In conversation with...Rutger Gyllenram

If you're going to ask anybody a question about the state of the steel industry, in a technical sense, you can't go far wrong with Rutger Gyllenram of Kobolde & Partners. It was fortunate, therefore, that STI was in Stockholm where he is based, and that he had a little spare time to discuss, in some depth, the decarbonization of steelmaking. **Matthew Moggridge*** took copious notes.

"I believe we are now starting to understand that decarbonization is not all about using hydrogen," Rutger told me as we sat in his bright and breezy offices on a Wednesday afternoon in late August. "You have to take into account what kinds of iron ore do we have available on the market and is the electric arc furnace possible for all types of DRI?"

Steelmakers have recognized this but it's still not something you will see in open discussion, he asserted. "It's still all about hydrogen," he adds, arguing that while the 'nice coloured drawings' produced with CAD/CAM software are all well and good, they are very far from a realized process, possibly in the region of 10 to 20 years before such process alternatives become a reality.

For Rutger, however, there is a problem and that is possibly a lack of urgency. Steelmakers are quite happy to put up alternative production technologies and say that it is something they will be doing in the future. That, he says, is a major problem 'because it reduces the drive to do something immediately'. And if you're looking at doing something immediately, how about using the processes that are at hand? "We all know that producing DRI with natural gas is cost-efficient and of course you have a carbon footprint, but it's lower than the blast furnace so just by producing DRI, for example, in the Middle East, and charging it into a blast furnace will reduce the carbon footprint of blast furnace iron globally," Rutger enthused. "And this could be done on a large scale within the next 10 years," he added.

"If we look at the hydrogen route, it's not going to happen in the next 10 years because we don't have the fossil-free energy to produce the hydrogen," Rutger explained, adding that submerged arc furnace technology on a commercial scale won't become reality for at least a decade. "Such plants exist, but not on a commercial scale and not in the volumes we need to make a difference," he added.

I suggested that coke making and sintering are the problem when it comes to blast furnace steelmaking and reducing that all-important carbon footprint, which needs to be reduced considerably. "If we are keeping the blast furnace, we need some portion of coke. We could reduce coke consumption by half, perhaps, and that will make a difference and we can make it up with other fuels and, of course, by charging DRI. But the basis of how the blast furnace

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works is that the coke creates these gas windows and it's important to have gas flow through the furnace," said Rutger.

Coke making and sintering cannot be completely eliminated in blast furnace steelmaking, but it is possible to use pellets instead of sinter. "And the good thing with pellets is that you could have a very good reducible pellet with a lower silicon content compared to sinter, so just by doing that you could reduce the amount of slag and, therefore, reduce energy usage," explained Rutger, stressing that reducing coke and coal consumption are things that can be done today.

And there's the rub, so to speak. There is a lot of talk about hydrogen steelmaking, quite rightly, as a technology of the future and not of today – a perspective that breaks down a little when you consider that H2 Green Steel is hoping to be up and running in 2025, which is just around the corner, and that the people at HYBRIT have already proved that it is possible to produce steel using hydrogen. Steelmakers, says Rutger, understand there is plenty they can do now to reduce the carbon footprint of steel manufacturing and while a lot of them have their sights set on the bigger picture – high-capacity hydrogen steelmaking – they are currently operating within the confines of their own economic resources.

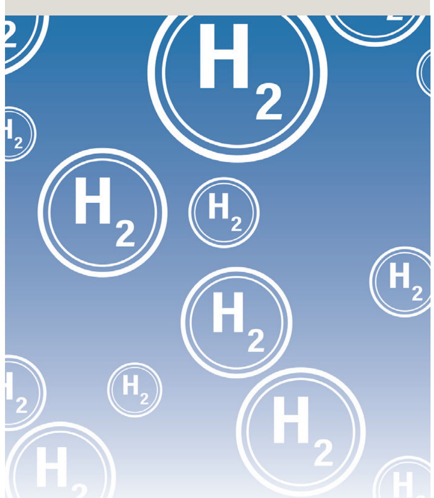
In other words, this isn't the end of the blast furnace – far from it. "Oh, yes, I think that everybody agrees that. What we have to say is 'keep your blast furnaces, but you must do the improvements that are possible; and I think that would be a much better attitude, and the companies can then say, 'okay, we have the blast furnaces, we don't know if we're going to keep them', but we must get rid of the possibility of doing nothing."

Whether the climate targets set will be achieved is debatable. "It depends on what we do and how we do it," according to Rutger. "To be honest, I don't have a clue, but what strikes me and what terrifies me is that people don't even consider the risk of standing there in 2050 without any improvement."

The steel industry cannot sit around waiting for the grand solution and must instead look at what can be done today. "And then we improve, improve, improve and the absolutely simplest improvement that you can make is mass produce DRI in countries with natural gas and charge that

Rutger (above) is optimistic for the future:

"I think that the sooner we have a discussion based on facts and not wishful thinking, the better"



into the blast furnaces," Rutger suggested.

Charging blast furnaces globally with pre-reduced material by replacing a certain amount of the burden with DRI will reduce the carbon footprint and it is something that can be done today using current technology. The DR plants needed, says Rutger, can be modernized later, converted to CCS or hydrogen. "It's the suppliers who say their technology is hydrogen-ready – very good – but you can start with natural gas. Let's stop charging blast furnaces with only iron ore and sinter and start charging them with DRI."

The whole notion of 'either we reach the top or we don't go anywhere at all' is misguided. And while, says Rutger, there are ambitious companies out there going for the top prize – HYBRIT and H2 Green Steel spring to mind – most companies will not reach that level for a very long time, but they could be 'carbon or climate-improved', which is a step in the right direction, rather than saying their steel is not fossil-free. It's all about taking whatever steps you can, says Rutger.

Kobolde is in the process of auditing existing 'new steelmaking technologies' to understand what kind of standardization will be needed going forward. So far, the company has listed 25 initiatives, some of which are very ambitious and others less so; but ultimately their existence is all about giving steelmakers something to show. But the auditing exercise, like most things, throws up more questions than answers and has led Kobolde towards answering questions on standardization and what kind of standards will be needed in the future – and working on existing standards. It is important that fossil-free steel really is fossil-free, says Rutger.

"You need to have all different kinds of levels: you need, 'climate-improved' – meaning the steelmaker doesn't have to go all the way; or you can have 'climate neutral' meaning it's not fossil-free but something has been done – offsetting or carbon capture and sequestration (CCS) – or you can actually work with something which is fossil-free," Rutger explained.

He says that standards – or levels of 'greenness' – are essential in the brave new world of green steelmaking. "You really need to have all these levels and, of course, if you can do things without involving fossil energy, that is the best thing for the future, but we will see where we land in the

An artist's impression of H2 Green Steel's Boden facility in Sweden

future," he said.

"When we talk about 'do what you can now', we must understand that developing a new process takes time and we haven't really seen what kind of development problems are possible with hydrogen. It is excellent in the way that it doesn't emit carbon dioxide, but that is the only merit. The reduction process is endothermic so there is a need to work very hard on heat balance in the furnace as hydrogen has a lower CP and, therefore, it carries less energy and, of course, travels very fast because it's very light. It travels very fast in the shaft and that is seldom mentioned in the articles you read. You say that, okay, you can calculate an energy use, you can calculate yield, perhaps, but you can't really calculate the practical problems. I'm not saying it's a bad idea to reduce things with hydrogen, just bear in mind it is not all that simple," said Rutger.

Rutger believes that current test facilities are small or medium-sized pilot plants. He believes, therefore, that it will take decades before the industry comes up with the same module sizes for a 100% hydrogen plant that it currently has with a natural gas plant. "If we have it by 2050, it's a great success," he said. "But that's my assessment, I may be totally wrong. I may be pessimistic, but the problem is not if I'm right or wrong, the problem is that when we make our decisions today about what to do, we should take into the calculus that we have this risk and then if we solve it, wonderful…but don't count on it

"Nobody has done it yet, in terms of work out a way of using hydrogen bearing in mind its low capacity to carry heat and other aspects and yet that is what SSAB and H2 Green Steel are saying they are capable of doing," Rutger said. "I can't say they are wrong; I can only look at the number of process ideas that come up every year and how many of those actually succeed, which is close to zero."

Another big question is whether operators are confident that those supplying the technology can do what they claim they can. Are they trustworthy? "Anybody buying this technology off-the-shelf must buy it with guarantees," he said.

Lastly, the question of DRI, an essential ingredient for fossil-free steelmaking, but is there enough of it or will operators have to rely upon scrap?

"Well, it takes a couple of years to build a DR plant so I think that nobody would build an EAF plant without having sorted out where they would get their raw materials, so I guess it's self-regulating in some way," explained Rutger. "Sweden, for example, exports scrap so I've done some calculations and for Sweden to supply SSAB Oxelösund and H2 Green Steel in Boden with Swedish scrap, it's possible to a large extent, but we'd have to upgrade the scrap; so if we're only talking Sweden for the first part of H2 Green Steel's expansion I don't think it's a catastrophe if it takes time for them to start their DRI production. It may be possible, but of course then we would remove some scrap from the world market and scrap prices may surge, so in the long run I think we really need to produce more DRI globally."

At this moment in time there are only two DR processes – Midrex and Energiron. Operators must have one or the other. I asked if that situation is likely to change and whether a third process was out there somewhere.

"There is an Iranian shaft furnace process and they've built some shafts in Iran, but of course it's similar to Midrex or something like that," Rutger said. "The big difference between Energiron and Midrex is that the former is a high-pressure vessel for auto-reforming of natural gas in the furnace, whereas the Midrex process has the reforming outside."

As for which process to choose, certainly it's a case of who gives you the best deal, that's important, said Rutger, and there are trade-offs between the two processes, he added. "I've spoken to a guy who has been working with both processes and he said that Energiron is the process with the lowest OPEX. The Midrex process is more stable and easier to use," said Rutger, and there are clearly advantages on both sides.

Whether one process will become the dominant force in the hydrogen era is uncertain. "I don't think anybody wants to have just one player in the market," said Rutger, arguing that more players are needed. "I think HYBRIT is trying to develop a third [process] and I think their plans are to develop a process of their own, which they will sell or licence. Cost for development of a new process, of course, is a big problem.

Making fossil-free steel isn't rocket science, according to Rutger. "If you take iron ore and pour hydrogen through it you will get iron," he said. "The interesting thing is you need to get it with a minimum of hydrogen circulation because if you have a very low utilization ratio of the hydrogen at the top then you will have to take it back and cool it, dry it and heat it and send it in again, circulating it several times. The basic idea is that you need to reach close to the equilibrium between hydrogen, water vapour and iron oxides in the off gas and if you don't reach that then it will become very costly."

The cost is immense, said Rutger, and

the best calculations suggest that it will be 30% more expensive compared with conventional blast furnace steel.

But what about the consumers? What if the automakers say they don’t want to pay X more for fossil-free steel when they can get ‘climate neutral’ steel cheaper? How much is the stamp ‘fossil-free’ worth and will consumers consider it worth buying when there are other categories of ‘green steel’ out there that might be considerably cheaper?

In other words, a huge minefield awaits operators in the steel industry of the future. “They will need to put a lot of effort into promoting the ‘fossil-free’ concept in terms of comparing net and gross CO_2 emissions. Gross emissions are before offsetting or CCS and then you have the net, which is what comes afterwards, and if you only look at the net then you may have climate neutral steel from a number of production alternatives. With hydrogen reduction gross is fossil-free which is an advantage that has to be explained, and companies going for hydrogen reduction are aware of this and are struggling with it now,” explained Rutger.

“A waiting game is in progress,” said Rutger. “We have Hybrit and H2 Green Steel and many other different processes at different stages of progression. We’re not quite there yet.

“I started my career in the 1980s, we had the steel crisis in the 1970s and everybody said then that we must renew the steel industry in Europe and America and do something new, get rid of the blast furnace, the sinter plants, the coke plants and do something different,” said Rutger. “In Sweden we had five or six process ideas and many more in the world and many of them were developed to pilot plants and later closed. As a young researcher I spoke at a conference in Jamshedpur, India in 1988, talking about iron and steelmaking under Indian conditions. It was great fun, we compared the different processes and, of course, since the new processes didn’t have the capex of the sinter and coking plants, many of them out-performed the blast furnace by far in theory. But the reality was that if you have good raw materials, process them in the coking plant, in the sinter plant, you charge it properly mixed and you replace some coke with coal injection and so on, the blast furnace becomes extremely competitive and furthermore, it was possible to scale up, so whereas many of the new processes could go to 500kt-1Mt, the blast furnace went up to 3.5Mt in just a decade. In the end, from all these projects, only Corex and its sister project Finex based on coal gasification technology survived the development boom. Otherwise, some of the alternatives were built in one plant, and operated for a short period.”

Ultimately, Rutger is optimistic for the future. “I think that the sooner we have a discussion based on facts and not wishful thinking the better, and then we can do the real stuff and companies will understand what they need to do and what they need to do now,” he said, adding that he is currently working in industrial consortia on iron reduction with syngas of biogenic origin that with CCS can create a carbon sink and on improving the quality of recycling, taking care of the alloys and finally trying to get the industry to understand that we need to go to the start on a wild scale, to charge blast furnaces with DRI.

“And understand that you may produce DRI in one place and use it in another place and if you do that, you’ll have a good start, a reasonable way to start, and you can start now, tomorrow, and then, when we have the new technologies, then we’ll go for that.” ■