Advances in Additive Manufacturing of Materials: Current status and emerging opportunities

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Welcome back, let us continue with our next topic. We saw in general the AM flow, how the technology of laser powder bed fusion works, we have seen different case studies, we saw multiple of the application use cases, how industry has been using from medical to automotive to aerospace and many other engineering cases, how this is being used. Now let us look at some of the actual practical challenges that are there in this whole technology and what sort of solution can we offer to the industry. Now this has been our additive journey in terms of what we have been working on from design for additive manufacturing to printing multiple parts, manufacturing multiple parts to understand the customer requirement. producing them from rapid prototyping to batch production to volume production. We have understood qualified new materials and offered it for different applications and finally we have come up with our own indigenous development of products and solutions.

Now before we move further let us look at the challenges that are currently there in the industry. If you look at it currently the lower adoption of this technology is largely because of low productivity rates people are still comparing this technology to the conventional manufacturing when you look at it in an automotive or in a conventional manufacturing route where you can get parts out in a few seconds or in a few minutes this still takes many hours if not longer. your production rates are lesser, your availability of equipment itself is very high people believe or at least the product costs are very high which is making it very challenging to adopt it much better. We have maintenance costs are high because of the low volumes to maintain them you have much higher spare part costs of these equipment.

Your conventional manufacturing processes any day cheaper or much more cost effective than the printing route or the additive manufacturing route. Then we have when the machine goes down availability of spare parts or having service members, service engineers is again another challenge. You have a lot of restrictions in the process. in better adoption of this whole process. So you do not have a lot of flexibility in the parameters and using them.

Then you have limited application support, there is limitation in terms of the material, suitability of the material for the end application, you have limited application knowledge in the industry. this is again another limitation that is there and finally we are unable to monitor, we do not know the productivity, we do not know how this performs in the actual application and then finally see what sort of results we get out of this. these are some of the challenges which have been there for many years which is what is causing lesser adoption of this technology by the industry. Our intention is to see how we can change this by providing solutions around that. this is our flagship product what we have launched which has high power from laser perspective which can address the productivity application or the productivity issue.

It comes with a large build volume so currently what machines are there in the market are largely small and medium size but our intention is to see how we can address larger size requirement problems. and complete flexibility in development, we co-create material, we co-create applications along with our customers and much higher printing time in the whole process. Now, we have included a lot of smart features on this to make sure the whole raw material processing happens faster and is much more smarter and intuitive in its nature. There is a lot of real time monitoring, so it gives you remote connectivity, you are able to monitor, watch what is happening in real time. These are all some of the challenges for which solutions have been found by us.

Complete hand holding, there is a lot of awareness building and hand holding that is going in, in terms of better adoption of this technology. A lot of application experts interact with customers to give this solution. And we give an entire end to end solution for additive manufacturing to our customers when it comes to better utilization of this technology. what we have developed as one of the first metal 3D printers in the country is this machine called as STLR 400 it comes with a large bed of 400 size multiple lasers gives lot of flexibility in the layer thickness where one can go from a very small layer thickness to a high one it comes with a laser spot of a good size of about 75 to 90 microns a lot of innovative features on the product itself has been adopted here. We also have couple of other products we call them as STLR 180, a smaller one more from a small size faster production perspective and we also have a STLR 120 which is a new launch for research and lab applications where very small components can be done in a very fast turnaround time.

these are some of the products that we have from a size and build volume perspective which has been serving defense, space application, aviation. medical automobile and mold making engineering applications. some of the materials that we worked on or we are still working on include these and not limited to these you have aluminum alloys different types of aluminum alloys in different layer thicknesses for various applications.

Aluminum alloy gives you not only light weighting as an application it also comes with the many other features in terms of non corrosiveness and very stable in terms of the reaction to environmental materials. You have stainless steel different grades of stainless steels which have been worked on SS316L, we have SS304, SS310, they worked on 15-5 pH, 17-4 pH and many others.

We have a tool steels titanium for again titanium for aerospace application, titanium for medical application. We have seen maraging steel plenty of applications that have been done. We are working on some combination of materials for specific use and application today be it magnetic material like FeCoV or diamond based material again for some high hardness applications. We worked on cobalt chrome again specifically for medical application. Copper chromium zirconium is another interesting material which we worked on and developed and offering for customers.

you can see one of the biggest. A growth area today for additive manufacturing is material development, suiting specific application. Still this is not a match compared to what is available in the conventional manufacturing route where we have hundreds if not thousands of materials for very specific application. What we end up doing is identifying what material meets what properties of the end application and we try to match them as closely as possible either in its native form or after some treatment. be it heat treatment or some surface treatment processes.

we meet the end application properties as closely as possible to make sure that the materials can be used by 3D printing. Now some of the other aspects that are required are software, software is a key aspect so we have a lot of software being developed in house be it from powder management to the screen that you are seeing here where a lot of intuitive features have been built in to make sure we have smartness that are included a lot of color coded screens are provided to ensure all the necessary aspects including IOT and other features are demonstrated and provided to the customer so making it very user friendly for the end user when they are putting it all to use. This is a software you can see all the color codedness here making it very fuzzy where the operator or the user does not have to remember the parameters or the features that are there. Green and red colors is sufficient for them to understand how these software can be used and making it very user friendly and interactive. Today something that is missing in the conventional 3D printing route is having reports I mean to have data or information of the printing process.

these are interesting aspects where you are able to capture all the aspects in terms of what for the process condition during printing after printing. or what sort of interruptions did we have during the printing process, what material got used, who was the operator, what was the filter status and how the transition happened during the printing process. All

this is captured and provided in the form of data, this data is available for any particular processing in terms of any data generation all this data will be stored and available for any model that is to be built around either statistics or for any future development of a software by the end customer themselves or co-create along with us. all the data is recorded and then made available for the end customer. We have in-situ monitoring where we have camera vision based system again here we have an interesting software that has been put together where on an edge detection basis we are able to identify any war pages any sort of a defect that is potentially arising in the whole printing process and we are able to detect that and the operator is free to decide if this has to be continued or this can be stopped and then further modification has to be done.

such intuitive solutions are also provided. you can see the part that I showed earlier which was printed in Inconel 625 in as low as 19 hours this is basically an exhaust mixture of a rocket engine which conventionally followed a different route of manufacturing. Now, we come from a machine building background, so we have manufactured varieties of machines with over 90,000 machines installed all around the world, many years of experience, many customers and many of them are repeat customers. We are driven by technocrats who have been founded the company and running the company here. And we offer end to end solutions is not just one technology but complete design to manufacturing process and finishing process is what we offer as a end to end solution including material development and raw material provision and completely finishing the part and getting it for final use.

this is what we have on offer and we make sure the entire solution can be offered by the group here. A lot of R&D has been happening, we collaborated with the different academic institutions in and outside the country to learn faster and accelerate our development processes in the whole journey of what we have achieved till now. One of the unique aspects that we are working on is to see how we can make this whole solution available for the mass utilization in the country and outside. If you see the original comparison between metal 3D printing to conventional manufacturing there is a huge gap between what the productivity and the cost per component is currently. our intention was to see how this gap can be bridged so we identified larger size machine that we have built so you can produce more number of components if they are smaller in size then we have done multiple multi laser solution which can print faster and produce much many more number of components.

And combination of higher power along with this allows you to print at a higher layer thickness making it even more faster in the whole process. Then we also work with more cost effective powders to ensure that not only the equipment cost but also the raw material cost is much lower and as a combination of all this the intention is to see how we

can come much closer to the conventional manufacturing process. If you see conventionally the multiple can be anywhere between 10x to 20x. times the conventional manufacturing. Our intention is to see how it can come down to at least 1.

5x going ahead so that 3D printing can become more and more affordable. This is just a tangible multiple of what the manufacturing cost is. The other intangible solution or what the technology can offer in terms of your light weighting saving of raw material, the advantage that it can give from making it available much faster, faster development and complex geometries all those are additional benefits that manufacturers are exploring. Today in many cases as I explained earlier the solutions where the volumes are very low be it engineering, energy sector, defense and aerospace applications people are finding this much more easier and faster to adopt. today people have considered this as one of the key manufacturing technologies in the process.

If you actually look at manufacturers like advanced manufacturers like Boeing, Airbus they are all designing aircrafts which are to be launched in 2030-2035 which will have significant amount of additive manufacturing used in their in the whole manufacturing process flow. the advantage that this is offering is as I said the light weighted structures. Today if aircrafts are lighter they are able to fly much longer as you can see today there are aircrafts which are flying much more than 20 hours and 22 hours which earlier used to be not more than 10 to 12 hours. the advantage that it gives you is shorter journeys and better comfort to the end user. additive is only one of the technologies but there are many other material advancements also which have led to this as a solution.

As we speak today already there are more than few hundreds maybe at least about a few ten thousands of parts which are printed in metal which are flying for even commercial aviation. When it comes to defense and outer space applications there are many parts which are being 3D printed and being put to use by most of the space application enthusiasts and the advanced manufacturers both in India and outside. that is the advantage that 3D printing is offering to different application segments. Coming back here the advantage is that we are looking at is bringing the manufacturing process cost to much closer to the conventional manufacturing process. Some of our current research areas that we are working on are multi lasers today as we know lasers is what is going to be contributing number of lasers is going to be contributing to the productivity.

what is currently taking many hours the idea or many days the idea is to bring it maybe less than a day for making medium sized parts. It still has human dependence so trying to see what amount of automation can be built into the whole process be it from a design perspective what can be automated taking either as I explained earlier the human involvement in identifying components, screening these components. Today if you see

there are only limited number of components that are actually has a value proposition to convert it into 3D printing. Not all parts are readily suitable for 3D printing, it will have to be converted either by doing a lot of design for additive manufacturing wherein you are making it lighter or combining integrating multiple parts into individual parts thereby giving you that value or by maybe doing something more complex in the whole process. that is something that we are working on starting from software automation to identifying parameters, manufacturing process identification and finishing the part the printing process itself trying to make it more automated and then once you are printed the finishing of it trying to see how that can be automated in the whole process.

automation is the key. The volumes are increasing if you see as we spoke as it is we have multiple sizes but the general trend that we are seeing is the sizes of these machines are growing as we speak because adoption is increasing more and more larger size parts are being considered for 3D printing. the expectation in the industry is to have larger size machines which could be which can accommodate much larger size parts in the whole printing process. this is something that is coming up as a growing trend in the near future. Coming on the other spectrum we have the smaller size machines people are exploring more precious material to be printed we have interesting exotic materials which are very expensive to be manufactured today people are talking about gold, silver for jewelry applications people are talking about niobium for very specialized applications and space and others. many other types of exotic materials which could range the cost of which could range anywhere from about 25,000 rupees a kilo to about 4 or 5 lakh rupees a kilo.

now that is going to be making it very difficult if your machine sizes are large because the entire part which is getting printed. has to be submerged in a big cake of powder. Now when you have lot of powder being used it becomes expensive to manufacture them even if you are printing a very small part or a very light weighted part to have that submerged in a large cake of powder is going to be very expensive. making machine smaller is also interesting and today people are talking about nano printing or nano manufacturing where your laser spot sizes are very small. Where it is getting to close to 10 or 15 microns, so you are able to print much more accurate parts, much more thinner wall structures.

You have the entire science is different when it comes to that because your powder geometry changes completely, your laser spot changes, powder flow ability becomes different. making sure all of that are addressed is what can happen as a growing trend in the future. this is again something that is happening more. And as I said, there is a lot of AI and IoT features that are coming in, a lot of conversational programming, a lot of interactive aspects where user gets to be more involved and a lot of machine intuitiveness

is being built in, experience of the past by manufacturers are being captured both at a design stage. to create parts to screen the parts quickly and identify suitability from additive perspective.

There is a lot of work going on in terms of understanding how these parts can be made more suitable for printing through design for additive manufacturing where be it automatically by feeding certain parameters which are required for the end application software should be able to give you feedback in terms of what can be made in what changes can be made in the design to make it more suitable. for printing either make it lighter or make what sort of combinations of these parts can be done to make it more suitable for printing. And then finally when it comes to the printing process itself lot of work going on in predicting the whole parameter set to tell how we are able to achieve the end goal. Now the end goal for every application could be different. Someone could want might want hardness and strength as one key goal here someone would want higher surface finish as a specific end requirement or maybe another application might want integration of parts as a goal here or minimization of rejections here.

better temperature distribution could be another goal here, so meeting specific goals is what software is offering today in terms of prediction and trying to demonstrate the intuitiveness through prediction and many other tools of additive that is coming up and of course as I said today machines are remotely monitored, remotely controlled, so one is able to see what is happening. Today people are talking about lights off factories where multiple of machines are going to be working with raw material being fed continuously and parts being removed automatically and being distributed for different applications. this is not going to be too far where we will have factories where multiple of these machines are working and you will be pushing programs from different parts of the country or the world and parts will be manufactured more in an autonomous way. A lot of material research is going on as I explained earlier today the material basket is limited to the printability, the weldability but if you actually see some of the most advanced academicians today are researching on converting material more and more to suit 3D printing. what additional alloying element can be added to make it more weldable, more printable is what is the research area being worked on by many researchers, many academicians which is very interesting because as I said some of the applications are very critical be it marine applications, be it aero applications there is no flexibility in changing the material.

which is what is has been one of the limiting factors or in adoption of this technology into a wider spectrum. now this is an area that all of them are working on or many academicians are working on to see how we can create more and more materials both from the mass production automotive industry to the highest level of medical and aero

defense applications, marine applications as I said which is the cream or the top end of the entire manufacturing pyramid. a lot of work in this material development is happening some of the other conventional material manufacturers are trying to see how we can create these materials more and more to suit the end application. the challenges involve manufacturing of these powders. How do we get the gas atomization or plasma atomization of these powders or materials into the volumes that are required, getting the process parameters right and making sure that these materials are actually printable because through the process of laser powder bed fusion, we end up having a lot of cracking and other deformations which are challenging to control in this methodology.

getting that process right is what a lot of research is going on. And as I said productivity parameters one of the key aspect is that even today one of the concerns that manufacturers or end users have is the time that it takes to manufacture. as I said one of the goals is to see how this can be made faster better and more cost effective. the productivity is the key especially for a higher volume market like automotive or general engineering where we are talking about few hundreds of thousands of these parts being produced on a daily basis. Today we already have manufacturers who are working with 10, 20, 25 lasers on a machine much larger size machine much higher layer thickness.

what used to be very very long printing time are already shrinking down and people more and more are adopting to this because for their volume requirement it may be sufficient which I said as I earlier said medical application aerospace defense and space already have started adopting this more and more as they progressed into this technology. this is going to be a requirement in the near future. that brings me to the end of this presentation here where we have seen the materials, we have seen applications, we have seen different case studies by different manufacturers and we have also seen how additive manufacturing has moved from just a prototyping to batch production where lot of small volumes are being printed for various applications and in many cases it is also more to serial production be it in space, aerospace, aviation, defense, medical be it as we said dental copings and many others which is being used for mass production also. this way additive is not just a tool today it is an entire science which is being used for a diversified application segment and it is going to become more and more useful in end use application. thank you very much for listening to us in this whole lecture series. Thank you.