can produce enough biomass [to attend the wood sector for charcoal, but simultaneously, we will] need a lot of things to be brought to the farm to make the farm more fertile, [and more economically richer, and biodiversity is a tool for it]. And when I say, what happens? My wood, I need to put nutrients in the earth to make it, [besides water and care and part of those nutrients will come from the industry wastes].

The nutrients that went with the wood and the wood were transformed to charcoal, but the nutrients stay there [in the charcoal]. And when I went to the blast furnace, I put the charcoal inside it, and I put more lime (limestone into blast furnace) [making the blast furnace slag a source of nutrients to the farmers]. The farmland areas in Brazil are poor in lime to correct soil acidity, and we need to put basic oxides on it, the slag that contains lime and other nutrients. Besides the micronutrients that already was in the trees, that we recycled them back to the farmland sector. So, we were, at that time, applying the circular economy concept not only for the solid and leaked wastes materials from the iron mills but as well as for the industry off-gas. [The photosynthesis-based processes] are the only ones that pumps oxygen into the thermosphere, [diluting the CO2 on it and fixating a lot of CO2 as biocarbon in the soil and in the tree parts].

16:31 RECRUITING AND COLLABORATING – GETTING THINGS DONE AS A TEAM

Santos Sampaio:

I am a team person, so anything that I did, I was never alone, and I will never be. For example, my master's degree thesis was the first one of an Indian [professor], PhD from Max Planck Institute, that came to be a professor in my department, my adviser, Professor Dr. Varadarajan Seshadri. It's with him that I did hydrogen use in ironmaking to my master thesis.

Two of my [best] students that graduated one year and a half after my graduation also became professors like me, and they were really good [and became my best partners]. They're still alive [and retired from university]. And so, I said, "Why be alone?" I have a lot of [demand] of services from the industry, I need to share them with those [young professors] because, later on, they'll be as me. They'll have a lot of services, and I'll be part of their team, also. A lot of them have different skills than me; they are more powerful to learn than myself. And I said, "It's better to be with them than be alone or with people that I don't know."

So, I start to share with them my revenues from the consulting services, bringing them to do together with me. Sooner, they speed up even more than me. But all those big things I said we did, they were together. They are Professor Luiz Fernando Andrade de Castro and Professor Roberto Parreiras Tavares. In Brazil, in my department, Professor Vicente Falcone was one of the leaders, a smart person, and a strategic thinking mogul. [Him, together with other professors of my school] brought to Brazil [the Japanese Total Quality fundamentals—and they developed excellent notes and lectures to introduce them in Brazil] the total quality program. this happened in the 70s. Americans only paid attention on that in late 80s.

But he brought this to Brazil. Not he necessarily [only him], but almost all my department professors participated—pioneering in Brazil in the total quality program. I had to learn classes from the people that were being trained in Japan. They came to teach us, and we had to apply those methodologies based in total quality fundamentals [and methodologies]. That keeps in my brain; it's part of my way of being. So, we became experts in avoiding wastes of any kind: not waste time, not waste materials, not waste energy everything stays in my brain permanently since then.

Professor Falcone used to prepare lectures [utilizing well-done designs in such a way that complex things became easier to understand in those the pictures]. He was very smart to only show things that he really mastered. He did not have to go like I did, teaching things that I have a hard time to understand. But according to university demands, you must go over those materials. He was smart. He said the only things that he can shine, he does. And today, in my era, the only professor I know that became a billionaire in dollars terms. But it's still a person that I always remember when I must prepare [lectures about any subject].

19:56 BEGINNING MY PHD PROGRAM IN THE UNITED STATES – "ONE OF THE WORST PERIODS OF MY WHOLE LIFE"

Oliveira:

Okay, Ronaldo, so we see that you had a very fruitful period between your undergraduate to after your master's in your career as a professional. And 1983, you went to the United States to start what would

become the first phase of your PhD studies. How was that period?

Santos Sampaio:

Oh, man. One of the worst periods of my whole life because, first, I did not [wish] to be a PhD. As I said before, I was always planning to go to the industry floor to be engineer, have that kind of life. The master's degree, it's not for me, but being a university professor is an obligation. I had to. So anyway, I was always managing to not [go overseas]. For you understand, when I came here to do a short course of the Iron Steel Society, at that time, the lecturer was Professor Richard Fruehan, and I was a professor of those same subjects in Brazil. [During the short course,] I discussed very nicely with him, and he likes the way I talked with him, the way we discussed, and said, "Why don't you come to do a PhD United States with me?" I said to him, "I will never pass an English examination “TOEFL."

"You know why? I am the foreign student advisor, and you can come; I'll make that." I said, "Okay," because I didn't want to come. So then, I returned to Brazil, and I had to apply for the science foundation in Brazil to come here because they must pay the university and things like that. They said, "You have to have the TOEFL." I said, "Oh good, so I do not need to go." So, then came the letter of Professor Fruehan saying I'm exempt of the TOEFL. Nobody could say that, probably. So then, I said, "Okay." They said, "No, you need to do the TOEFL,” I will not do [because I did not want to go for Ph.D.]

So then, in Brazil at that time, the inflation was huge. For example, my salary as a professor, put in dollars terms, was $1,500 in January, and It was like $500 in December equivalent. So yeah, I had to come [to USA] and survive with that money. Nobody [that were a professor] was looking to be a PhD United States at that time. I tried to avoid it, also. They gave it to me. I said, "No, I will not go because I have a wife, and she needs also another scholarship." They give it to her [also]. Therefore, I had no chance [to avoid my Ph.D. in USA].

But for [my wife], with me here, two years at Carnegie Mellon was a pain in the neck because we hired a basement to live. In the basement of a very old house. (It was demolished and doesn't exist anymore). Above it, there was those retired men that used to drink a lot and always in the night, never during the day. I was trying to sleep, and nervous because I was a professor in Brazil and I became a student here, and I had to get B+ grades because if I don't, I would not go to the qualifying to be a PhD. I was very worried about what my fellow friends in Brazil, my peers, will think if I fail, you know, would be bad for me. It's not like a younger student that comes here.

I didn’t have, at that time, those medicines that you could drink to relax or things like that. So that elder in the floor above mine [gestures with hands]; I could not make him stop. I must survive that way, and at those years, I used to drink. So, when I arrive home on Fridays with some of my Carnegie Mellon colleagues, we joined in my basement and drank a lot. Saturday morning, I was refreshed. Everything was new for me. Everything became my life easier. Then, another thing happened. Professor Fruehan must do what the industries are buying from him in research-related subjects.

24:22 NITROGEN SOLUBILITY IN STEELMAKING SLAGS EXPERIMENTS AT CARNEGIE MELLON – MY FAILURES AND SUCCESSES

Santos Sampaio:

At that time, one of the [R&D] subjects was nitrogen solubility in steelmaker slags. Steelmaker slags are

not carbon-rich, and you cannot have carbon in them. I could not use a graphite crucible to make the experiments, which is very easy to make and very easy to use. I had to devise a technique to produce lime crucible myself. So, I had to learn from others how to do that. [During the learning stage], I destroyed a high-temperature furnace for United States Steel R&D Lab because when I went to try to do my first crucible, I put some lime in the very expensive furnace and put some alumina powder as a substract and put my lime material to be burned to 2000 degrees C, and they melt the furnace.

Another point is when I start to do my experiments, the nitrogen chemistry [analysis from the slag samples] should be done. I had to do them myself. I built all the necessary apparatus using expensive glassware necessary to put the [analytical dangerous acid] reagents to execute the so called Kjeldahl Method. And that method was very complicated and took more than one day to get one sample analysis done. And I had a professor at Carnegie Mellon, visiting professor, that became my friend for life, Professor Fumitaka Tsukihashi. He was like an angel for me. He helped me to assemble the chemistry lab, teach me how to do the chemistry analysis, and that helped me a lot. And that friendship is still up to date.

26:20 SHARING THE BEAUTY OF THE STEELMAKING AND IRONMAKING PROCESSES IN JAPAN

Santos Sampaio:

[By invitation] I gave a few lectures in Japan. I gave it to universities, Sendai University, United Nations University, [and in the First International Ironmaking Seminar of JISF where] important lectures [about CO_2 emissions reduction were going on in 1994]. I was involved in those CO_2 reduction subjects that very few people were, here or there. My hobby of biomass use to produce metals. I was always able to design a steelmaking and ironmaking [scenary to demonstrate] the beauty of this process [photosynthesis-based process]. And I always challenge, in all those congress [audience, hundreds] of people listening, like 1300 people in Tokyo, I said, "I want any of you to give me a process that will be less environmental harmful than this one I'm showing to you." Nobody could do it up to date. That's why I'm still excited because the society needs to pay more attention [in this option to produce steel now].

At that time, some of the students that I most had relationship, I don't have pictures with them because I moved to places at those times [and I lost those photos]. Now [in the mobile phone era], we have a lot, so it's difficult to find them. In the past, I had almost none. But I found in a friend's house the picture of my advisor, Professor Fruehan, the first time I came here, and I could remember the name of some of my colleagues, like Danielle Goldstein, [who] by coincidence is today in California Steel and Header. I don't know where she is. Mariana Moralis, also, I don't know where she is today. Dr. Balu Sarma returned to India. And the second secretary of Professor Fruehan, Madeleine Lesko, I might find her here this week. She's really tough but a lovely person; really was helpful, and I love her since then. Before her, I had Michelle Collon, which also was a wonderful person. We're still friends up to date.

28:47 MY RETURN TO BRAZIL AS THE CEO OF A JV WITH VALE DO RIO DOCE – BIG CHANGES IN ONE OF THE LARGEST MINING COMPANIES IN THE COUNTRY

Oliveira:

Ronaldo. You spent two years [in the] United States, and then you got back to Brazil. What were your professional activities when you came back after this first phase in Carnegie Mellon?

Santos Sampaio:

That was interesting because that thing that I was afraid to miss which is the qualifying exams, I passed it. So, from that moment on, all my life would be less stressful. But I had a problem. Someone in Brazil knew who I am, invite me to be a CEO of a company that is part of the largest mining company in Brazil, which was CVRD, today, Vale. [I imagined] Oh man, what a beautiful thing. Let's grab it. I accept it. But also, I had the second reason to go. You know which one was it? Nitrogen analysis [in steelmaking slags]. I did not want to spend days and nights, days and nights, doing the analysis. I envy a lot of my Japanese friends from the steel industry; they got their experimental samples, put them in a vial, and mailed [to their labs in Japan] to do the analysis for them in their company, and they send the results back to them. I had to do everything myself. I said, "Okay. That's the main reasons I really returned?"

[Also], the subject was not really attractive to me. No way. So anyway, when I went to be a manager of this [CVRD JV], I arrived there and it was a small company. It's like 40 employees, and they have a complete methodological sequence: grind the iron ore [together with barium carbonate in a ball mill, dry the resultant pulp, sinter this pulp in a rotating kiln and then mill the produced] barium ferrite to the [commercial sizes and send to them to the clients to produce speaker magnets, magnetic paints and so on. This company, Ferritas Magneticas, had a director partner representing an Italian company, and the Italian person was really tough one, but we really managed very well. [To be a small company makes me act in all positions inside the company, from] an office boy, a secretary, an accounting, a seller, and a technical assistant, a metallurgical engineer, and I had to do all sorts of [political] things. Because I knew a lot of people in this area of science and knowledge. So, I brought to this industry the first [total quality methodology]; they had to do experiments to qualify the material inside instead of sending to the clients to know the quality. A lot of things like that [changed the company results for better].

I started to manage how to sell better with more profit. I reduced the production costs because I was good in combustions, in sintering process. Therefore, quickly we were able to—oh, by the way, I brought one student as intern student from my [former] department, the metallurgical one. That student stays there [as an engineer] when I left. But in three years, it became the highest profitable company, in terms of the total revenue it had, and in EBITDA terms, for Vale, and they were able to privatize it.

32:11 GAINING INDEPENDENCE AS A PHD STUDENT AND RESEARCHER

Santos Sampaio:

So then, they invite me, "Do you want to come to join us at main company, Vale?" And I had options, very good ones, to the top areas to work as assistant to directors and things like that at the main office in Rio. But I had a very good friend as a superintendent of the Vale R&D department, SUTEC, and he was a very famous inventor also, José Marcio Jardin Paixão. He's still alive and is a friend today. And this, he said, "Ronaldo, come work with me because I arranged a way for you to return [to CMU] by CVRD to finish your PhD." Now, I will not come to Pittsburgh starving; I'll be like a CVRD [officer]. But then, it happens. I went to the research [of CVRD], and soon, he managed for me to come back to finish my PhD, which [becomes] the CMU second round, which was doing my research at the Center for Iron and Steelmaking Research, CISR, also with [Professor Richard] Fruehan. I will never leave Fruehan as adviser. I love him for a lot of things he has done for me, CMU, and his students.

And then, when I arrived [in Pittsburgh], Professor Fruehan went on sabbatical for six months in Australia, and he gave me a subject, another pain in the neck subject: coal devolatilization in

steelmaking slags. So, he said, "Okay. It's part of the continuous steelmaking developments we are doing to try to [succeed in] direct steelmaking," which we call, at that time, bath smelting [experiments].

And then, we need to understand how [fast different] coals we add in the [smelting reactor] are losing their volatile materials, and which speed and which conditions, and that is your subject. [First, I start through the use of thermogravimetry as suggested by the adviser]. The lab had a very expensive Can balance to make the thermographic metric experiments for that to happen. [The adviser] went to Australia and left me alone, and I had to find how to purchase this [sophisticated balance], find needed parts for an apparatus with almost 100 years old, full of gold, and very sensitive [weighting devices. To introduce, fast, the coal samples in the balance], I had to make holes in the floor [above the room] to be able to [fast feed] the sample into a high-temperature furnace and being able to manage that the balance to measure it [on time].

And then, while I was in this effort for six months, I helped [my colleague] Joyce [Niederhaus], one of my PhD colleagues, do her experiments. I had to go to her lab to take samples from the steel, liquid steel, and she used the acquired [fused quartz] vials to suck the material, and then we immersed those vials in the water to cool. And I said, "Those dumb things never breaks. This is resistant to thermal shock. It's humongous." So came my idea in my brains because I was a thermodynamic professor. You know the word "PV equal to nRT? Ideal gas law?" Say, "Okay. This is interesting, but where I'm going to find the pressure measurement device sensible enough?" Say, "Okay. I have another friend, colleague doing PhD in isotope exchange technique, and he had to use a very sensitive pressure transducer. I can borrow it from him, and I can [build] a constant volume system [with those refractory fused quartz tubes] to assembly my experiment."

Before that [stage], I went to the Iron and Steel Society Congress in Las Vegas, like AISTech today. That was exactly when Professor Fruehan came from Australia to Las Vegas directly. He arrived at the hotel at 5:00 a.m., and I was very anxious to meet him. I called him at 8:00 a.m., and [the professor was very tired; he shouted at me as much as he could]. And [later that day], when he went to [the congress main] floor, like we have here with those booths where all the companies are [presenting their goods], and we [CMU students were there], the Carnegie Mellon [grad students], waiting for him, he came in and said Ronaldo come right here, "You should not call me at that time. And what about your [experimental] results? Where are your results?" In front of everybody in the congress. I was a man with almost 40 years old and say—I suffer a lot with that.

36:58 INVENTING A NEW TECHNIQUE AND TECHNOLOGY FOR MY PH.D. THESIS

Santos Sampaio:

But then, when I came and built that idea to do those experiments, I needed $5,000 to buy the glass [ware and pay the gas] blower to make those things, and he paid, and I did it. It became a new technology nobody has done it before, that we called CVPI technique, which is Constant Volume Pressure Increase technique. And many other people used it at MIT and in other parts of the world. Also, at that same time, to prove that the direct measurement of the gas flow rate coming out of the coal particle did not have any contact with the liquid slag because I did this without having the slag in the system. I had another professor, Alan Cramb, here at Carnegie Mellon, and Professor Itaro Jimbo, which was also a [Japanese] visiting professor. They had built an X-ray continuous measurement apparatus for high temperature [experiments]. So, you have things, like at 1600 degrees C, and you have an X-ray movie of them. So, they let me to put my coal samples inside a platinum screen and immersed it in this

lag, and I [could demonstrate] that while the volatile material was coming out of the [coal] particle, no coal particle was being wetted by the slag.

So, my technique and my thesis were proven, and the kinetics of those reactions became easily to [be measured for many other similar situations]. The experiments [became easy and fast, and] I could do as many as I want per day. The [challenge] became only how to write a good thesis book and how to make those discussions. Then came Jeff Simmons, one of my best friends since then. Since the first time I came, he was there the second time [also]. He took like ten years or more to finish his PhD because its subject was a very complex one. And then he was here the second time, and he kept helping me when I write my thesis things. He corrects the English and discuss with me, "What you really want to say with this?" I said to that, "I want to say this." He said, "No. It's not that. Do it again." This helped me a lot to have a good thesis written. I owe to him this favor and this help forever.

Oliveira:

Okay. Thank you very much for sharing those amazing experiences of learning. Those were very inspiring.

39:45 WRAPPING UP MY STUDIES AT CARNEGIE MELLON AND MY LIFE AFTER UNIVERSITY

Oliveira:

Thanks for sharing these learning messages, Ronaldo. They were very inspiring. After going through everything that you went through, how was the feeling of getting to the end of your studies? Would you like to share any comments or memories about that?

Santos Sampaio:

Okay, to be a PhD at Carnegie Mellon, as you know from my start of my presentation, was not my dream. But, since I lived the life here, I became very proud of Carnegie Mellon because it's really a serious and very good school. And here, I had so many friends that are top persons in the community where I lived, in USA and overseas, that I'm proud of that, twice.

It's a thing that also helps to sell myself, "Okay, Ronaldo, you did it." Even though you are not really planning that, right, because I said I want to be probably only the CEO of a company by working hard and things like that, but things change. I was a CEO at that moment, I said to you, but I suffer too much that I prefer not to be it anymore.

While I was here in Pittsburgh, for example, the second time, I had a better place to live. I had a car. As a matter of fact, when I first came, I was introduced to the Knapp family, Inah and Charles Knapp, and three of their kids. They were like three years old, one year old, and five years old, three. Two boys and a girl. [The girl of 3 years old is today a well-recognized expert nurse here in Pittsburgh. One of the boys is a medical doctor, and the old boy is an entrepreneur in California. They treat me as an uncle, and I love them].

Also, when I was here, I had time to go to the gym. So, the girls started to interest on me. At that moment, it was very important because I was single [and needed a girlfriend]. Then, one of them invited me to be “auctioned” in promotions to raise money for Republican candidate in the city. So, I went. I

had to rent those black-tie dresses, and we are going to see the picture. I was sold for $500. Not much, but [laughs], I think I'm worth more.

Anyway, it was funny because the second time, I had time to [have a real life] in Pittsburgh city, meet Pittsburgh people, and even [go to] restaurants. I remember [from the first time I came] when the only aunt that came to visit me, she said, "I'll pay for the best food you want. Choose the restaurant." I had no one to choose. I was only living under the basement [of an old house near] to Carnegie Mellon. [From CMU to my basement], then [back] to my room [at CMU], and that's it for two years. It was tough.

It's so tough that when I came the second time, my wife said, "Ronaldo, I will not go." I say, "Okay, let's divorce." She said, "Okay, I prefer it." So, she did not come because [she also] really suffered a lot during those first two years. Imagine you start a month with $1,500, and you end up with $500 in December, just in Christmas time. You couldn't move. You couldn't go anywhere. You know? So, it was tough. I think that's important to say.

43:27 BACK TO WORK – DEVELOPING A NEW ORE-SELLING SYSTEM AT VALE

Oliveira:

Could you tell us how did you go on with your professional career after you finished your PhD studies?

Santos Sampaio:

Okay. [The second time] I was here for CVRD. I had to return to the [CVRD] research department. The superintendent [that] was there made me his assistant. Assistant to the superintendent [SUTEC]. I had to be involved in many areas of subjects and [different] projects that Vale was doing at that time. They had gold [mines] and titanium [ore concentration developments], besides the iron ore stuff, which is its main good up to date. [In my return to Brazil in early nineties my friend superintendent retired, and the new superintendent put me in the new ironmaking technologies tracking to identify the iron ore quality challenges to attend those processes such as Iron Carbide, direct reduction processes such as Midrex and HyL, Bath Smelting Reactors, etc].

I'm always anxious to innovate and to bring things to the Market. So, instead to be just following the quality of the CVRD ores [and simply compare them with the competitor's ore], let's develop the way to sell better the ore. Let's say that if I bring an iron unit from the Vale mine since we know our ore—Brazilian ore especially, is the best ore in planet—and if I prove to the clients of Vale that if they pay more for this iron units at the mine when they have it transformed into steel, they'll have the cheaper production cost and better-quality steel, even paying more [for the CVRD ore] at the start.

That is the [use of the Value-in-Use] criteria. To use those value-in-use criteria, I had to utilize a lot of thermochemical models [from all the major ore user reactors such as] Blast Furnace, Direct Reducing reactors, ore agglomeration processes that I had done in my past, like blast furnace charcoal or coke like a blast furnace, steel refining reactors such as BOF and EAF. So, sintering, pelletizing. We put all those ironmaking integrated flows together, and we still show how important are the iron chemistry and the iron ore properties to the final steel cost and quality. That became a very good system to sell ore for CVRD. Those techniques are still being utilized to date, and their development happened in the early nineties.

When I left Vale to be a consultant in 1997, first one of my clients was just another company, mining company, to introduce to their engineers the value-in-use method. Also, some consulting services company [in the] United States at that time was named Intertech [consulting paid me to a short course on that subject. They invite me to give full morning in value-in-use fundamentals and practice. I did this in 1998, something like that. I think it was in Pittsburgh, but I don't remember more the city.

I came here as a consultant just to do this short course and [those methodologies] that are still being very practical and useful up to date. I also use it to show that the pig iron, Brazilian pig iron, was better than the other pig irons because it didn't have sulfur. Then it has also those CO2 advantages that help a lot the sector to sell its [merchant pig iron].

At that same time, my boss at Vale, a state company, put me to help the state secretary of science technology of [Minas Gerais] to help the independent pig iron sector to improve and to be reliable and to be sustainable. What could we do to do a strategic study to make that happen? What can [CVRD help our state of Minas Gerais? "The CVRD Superintendent said that he had an engineer there that will help on this matter." [So, he] sent me to be secretary of science technology assistant to this project.
I was able to bring my peers, friends that I know at university, and research centers that were really good in the area. For example, charcoal making and charcoal off-gases, which is wood tar and [wood] water [pyroligneous liquor used in] the chemistry industry, like a food industry, and carbochemical industry. We used previous developments from those chemical raw materials that was done by Acesita Energetica before it was privatized. [In middle eighties] I was a member of the board of directors of that company. At that time, we invest in a continuous carbonization process done out by Brazilians [utilizing public informations realted to the Lanbiott reactor], a hundred-years-old technology. The problem that came after the building and the construction, the operation of it, was just the volatile materials. Too much [wood] water and too much [wood] oil, which is wood tar, and what to do with those materials because the oil was very cheap at that time [and the use as fuel was not viable.] We had to build more value on it [those volatile materials from wood carbonization].

The research of ACESITA Energética, [another state-owned company,] had a group [of researchers developing] the full spectrum of possibilities for those [volatile] materials [coming of the carbonization reactors fumes], to produce fine chemistry products, like the Bactrim used for antibiotics, the [material] to make carbon fibers and creosote to be used in food industry as smoked flavors and wood vinegar with a lot of [uses in natural agriculture]. Then, [a few times later], while I was at the Vale, they privatized this company, ACESITA, and the man that went to be his CEO was the one that invited me to be his assistant at Vale when he was there [as a financial director]. His second man, [ACESITA VP], was another one that was the president of the [Administrative Council of FERMA], the company that I was CEO of before. [I went before him, and] I prayed to him, "Don't do that; don't stop this [wonderful development going on in the carbochemical of the wood carbonization volatile materials]." They said, "Ronaldo, our business is to produce steel, not to produce forest, and not to produce charcoal [and its byproducts]. We can buy Coke [without the need of any investments and long time to pay and produce our steel without this complex and expensive option that is to plant forests to have the biochar]. “If we have a forest, it's a living creature. We must take care of it all the time, [and the steel business is cyclical]. So, it's not our business, our business, to produce steel."

As a matter of fact, a very interesting thing happened here while I was [here] for the first time at Carnegie Mellon. What happened? The [integrated] steel industry in America, but [the] United States steel sold their mining and their coal assets. The USS didn't. What happened a few years later? A hundred percent of them went bankrupt. Only the United States [Steel] survived. Today, what's

happening? A Brazilian acquaintance, Lourenço Gonçalves, became a CEO of [Cleveland] Cliffs, and today [Cliffs is the top producer of steel] in America, which is the iron ore bought the steelworks. Just the reverse happened. [Lourenço], this [Brazilian engineer and entrepreneur], I am his fan, so I'm proud of that.

50:51 LOOKING TO THE FARM – THE FUTURE OF THE STEEL INDUSTRY

Santos Sampaio:

[Lourenço] has done his master's in my department, in my university in Brazil, because we were the best in the country. So, then besides that, it's very important to say those things because at that same time came [Dr.] Ken Iverson. And Ken Iverson, I was able to know him in five meetings in his room at NUCOR Charlotte office because they were trying to [convince] CVRD to be part of the iron carbide investment, a new iron-making technology. I was the expert in new [iron] making technologies at CVRD because everything I had done in my PhD at CMU was related to those subjects. So, I came here, [USA], I have five meetings with Ken Iverson and his [management] team of big guys, and I was the only one against [the iron carbide at that time]. I didn't like it, because I like the thermodynamics of it. It's worked very nicely, but I knew there are [kinectics difficulties] problems to be succeed in that technology for it to be commercial. So, I was not favorable to CVRD be part in that JV with NUCOR to invest their money in this business, and Vale wasn't [iron ore] buy[er] anyway. So, what happened? They had to move me out of this [project at CVRD], but happily, other Brazilian companies went and put the money, so Vale saved at last, at that time, 50 million dollars.

The other Brazilian mine lost [the] 50 million dollars. Anyway, I tried to do my best, and the manager they want to be together with NUCOR because it's a very famous [steelmaking company]. Then, NUCOR and Ken Iverson is a man also that deserve one of the most important positions in this industry globally speaking. One thing he did that I love is he brought the first seamless [direct thin plate production plant, opening a new window to produce flat steels with less energy and capital]. The Crawfordsville Plant was placed inside a soybean and corn farmland area. He trained the [local] farmers to operate the steel mill, and the person that [started as its first] superintendent of [this new mill, I think, was one of the engineers that worked in building it in that place. That man was] Mark Millett. You know this [engineer to become a steel entrepreneur] today. I went there to visit [the mill as a CVRD expert], and we're proud of those things that happened in our life that we were around. I know the guys, and some of them remember me.

Then, today, I went to my [paper] presentation to say to all those problems we are having with Chinese steel, with environmental CO2 emissions, the steel industry [must] do like Ken Iverson did. Among many other opportunities that are viable, they should look to the farm again. They should look to [sustainable] photosynthesis because your country, [USA], is the one that most use wood in this planet. Do you know that? All your houses are wood-made, and wood is storage CO2, but not only storing CO2. It's oxygen production diluting the other gases that are in the atmosphere. Then comes a thing that we finished this presentation, which is a paper he did with me. In a very smart way, he approaches it. That also part of my full life; I rely a lot on bright young students and start to became just [like] a teacher, "Do this way, do that way." No, you [need] to find the best way to do.

This I learned with [Professor] Fruehan, among other things, because [Professor] Fruehan didn't give me anything. I had to learn [by myself. I have learned that this strong individual effort is part of the learning methodology] here at Carnegie Mellon. It's the American way to do a PhD. The graduation [courses] of

United States universities are the best in the world. That's why Korea, Japan, Singapore, even China has [followed] the same USA method. They really push the human to give his best with his hands and [intellectual] abilities and connections. So, I'm very proud to be a Carnegie Mellon student today. But what could I say to not mix up? I'm mixing up everything like I always do [laughs]. Let's see if I can remember a very important thing. It's that when I start to be a consultant in '97, when I left CVRD, I felt my life would be different, more freedom, and I would have a lot of customers. Man, but that did not happen [as I had dreamed].

PART 2

00:30 IMPRESSING MY SUPERIORS AND ADVANCING MY CAREER – "I WORKED LIKE AT LEAST 15 HOURS A DAY"

Santos Sampaio:

The people in Brazil, even up to date, they think knowledge is free because almost all universities in Brazil, but a few, are government universities. They don't pay nothing. And the professors normally give consulting for free. So, the industry, especially the poor ones, they don't want to pay any knowledge, or any consulting service to no one. They wanted it for free like the universities were. [Therefore,] they don't give value to knowledge. And this is a thing that I say, "Okay, that's really bad." I suffered a lot in the first three years [after I left my paid job at CVRD to become a consultant]. I did one service here, another there. [I did a good service to the Pig Iron Independent sector,] but they pay very little. Then, when I start 2000, one of my former students that was [my] TA when he was a student at Federal University of Minas Gerais [pointed me to do a consulting service to the upstream area of the steel mill, he was a director]. While he was my student, he did wonderful research, assembled all the lab like the Americans does, published a paper with me—it was an award paper—while he was a student. [His name is Dr. Marco Antonio Castello Branco.]

And then, I got a consulting service in a company where he was a director—but [my services was to] the superintendent of upstream: blast furnace and BOF [processes]— [This superintendent] gave me four months of consulting services to do a complete audit of the blast furnace up to the liquid steel. Then, I said, "Now it's my chance to be known by the ones who pay better consulting services, which is a German company. It's a big steel company. So, I'll probably now be recognized, and I'll have my opportunity to grow." Those four months, I worked at least 15 hours a day, Saturdays and Sundays. I was able to apply everything I learned before and also from [my lectures and books, other experts, and I wrote how to do easy-to-understand] reports where I have [drawings of] the reactors and [pointed visually] the solutions [for each one of the problems I identified], like an animation you can see on TV.

I did by hand in Excel spreadsheets things for the blast furnace runner, things for the raw materials preparation, things for the dedusting systems, things for the torpedo cars, things for the BOF. I did calculations in such way that I put all my thermochemical models [in use to better understand and explain the wrongdoings and how to solve them]. "Okay, why are you utilizing a certain amount of coke in a charcoal blast furnace? You are not getting enough [energy and reduction from its use]. You are only [putting] sulfur [in the hot metal]. Don't [do that!] They have a desulphurization station right there. [It that was increasing] the loss of hot metal, loss of temperature, loss of money, and then they produced [less] steel [in the BOF]. I did a really strong methodological and economical [report] and proved everything using my Value-in-Use expertise and [tools] like that. Then, I said, "Now I believed that the superintendent will like it." And he really did [like the report, his decisions was the worst for me]. The

superintendent said, "You did a wonderful service. Too many recommendations for improvements you have done to us that we are going to take at least four years to fulfill them. Therefore, four years from now, you can come back." [that was bad for me].

So, the sky fell on my head, man, but I said, "I'll not leave this company [until I´ve spoken to the director]," because the director, the [manager] above [the superintendent,] was my TA, my [former] student. I'll talk to him. I went with my report, PowerPoint color printed, a thick book like this [motions with fingers] and knocked in his office. He said, "Oh, Ronaldo, come in. What you did [to our upstream]? Okay, do you want to show it to me? Yeah, then he called the superintendent to watch [my presentation to him]." So, the [superintendent] stays there [in one side of the table], and I stayed in another side [of the table]. I [started to show] one [by one] PowerPoint presentations. He [liked it and got very impressed with the report and said to the superintendent], “You did not show this to me. You did not show that to me. You did not show this other one to me." After 15 minutes in the presentation, [the Director said] "Ronaldo, do me a favor. Wait outside." I left his room and stayed there waiting. One hour later, he called me back [inside his office]. He was alone.

He said, "Ronaldo, you did a nice job [and an excellent report about it]. Those [managers] have few money to pay consultants; they have their preferred ones. Do you want to be my consultant?" So, that's what I am today. I started to be a consultant of this [director], and one or two years later, he became the CEO. I stayed [as] his consultant, but he didn't care about my [work with the] students; he didn't pay attention [to] them. He made himself a new trainee program for the whole company, a national thing, and he himself verified each one of the 20 trainees. He was the one responsible to follow them. I was doing my consulting as usual, and I always used my students to help me in the consulting services [as interns]. Those interns had the opportunity to be hired by the company [when they graduated], and they stayed there [and after some years, the number of them that become engineers at the company increased]. They stayed there. So, came another CEO when [the director, my former student], went to Europe; he was promoted to the European management positions, and the [new CEO] knew I was a friend of his and a good consultant and kept me [as his consultant].

06:17 “THE BEST THING THAT HAPPENED IN MY LIFE” – A NEW OPPORTUNITY FOR MY INTERNS

[This new CEO, Dr. Flavio Azevedo], did a very interesting thing that started to change the way I do consulting. He said, "Ronaldo, you do those nice presentations, very detailed ones, and that shows the things that I can understand, but you are a consultant, and I want my people, and the students (interns) that are with you, to learn, not you show that you know. So, you are not permitted from now on to give any presentations of what you are doing here. It has to be someone of this company or one of these students." It was mandatory. If I didn't, I'll lose my services. It was the best thing that happened in my life because now I could hire more students, produce much more, and I realized, "Why do I have to use only my own knowledge? All of the things that I really know a lot. Those come through an automation [related subjects], those mechanical stuff [challenges].

Maintenance is so important [in the metallurgical industry]. Those refractory [problems and a good number of others]. Why not bring this knowledge with the students [interns that are] with me and try to make it?" I start to accept challenge inside the company, in all [the] company from their forest plantations sector, charcoal making sector, [iron ore] mining, blast furnace, BOF, and [the seamless pipe mill area] where I did not know anything. But I brought good mechanical, [chemical, metallurgical, electrical, control & automation] engineer [students, also a contract] good [experts] in combustion [and other industry knowledge needs]. I start to bring famous professors, my friends. [Like professor]

Fruehan, that went to teach for me in Brazil. [Many others like him also came.] The one that stayed with me for almost ten years was Professor Klaus Schwerdtfeger, [a retired professor] from Claustral University in Germany. He was so good because the kind of person like [a father], the one I loved, he knew strong fundamentals, and he's a practical [person]. He stays with my students, with the [industry technicians and engineers] people, listen from them what they had to do, what they did, what's going on, to understand each one, if they knew something or they don't know anything [about the necessary knowledge for that area].

[Professor Klaus] consulting services to me, last almost ten years [and it contribute to build] a strong knowledge base for those people, much superior to the one I could do myself. I always say, "Okay, my problem is to build knowledge in the others, not necessarily to know [all needed knowledge but consider] the others that have knowledge [that is in demand]." I started to invest more in my “raw materials,” which was the [student] interns, my interns [team. A few years later] came a new CEO for that company, and it was already a French company. At that moment, they were verifying the young talents of the whole company, globally speaking. In Brazil, from that very expensive training program, less than 15% of the young talents [identified] were part of that group and but someone in HR department notice. "There is something interesting: almost 50% of the other [talented] ones here in Brazil were interns of Professor Ronaldo." So, the new CEO probably was planning to fire me at that time because he was in downstream side [engineer] where I'm not involved, and I had some people that didn't like me [around him]. In my life, I always have people that don't like me because I am very concise [about] what I want. If the people are not good enough, if they say something wrong, or they treat my students badly, they have a problem with me. They do have. It's a problem I have, [and I should pay more attention in not doing it].

I've Italian blood, I got mad with that. So, most of them, some even avoid to have my interns because the consequences can be harmful. Then this [new CEO] invited the students to see what they were doing there and to know them before to fire me. He liked what he saw, so instead of firing me, he said, "Okay." He called me, "I want this to be officialized, and you are going to meet with me, with the students presenting [their work results] every two months." And this [is] being done now. Now it's every four months, every six months, but we still have [the meeting with the CEO]. Now in June, we have a meeting with him. This empowered [my services with the interns] because every place I go is a thing that came from [the CEO, and now I remember what] Professor Vicente Falconi. Falconi said, "If you want to sell something that is knowledge-based, if the CEO doesn't have knowledge, you're going to waste your time, but if he has, it's only to him that you have to sell.” Do not waste your time with the second guys or third guys. Do not waste your time. He buys it, or he doesn't buy it."

11:30 THE IMMEASURABLE INFLUENCE OF MY INTERNSHIP PROGRAM AND MY STUDENTS

Santos Sampaio:

It is a true thing. If I lose distance from the CEO, I lose power, and my kids lose opportunities. I try to keep this way up to date. I don't know how long it'll last, but this is more than 250 interns [that] went through this process. Today, they are everywhere. For example, at McKinsey, we have five; at [BCG, we have 3; at NUCOR, we have 3; at Arcelor Mittal, we have 11; at Itaú] Bank company, we have four. In other Steel mills, we have a [good number] of them. In different industries, in different areas. For example, those startups that are going on are all very fashionable, a lot of the most famous startups in Brazil; I have many of them that are key persons inside already.

Now, in our WhatsApp connections, every problem one of them have, they put in there, a solution comes. If one needs an opportunity, the opportunity will come. A lot of opportunities, [we have excess demand coming from the former interns] they are offering [to the actual interns], and they are the preferred [in HR departments]. Since the beginning, when I was a teacher, I was related to the metallurgical and chemical engineer departments [of UFMG]. Now, [I am well related to other departments such as] production engineer and control & automation [engineering], they go after me, not me myself. I said, “I want to build leaders. I don't want to build what they call in Portuguese “Pau mandado” [= followers orders]. People that just receive orders and do it without thinking. I wanted them to be owners of their own businesses and to be CEOs of the companies where they are. [I am picky on them], this happened more than ten years back; I say you are going to be my boss, and you must learn to be my boss. I'm a very complicated person.

That is a process that's going on up to date. When the things is very smoothly, very nicely, I know I have very good leaders in the team. When the thing is not being smooth, I must go inside [the team] and see what's going on. Who is complicating things? Who is not? And I also go directly in everyone’s success [goals and how] happy he is. That's what important for me. So, I say this [intern] is happy with what he is doing? Is he doing something good? Is the ones that are working with him liking what he's doing? I always keep this all the time. [I used to do the same for previous interns that left the team more than 15 years back. In the company I am now I verify] "That guy is not working [as he should]," but man, guys like him 15 years that are in the company [and now are not motivated]. I go there and see how they're going, if they're happy, if they're improving, if they're growing.

I said, "Man, you always have to be prepared to go to the next company. You should never stop because while you are there, the company is not the mother of no one. You have to learn [every day]." So, the old ones, when see me come after them, they say Ronaldo is going to push my [pulls ear] because something he thinks [I am not happy and] I'm not doing something properly. I keep guard, helping. The weak ones, when happens to be in the team, I bring the other ones [to help him], "That intern has to learn from you more, and you have to spend some time off the team with him. He needs your help." I have almost 50% women, 50% men, [all kinds of genres you can imagine]. I love them all. A lot of them became friends for life, more than friends, sons, daughters. That makes me very happy, very happy. [This is the most relevant accomplishment I had in this life].

15:25 Making My Dreams into Reality and Creating a First Zero Emissions Mill in Brazil

Oliveira:

So, Ronaldo, there is a very important project that I would like you to give us some words about it. It is related to the first integrated hybrid integrated [steel] mill of Brazil.

Santos Sampaio:

Okay. When I [returned to Brazil from] Carnegie Mellon, I was invited to give a lecture about new iron-making technologies in the Brazilian Metallurgical Society, ABM, like an opening lecture in the iron-making conference. The Brazilian equivalent of the Iron and Steel Society (AIST) at that time which is ABM [Associação Brasileira de Metalurgia, Materiais e Mineração]. I talked about all those new iron-making technologies, and I also remember, no, it's time for us to think and mix the integrated with a non-integrated sector. For example, I will bring a hot metal from a blast furnace and feed an Electric Arc furnace to reduce electricity consumption [for EAF] and improve iron quality to dilute more scrap [using

local hot metal] and things like that. And I knew if I did that using charcoal from sustainable forests, it would be a marvelous thing. That was one of my dreams at that time. So then, that person that saved my life in [the stating of] this century, which was my TA in the early eighties, Marco Antonio Castello Branco, now a doctor from Claustral University, with my friend Professor Klaus Schwerdtfeger. Marco was in Europe as a big director [of Vallourec group]—and they were doing a study, where a joint venture between Sumitomo and Vallourec should be placed on earth, which country, to bring them another one million tons of seamless pipe production.

Brazil was the fourth place in this European consulting services selection. He said, "No way, called me in early June 2006, Ronaldo; I need your help. I know you have been those value-in-use things in new iron-making technologies, doing those economics for CVRD. I need your help to redo completely what the European [study McKinsey] did, to [also take in consideration those renewable technologies] things we love." He loved [sustainable] charcoal making; he loved [blast furnace] iron making. And so, we built seven integrated steelmaking scenarios [to compare each one], and we finally won to Brazil in the first place. We were able to reduce operational costs and capital costs to almost half in both to compete with the first place at that time.

Finally, the project was select to [be in] Brazil, what was at that time 1.6 billion euros investment and 6,000 employees from Brazil. So, you can see the mill they're operating nicely with the design we did. In that design, I put a lot of my wishes in the biomass life, photosynthesis life. For example, the [first and] only Great Kiln Pellet Plant in Brazil is in there, but it operates with charcoal fines instead of coal fines and or natural gas. And the charcoal is a sustainable and zero emissions [at the pellet plant]. So, it's the only pellet produced in the world with [almost negative emissions], and it feeds a blast furnace that produces hot metal and also utilizing charcoal and feeding the hot metal into a Consteel process with EAF. The Consteel process is an electric furnace with this [continuous scrap feeding] that preheats the [scrap. The steelmaking expert] who helped me to find [this technology], to identify it, and to bring it to Brazil, is another friend of those many years, Jeremy Jones.

Jeremy is very famous in electric arc furnace [expert], globally speaking, and extremely active at the AIST. And then Jeremy Jones introduced me [to] Francesco Memoli, he was a manager of Tenova, to sell Consteel reactors and related things. With Francesco Memoli, I visited many mills, and nobody knew that it was a project from Vallourec and Sumitomo. I lied that I was doing that for the independent pig iron sector [in Brazil]. Their plans were to do that together and to build a [hybrid] steel mill with the hot [metal from charcoal] blast furnace [and an EAF together]. I came here [to USA], and Francesco Memoli took me to [visit a few] Consteel plants, starting with the first one. And I knew the inventor of Consteel, Mr. Vallomy, sometime before he sold this technology to Tenova. You know what? Because I was [an active member of] the Iron Steel Society, and I met him many times. He was trying to sell himself his own technology. So that old little [brilliant] guy, Italian one, he lived in Paraguay and Argentina, so we became friends.

Later, he was honored here at AIST also. Many people that we come up to remember, I don't know how I could remember Vallomy, [laughs] they did their Consteel [technology a global success]. But then, we can put that, and that happens. And I did also [choose to use] two [small] blast furnaces instead of a bigger one. They were able to build only one to cut capital expenditure; they left the other one on the ground.

21:06 Building the Bridge that Brought International Operations to Brazil

Santos Sampaio:

[Today] they need desperately the second one because the idea was so good that now the company shows they have the least costs [compared with] Europe and America. Brazil is one-third of the cost. The German operations are moving to Brazil, and the Americans are still alive, surviving here, because of [reasonable scrap prices]. But this makes me happy because it is my baby. But [we all deserve this new mill in Brazil to Dr.] Marco Antonio C. Branco, he is the man who said, "No, I don't agree [with this study. And we have to do a new study." And he was right].

And I myself, with some of my students at that time, [spent] 15 hours a day, 45 days straight, days and nights, we had to do to make this to happen first round. Then, we have a second round. The Japanese always wants a sintering [process]. I said, no, it's pellet [plant]. They want sinter [plant; they did not want to be a pellet plant]. They sent a Japanese report, a very beautiful report, and a well-done report—I learned a lot from those reports—but I [must] counter-indicate the reports and see. But this came like never decided. So, they said the ore should be Vallourec's ore. The owner, the superintendent of the mine, said, "Okay, which one do you want?" "Oh, has to be sinter [feed]." [He] said, "Oh"—when this company is going to start up 2010—"In 2010, we are not going to have sinter feed anymore. Sorry."

So, the pellet plant came. The pellet plant is there. It has proved so good that it is the second most profitable part of the company. So that makes me happy also. So then, something that I have to remember in this is I never do those things. For example, to do those spreadsheets that I knew how to do myself, but not the graphics, the built presentation. One of my students, former student [intern], was already an engineer at Vallourec Brazil. Kellen Steves she did the graphics for me, that every time I had to change the numbers, the things appeared very nicely. I had to go to Paris to show the French, I have to go to show the Japanese, and I have to discuss to Germans in Düsseldorf. And I had some help with some German [consultant] that I tried to remember their names. But when I choose an electric furnace and the electric furnace technology could be Consteel, one of the Germans directors stayed in my favor and with [Dr.] Marco Antonio.

That helps a lot because for process in engineer wise, the Germans are well-reliable, and everybody considered them most. And so, they were with me. Then I'm very happy because of this, and the same thing happens with continuous carbonization. The plant is there. Now they're thinking expanding it so many, and the smart knowledge behind it, I have it, and the technical ways to sell it better and even to get the most from it, I know how to do it properly. And I always teach the ones that aren't in there to do that themselves, like my advisor did with me since then. If I'm alone doing nothing, I'm doing the most you can expect from me.

Oliveira:

Right.

Santos Sampaio:

Yes, that's true. Because the ones that I'm training are being nice in what they're doing. That I'm proud of.

Oliveira:

That was nice. Okay. And building the bridge that brought a whole facility to Brazil is an extraordinary achievement. You should know that we are amazingly proud of you for doing that.

25:11 The "Ronaldetes" – Being an Educator and Mentor to a New Generation of Engineers

Santos Sampaio:

The EDP method, which called "Estagiarios do Presidente," which is CEO's interns, so I use his name. But Dr. Alexandre, the one that really officialize it and take care of it by just checking as what we are doing, he called them, those students, "Ronaldetes." I don't like because the CEO is more important, you know? And then his secretary became like my Director of Management because all the big problems we have in the mill that we need solve to speed up the agility of the students in the system; she always acts in our help and gives us, even to myself, a lot of advice, "Ronaldo, don't do this way, they'll kill you. Be calm; take it easy." [Her name is Inez.]

She helps me a lot. She just retired, and another one replaced her is called Keyla. I love her, also. She's been very nice since the beginning. I'm very happy with that. This photo is many years ago already, and you can see there are many other photos around the years.

And what I do with those students because I have all kinds of ones. For example, ones are very rich very powerful, they don't need to be there. Others are very poor, have hard time even to learn English. And all companies, English is mandatory, and I know the [intern] is a really good engineer. They say, "Okay, it's a language skill that will kill him." It's a problem I had with myself [when student]. So let me help him. I normally lend money to those for them to go overseas, do their English training, and come back. And I did that with many of them.

Others that I really want them to stay in the company and they want to go to other places that will pay them more or make their life better. For example, they are living this city. The job is in that city. They don't have to pay rent because they're living there already. If they have to go to other city, they still not have enough resources. So, I invested n them. Some of them even need car to work, and I give money for them to have a car. So then, later on, they pay me, or they pay the other one. I transfer the support to the other that [are in] need.

For example, one that went to England to learn English. She is now the technical assistant to the European activities of Anglo-America. I'm very proud. London is the place where she went to learn English. Makes me proud. So then, the EDP process has too many involvements from them, from me, from the university, from the community, because one has to take [care of] the other [or vice versa], one have to attract [the new interns at the university].

I go every year [at the engineering schools], first semester, second semester. I go to some colleges to give lectures. I talk with them publicly, ask them questions, and then a lot of my brilliant ones, students always capturing the equivalent ones. They are the ones. While you have a thermocouple to measure temperature is a brainy, smart [interns are the ones chosen] to select the other one [to replace him]. Not human resources people that are, "Oh, I have to [select a candidate that knows English. What else he needs to know? Oh, French? French."

This is not what you should do. This process eliminates the need of a training because they jump as a student, interns in the company. You are seeing their services. They're working together, learning

together, preparing themselves among each other. There are many techniques for that to do. For example, AIST. Today, in this morning, I was there in the presentation of five of them. Challenge is first place, second place, or third place in the AIST student contest. Every year we are here. Every year, they prepare the full year to come here. They [must] raise money to come, to pay their trip, their stay here, and AIST is the best organization ever to do that. You know why? They give to them $250, [plus] $3700 a year for [Brazilian chapter]. Besides, they [must] do all those sorts of things in the company [and at university to raise money for this trip to USA].

This year, [the CEO], Dr. Alexandre Lyra also wants to make sure they are doing social work in the company-related projects. [Therefore], they go to the schools nearby the mill where [they teach] poor people with [basic math and other skills], difficulties, and other things. Some do robotics classes to the students. So, they have to, to be part of the training. So, it's part of to see the society where you live, what's going on there.

Also, when they have weak ones, it's their fault. They choose the [intern]. So, the [intern] has to survive; now he's one EDP, and EDP is EDP forever. I will accept [them] as my sons. No way. If I see he's suffering, he's not doing, I always bring them, "Please, we need help this." When I can help myself because it's kind of knowledge I'm involved in, I do it. And sometimes, I know the [intern] will not succeed here, I will transfer him to [other place]. This continuous observation of the human being that is there is a thing that hardly managers of companies understand, but the product is simply magnificent.

They started at the company; they know everything. They know how to work. They already are [bringing] results. And every project—this is a mandatory by Dr. Alexandre—must be a strategic project of the company that previously they know will reduce the costs or improve the quality. They are always bringing money, and millions of reais a year for sure measured. Every year.

I call it a self-sustainable trainee process doing an intern while they still at university studying. This is the only one I know, globally speaking, of this thing. But needs someone with a stature like mine or equivalent and the love to really take care of them.

32:37 ABM Awards and International Recognition for My Metallurgical Work

Oliveira:

Okay, Ronaldo, building the bridge that brought a whole facility to Brazil is an extraordinary achievement. You should know that we are amazingly proud of you for doing that. You've already mentioned some awards you won. Did you receive any others awards or honors in your career you would like to mention?

Santos Sampaio:

Oh, yes. From the ABM, I think now it's 11 awards. Here, the Iron Steel Society haven't given an award because I know those biomass steel two things are not palatable for the American ones. Anyway, I have many awards from the ABM, but also, I am a distinguished member and fellow of the AIST, which I owe a lot of help because, since the administration of Ron Ashburn and my friend, Otávio Sanábio, that happens to be his colleague when he lived here before and was my first Brazilian chapter of AIST president. And after him came Marco Antônio, then Marco Antônio came Dr. Flávio Azevedo, then Dr. Flávio Azevedo came [Dr.] Lothar Birkhäeuser, that is here today [as the Brazilian AIST president].

And those big guys, I [must] put as the presidents of the Brazilian AIST. I can never be myself because they have the power of their company behind them, so they can give some money [and strong personal] support. For example, [last] night, they bought a dinner for the boys and the girls. It was very nice, and I appreciate that. I would never be able to do that. Also, I can attract more members for the AIST if I have people with this stature as a CEO, as a president of AIST Brazil.

I've been a volunteer secretary for four decades. This man. It's a lot of time, and I'm still active in the Brazilian Metallurgic Society, and I was also in the Japanese Iron and Steel Federation before. [The JISF] invited me to give lectures in Japan in the past, last century, as a matter fact. Those things make me proud, and I never really wrote too much about that, and you are going to see in my curriculum vitae a lot of papers I have published. There are many, probably more than a hundred, besides those books, and that's around 11 books or something like that.

35:24 Reflections on My Career and Advice for New Engineers

Oliveira:

Can you sum up your career in three words?

Santos Sampaio:

Okay. Hard work is the number one. And commitment because if you're not committed, nothing will happen. And seriousness because seriousness keeps you respectful and respected by the society forever. So, I don't lie. The people I don't like, I don't like. The people I like and love, I love, and I like. I'm very open, and they know that. That's why I say my enemies know I don't like them, and I'm very clear about that, but I'm very open to pardon everybody that recognize their mistakes. I do that because I'm a Christian person, and I love the others.

Oliveira:

And talking about connections, how did you get involved in your member society at the beginning, and if you were to recommend your member society to a new graduate, what would you tell them about it?

Santos Sampaio:

Which Brazilian is part of this oral history here? I have so many friends, colleagues, highly superior to me in what they have done, but they never show up. Things that I teach my students is you are beautiful, but the world must see that you are beautiful. You [must] show up. And this event here is a showroom for them. They do all those training to come here, which is part of the methodology, but they are being [seen and] connecting [with their peers]. How many people connect, man? All the most famous metallurgists that I read in the books, in the papers, in my master's in Brazil, and here, I know personally most of them. A good number of them are my fellow friends. I'm even upset if I can't remember all their names to put here, but are many.

But this makes me happy when I came here because I came with [only] four of [my intern] students, and I keep introducing them. Like Jeremy Jones yesterday, we find him walking in the street, and we took a picture with him, and that same month, he gave 15 minutes of talk to them, calling attention for them

how important for them to [come to this event], how important for them to connect people. Here, I'm like a bulldog. They're together, and I say, "Why you are together? Why you are not talking with these people, that people? Why are you not going after this and that?" You [must] know people to interact with people because you need to be known, and you need to know people. And if you are really committed to a certain area of interest, [it's] everything.

You know, to training any new engineer in this planet, the best playground is the industry because you have medical problems, law problems, environmental problems, mechanical, electrical, electronic, artificial intelligence, process, chemistry, safety. All sorts of knowledge in the same place are the best playground for any engineering [student] to be. That's why I have today almost 260 [interns] that passed in this process. Probably, I have less than a hundred in the steel sector, but the other ones are globally doing the best, and it's so beautiful. So beautiful.

Every once a week, I receive, "I was promoted to this; I'm now in this position." Some invite [me] for [their wedding]. One of them, I'm the godfather of his child. And the first [intern] was a mechatronics engineer [student], and he did the best thermochemical models for blast furnace and BOF ever, and I utilize them up to date. He was a mechatronics engineer. He grabbed the iron units, come inside the mill, put in all the process, with time involved, into the steel, made optimization inside Excel spreadsheet, utilizing what's best. And this [engineer] is Mateus Laponez da Silveira. You know what? He's a nephew of that Silveira professor that I most loved. The coincidence. I only knew that many years later.

40:37 "My Boys and Girls" – My Greatest Contribution to the Industry

Oliveira:

So, Ronaldo, after sharing so much today, we've seen that you did so many things. And I would ask you what do you see as your main contribution to the industry?

Santos Sampaio:

Oh! My boys and girls. Because I realize, as a consultant, like the report I did in 2000, the guy said it'll take four years. It's 22 years now; they did not fulfill it yet. You know why? The people that keep changing the mill, they're not keeping improving their knowledge base and their skills in that area that's needed to understand what I'm saying there. So I said, "Okay, if I don't bring those guys inside, no one will do that." The methodology that we do from this EDP methodology, their main objective is to build the new generation of engineers that are able to understand what their bright consultants are saying and to grab this information and introduce [them] into the system of the company and utilize [them]. Better than that, do themselves and go faster than the others. They really go fast.

And everyone that passed through [EDP methodology], this young boy here [points to someone out of frame] is one example that few people can see how smart he is to do things. Say, this [young man] has [the wisdom of a] 50-year-old [man; he] has [12] years' experience in steelmaking. He's a metallurgist? No, he's a chemist, and he knows more than most of the ones that have [25 years] that are involved in the steel industry know, and besides, he has philosophy background very strong. He understands what is written better than the other people. He understands people with eyes, attitudes, what they can do.

I always fight with this [young engineer] to say, "Please, help the other ones to have something like you;

give part of you to them." But the companies, when have people so good like him, they immerse them [with services]; they don't let them do anything but being exploited the most. [Therefore], they lose their own [private time] in life and the opportunity to teach others because they are always exploited. That's why this guy is now doing PhD here. It's a way to move him from this jail he was, for him to have time to breathe better, see world more wisely than he normally does, and connect with people that will recognize this brilliant person he is.

43:43 Co2 Emissions and the Future of Engineering

Oliveira:

Ronaldo, thank you very much for your words. They really appreciated that. As we are approaching the end of our discussion, I would like to ask you about your view over the history of your field. We've been watching many changes in the industry over the last years and decades. In your perspective, what were the milestones in the industry that had the biggest impact, and do you see anything coming that we should pay attention to?

Santos Sampaio:

Oh, yeah. Everybody now is talking about CO2 emissions reductions, hydrogen for steelmaking, and things like that. I mentioned before Ken Iverson, when [built] the [first thin plate] plant to Crawfordsville, he used farmer worker to be steelmaker worker, which succeed very well. Now I say, okay, it's time for the steel mill look to the farm again because, in reality, the emission solution is a global solution, is a holistic solution. It's not the solution of this company, that subject, or that other thing. Even I am breathing CO2 outside. So, we must look more wisely. As Professor Fruehan used to say, you should first look to the forest and then go to the tree, and then to the branch, then to the leaves. We must now look to the global situation and verify what the scenarios could be best fit here, [and in the other location, it] will be a different one.

Hydrogen is a nice solution. It's part of my master's thesis. But remember, to produce it, you have two chances. You are reforming natural gas, which is a fossil, or you are going to do electrolysis of water. Electrolysis of water demand a lot of electricity, an abundant amount of electricity, and cheaper electricity. And let's assume we have it. What we'll do first? Turn off all the coal power utilities and the natural gas power utilities, and then we'll get the remaining electricity to produce hydrogen for the iron and steel industry because the highest emissions sector is just the electricity production [sector]. You cannot use electricity from coal to produce hydrogen from water. It doesn't make sense. You are going to make the things worse.

I said, okay, why is that? If you look back in our history, the first and the best iron produced in this country were [based] on charcoal, like in England. There are a lot of opportunities to produce ferrous alloys (Ferro-Silicon silicon [metal], ferromanganese, ferrochrome), all could be done like it is done in Brazil using charcoal [and not coal]. And you have only advantages, no disadvantages, because charcoal is better for submerged electrical furnaces than any kind of coal. It has almost no ash, below 1% ash, and the ash doesn't have sulfur. And you have all the beauty of CO2 fixation and oxygen production.

If you do remember Ken Iverson again and say, okay, let's at least the steel sector look to the farms that are degraded, deteriorated lands, [that are] not being productive anymore, and start to increase its fertility in a more diversified way and parts of it I will have wood for furniture or for any applications, for

house construction. And while you are cutting the woods to make your house, the small pieces you can make charcoal. But here, while you have a shredder to destroy a car to recycle steel, you have a shredder to do the same thing with the old houses. They are wood-based. So you shred [this “scrap” in] wood pieces, and you [process it] in charcoal, and use it to produce electricity and to produce steel.

The solution's there. They cannot fulfill all the needs, but if you use 20% of it, at least 30% of the whole emissions you have here, you can reduce, and you generate a lot of jobs. For example, if I need mass like wood if I'm going to clean forests, they have a lot of dried wood there that are precursors of fire in the forests. If you clean, you can use it to produce electricity and utilize the charcoal in the steel mill, and the forest will not burn anymore. So, we're protecting the forest by cleaning it, and you have raw materials.

So, you have a lot of combinations that you can do. And the one I most love is WISE REVEGETATION, but I need to transform myself into an [expert in soil regeneration]. What do you call that? But then, I try to find some partners in this [knowledge-based] area here, but they don't answer my emails. They don't read the paper we did together. Maybe it's time to talk about the paper.

Oliveira:

Right. I would just ask you if you would like to say anything else.

Santos Sampaio:

Yes. I am for 25 years fighting for the justice about the sustainable photosynthesis. Because you see, today, farm is responsible for huge amounts of emissions, and farming is a photosynthesis process. And it's penalized too much because the accountability of CO2 equivalent emissions, accountability is wrong. It's not considered. This is atmosphere, isn't it? We have oxygen in it, don't we? If I take the oxygen here, two molecules of oxygen to react with one molecule methane, I will produce one CO2 and two water [molecules]. But, let the CO2 [stay] in my hands. I didn't feed it to the thermosphere, but what I did in the thermosphere? I reduced two molecules of oxygen, didn't I? A hundred percent was there. From the hundred percent, I took oxygen out. What happens with the concentration of the other gases that are there? They increase. So, by remove oxygen from the thermosphere, I'm increasing CO2 concentration, N2O concentration, SO2 concentration, SF6 concentration, all other gases [GWG gases]. So, oxygen needs to be part of the accountability of the CO2 equivalent.

And this guy, this student of mine, he gave me, after 25 years fighting, an economic way to make it happen, which is this paper we published, which is not only paper; it's a thesis because we show and we prove with real numbers. Because every time the atmosphere increases in one ppm of CO2, it is decreasing 2.15 ppm of oxygen. So, we are really removing definitively oxygen from the thermosphere, and the only way to avoid it is photosynthesis or electrolysis of water.

But then, he suggests in our paper the profit and loss [criteria]. If you take oxygen from the atmosphere, you are increasing the other gas there. So, CO2 equivalent should pay for that, so it's loss. If you are producing oxygen to utilize later or to really produce it like this one produced, and it's in the thermosphere, it is profit, so must deduce from your emissions. It's to give justice to photosynthesis. If this is done, the American CO2 emissions will be reduced by one-third of what is considered today because you are one of the largest users of wood for home construction in this planet because it's a permanent fixation. And if you start to put oxygen, this will be the number one in reduction. You are

going to fulfill your protocol, IPCC, faster than everybody by just doing this, and this is a true thing. It's a scientific thing. It's a proven thing. And I'm still fighting a lot with those [partners], those boys.

53:07 My Own Co2 Emissions Reduction Efforts

Santos Sampaio:

By the way, I just got a patent last year that I'm trying to reduce CO2 emissions due to my previous knowledge in pelletizing, and “my” pellet plant [in Vallourec, Brazil] is the one that has the least carbon footprint. In Brazil, you have an [iron] ore that's called pellet feed. It has below one millimeter down, but then you have to grind it more to have fineness enough to be able to make pellets, green pellets.

And then I say, okay, but all the ores have so many coarse particles or fine particles. Let's just before, in the mine, separate what's coarse from what is fine enough for the process and just grind [only] the coarse part. To grind the coarse part, let's use a cheaper in CapEx and OpEx [device], which is the high-pressure ruler press, instead of go to the grinding mill with balls inside, water, electricity, and so on and so on. I just pass [once] in the ruler press, and I get certain amount of fineness. This [fraction] mixing together again with the fine ore [fraction], I have enough fineness to directly produce [green] pellet.

Right now, the sinter plants in European steel mills, integrated steel mills, needs to be replaced. They could be replaced easily by buying the ore ready to make green pellets and use the sinter bed with few adaptations to burn their pellets and have pellets instead of sinter [to feed the Blast Furnace]. By doing so, they are reducing emissions [by replacing sinter with] pellets. Pellets have much higher iron content, so they're reducing fuel consumption in the [blast furnace], increasing its productivity, and reducing emission again.

This patent that I'm trying to sell in Brazil, because it's a Brazilian patent, nobody's interested. But I want because it's a true new product. Not myself. Like I said, I always when I do things, I have my ideas; I bring them with me the the guys that really can judge then for me. "Oh, Ronaldo, you are right."
For example, Floriano Wendling, a person that was the most knowledgeable person in pelletizing process in Brazil, he died last year, one year before our patent was accepted as true thing. He really said, "Ronaldo, I never thought about that, and I work with this for four decades, all my life, in this dumb pellet system. You came with very simple thing. We could be gaining money with that for longer." He was my partner with two other friends on this patent.

Remember, team is more important than individuals. If I say too much "I," forgive me and take it as we because I am no one without someone even to say me, "Ronaldo, go for it. Go for it." I need. I don't support be alone.

Oliveira:

Ronaldo, I would like to thank you for your time and for sharing with us your wonderful history. It's been a great pleasure for me. And as a senior student of yours, I feel myself in the position to say and to talk about the whole community of students that I know. And I would like to say that we have no actions or words to express our gratitude to you. To being around you is a life-changing experience; all of us know that, and you've been helping all of us along our lives. Thank you very much.

Santos Sampaio:

Thank you.