Design, Technology and Innovation
Prof. B. K. Chakravarthy
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Lecture-1
Jaipur Foot - A classic innovation Part 1

So, good afternoon all of you and welcome to the course design, technology and innovation. This course is a combination of three large sorts of areas, not even disciplines where we need to see you know how we can come up with innovation using design and technology that is our major focus.

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So, for today's class we will consider the Jaipur foot as our case study. Important aspect of the Jaipur foot is that it is prosthesis. The prosthesis are different from ones which are put inside the body.

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These are which are artificially they're supporting the body from external aspects when there is an amputation or in some deformity in the legs or in the hands.

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So, this Jaipur foot is an extremely unique design and according to me one of the best innovation examples in the country.

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This was started very interesting collaboration between a craftsman called Ram C Sharma who was you know basically building polio calipers for children and he observed a bicycle on the road and said why can't I make a foot as strong as the bicycle tyre from these.

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So, he started building wooden mock-ups because he is already working in the SMS medical college in Jaipur.

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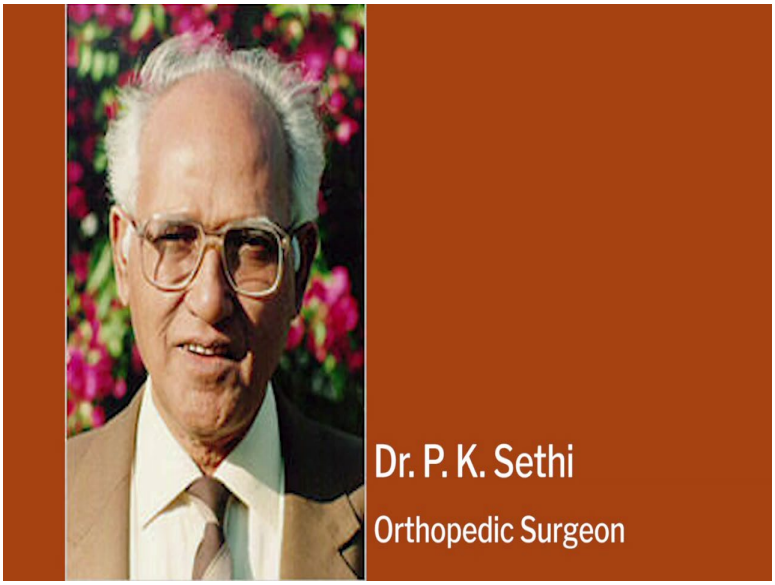

He had this orthopedic surgeon Dr. P K Sethi, so he would go to the doctor and say I am working on this.

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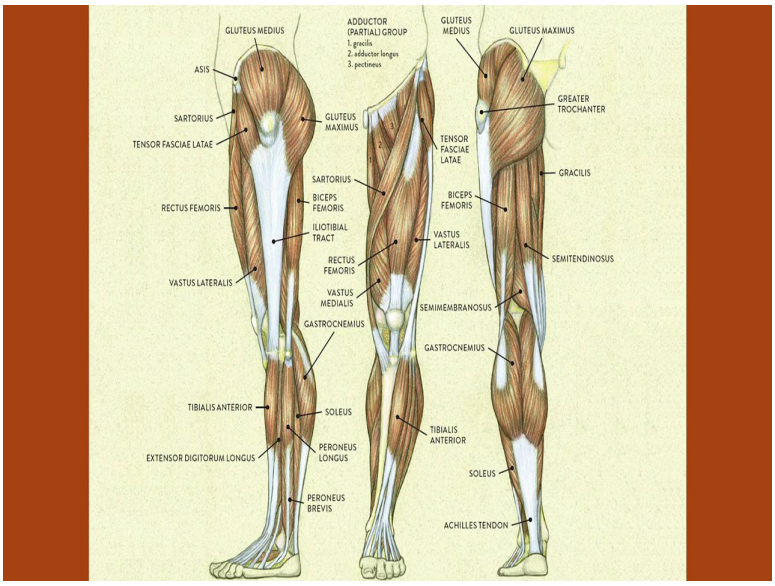

So, the doctor would give him all the anatomical details: what type of system should be done, what type of gait the leg would have.

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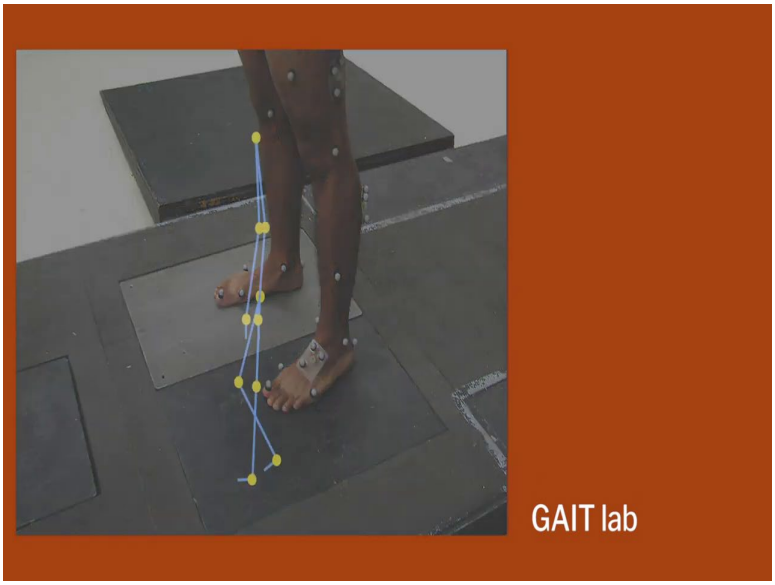

So all those details he would provide.

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And both of them together built multiple samples so there is an initial node development which happened. So, basically the Jaipur foot will have three major components.

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The prosthetic foot is the most critical one in this design.

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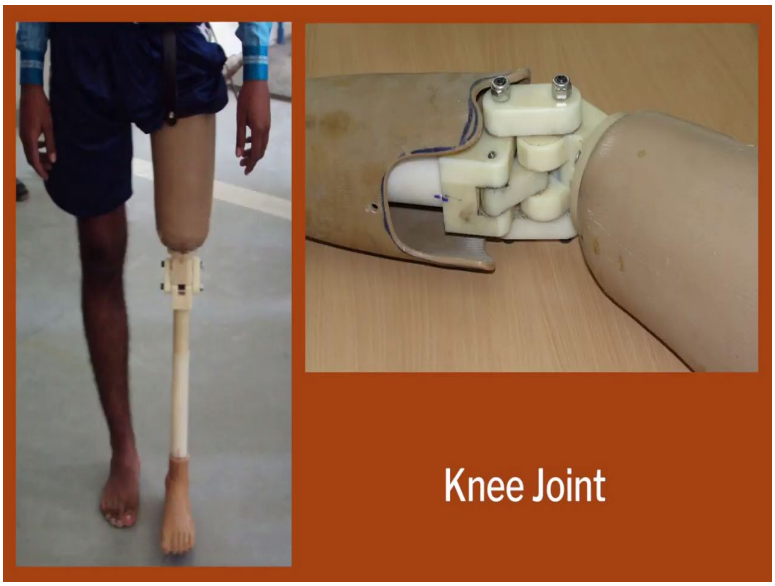

The knee joint if it does not you know upward amputation the above-the-knee amputation you will have a knee joint.

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And a socket and shank to fit the thigh areas;

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So, below the knee prosthesis, you will just have the foot and the shank which will fit into the leg. In 1969 they started, but it was not going forward. They were doing some 10 or 20 prosthesis for various you know patients who would lose their limbs and it didn't you know really scale up.

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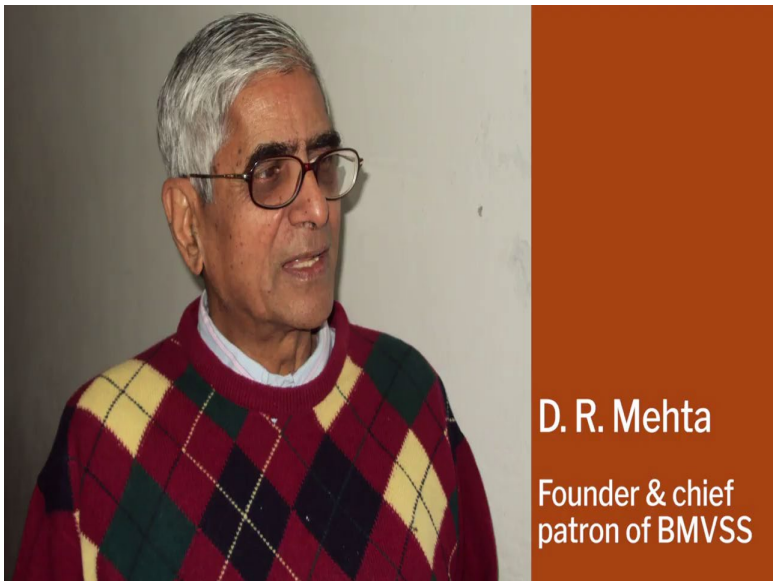

So, the scaling up was done by Dr Mehta who was an IAS officer who took special interests in the Jaipur foot.

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And he has to, he had to pick it up from the hospital and make it into a society and he said 'I am going to provide this Jaipur foot free of cost and the quality will be phenomenally good', and then since then you know with this has been a revolution. So, interesting situation is that the doctor and the craftsmen team kept the Jaipur foot at a very low volume level, not because the Jaipur foot did not have the potential, just because of the human tendency of not understanding how you can scale up whereas an IAS you know, an Indian Administrative Service, you know retired professional would actually talk about scaling right, talk about reaching more number of people. So his whole

strategy was how can I make this reach across the world you know across the country to all the you know people who were handicapped.

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We have the dancer from you know Andhra there was a movie called *Nache Mayuri* and she actually danced in a program and there was a large movie and that made it very popular. Everybody got to know about it and you know a lot of people started coming to Jaipur to get the foot. So, that is how the whole journey started and our interest in the product came up.

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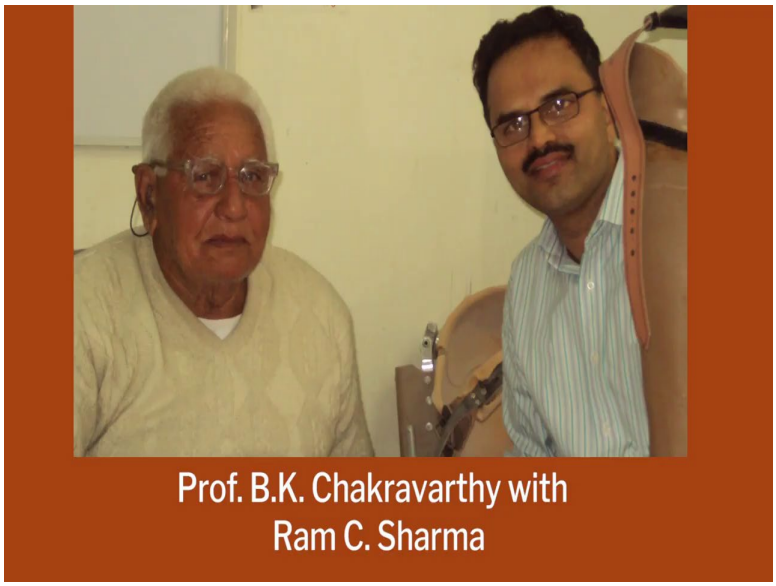

And I visited the place; I got a phenomenal insight on how this Jaipur foot was helping the poorest of the poor in the country.

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The people who get amputated generally are farm laborers, truck drivers, salt pan workers.

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Tell me why would a salt pan worker have an amputation.

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Salt panning, making salt, infection from any cuts or wounds in his leg while being on the sand. So, that infection can cause gangrene and then they would need to amputate the leg. Lot of people are like that. So you know that is a very good case for us to consider salt pan workers where else you see you know standard cases of amputation.

Student: Heavy machinery.

Sir: Heavy machinery, very good, heavy machine generally, you have amputated arms, legs in heavy machinery little, little less but it is there. And truck driving and you know accidents are more common you know for the leg amputation.

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So, here you can see the person walks in. He gets the prosthesis.

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And he goes back the same day walking.

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Unbelievable;

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All this is done because of the association: The Bhagwan Mahaveer Viklang Sahayata Samiti.

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So, the vision of BMVSS you know is that, you know, they want to actually give both the physical, economical and social rehabilitation. The whole organization which build that type of system because the people who come, is very important, the people who come are extremely poor, in fact, most of them who come do not even have their breakfast. So, when they come they give them food. For the everlasting credit of D R Mehta, that IAS officer he said 'Chakravarthy did you observe that these people who come do not have one disability. They have three disabilities'.

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One is amputation. The second is they are extremely poor, because why they got amputated I believe, they were out of work for six to seven months while they were recuperating with the operation or with the leg and they would their, all their finances would have dwindled and then the

third disability is that they were illiterate. They only had a skill. The large number of people who would come 90%, 95% of them.

So, I need to tailor make the design to suit the design of the complete system to see those type of people. If I identified only one disability as handicaped then I would do anything in the world. Let me give a small example over here.

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We had Abdul Kalam who was the very senior scientist at the defense metallurgical Research Laboratory much much earlier.

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He went to the Jaipur Center, Jaipur foot center and he said my god this Jaipur foot is very heavy because I am coming from the context of metallurgy and fiber reinforced plastics and polymers and all those things.

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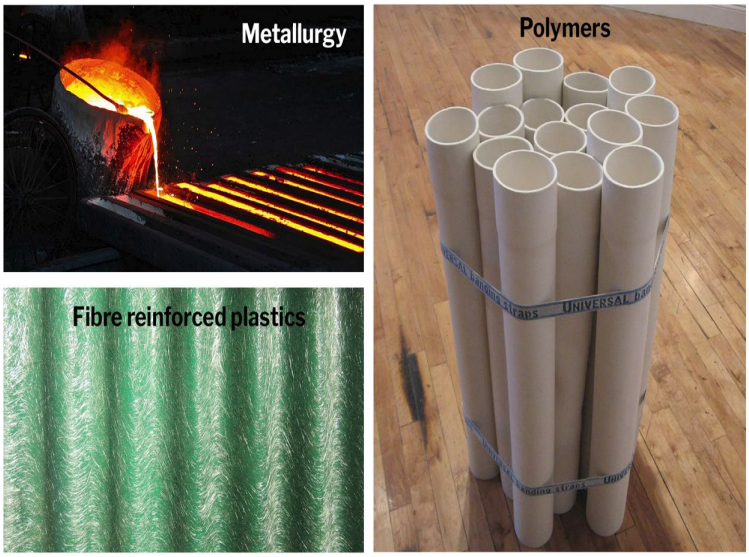

So, he said 'I have all these technologies in Defense Metallurgical Research Laboratory (DMRL), why can't I use it for the benefit of the people?' Very noble thought, ok? So the project was given to DMRL.

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So DMRL came up with this fabulous carbon-fiber shank to be mass manufactured in the factory, then made the foot design, the best possible rubber and that's it. And it is in the showcase of DMRL

even after 25 years now. I'll tell you what happens there. It is very interesting that it is not just technology or research or value proposition, it is about the combined effect of the situation for which the product is being made.

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Every small component in the product from the cost, from the customization, from the delivery, from the mechanism, from the deployment, everything is very important. Just imagine that prosthesis was costing thirty thousand rupees and the Jaipur prosthesis was just two thousand rupees. D R Mehta would said 'I would actually fit with two thousand, I will rather fit fifteen people rather give one to one high-end prosthesis to one guy. So, I will save fifteen lives rather than saving one life'.

So, he didn't pick up the technology. So, this is the interesting study where I am trying to say that you should not come from your perspective for any of these types of very interesting studies of innovation. You need to very, be very focused from the perspective of the end-user. Whom are you know working for? So, that is the issue about, the social rehabilitation for the disabled.

So let me show you a video on how the thing is manufactured. You all observe it closely of how the whole aspect of the you know aspect of the details I told you about customization, about finishing it off one day, type of manufacturing, what all is happening you know I like to run this video for you. So, this is the centre in Jaipur.

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They come in. They are sort of, they are taken in one by one. Everybody comes in you know to take their cards and a very simple process of using a plaster cast to get the exact mapping of the stump. Then you make a knee cast out of the female thing and you have the stump which is your exact replica of your lower knee prosthesis. And then you use, you know, the process of plastic forming and he is now adding the leg part to it so you add the PVC to fill plaster in that, so they get the complete leg part.

So these are those high-end or you know of no polyethylene pipes which are heated. When you heat plastic, thermoplastic, to a temperature they become malleable, they become moldable. So you know get the size into shape and then you come down to the bottom parts where single single plastic, you know, small small parts, various, you know, fingers are put together bound by rubber and then you know put into the dye and then pushed into the vulcanizing machine which is the oven.

And here you have you know after the vulcanizing you have your foot piece ready. So, once the foot piece is ready so you got the whole pipe ready and then it is fitted onto a human body and then you know the person then goes home with the leg. So, this whole process happens in a day because the BMVSS has done all the planning of keeping all the parts ready, manpower ready, who know how to, you know handle these types of large numbers of people and take the thing you know forward. So, there are a lot of things happening, a lot of tests happened, the whole world stood up to this innovation thinking that there is something great about this part because this leg, the prosthesis was better than the imported prosthesis in multiple ways.
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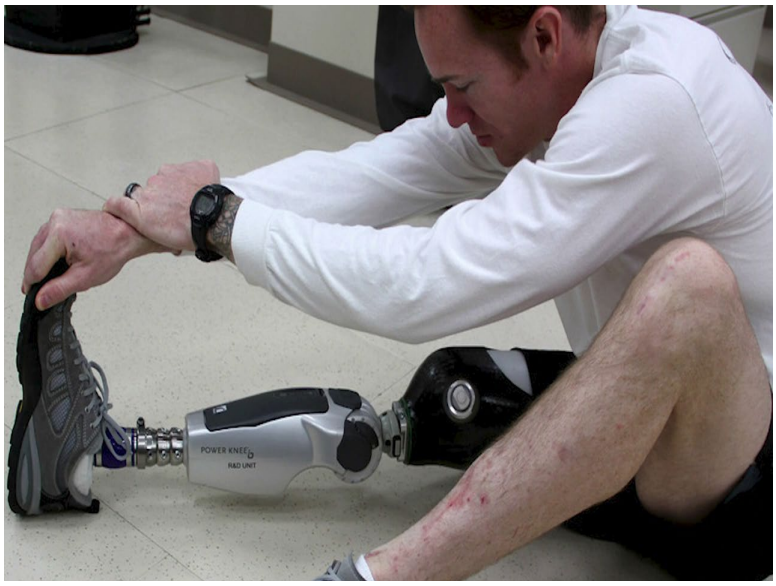

Tell me one thing if this prosthesis was costing two thousand (rupees) and it is better than the prosthesis from Germany's Ottobock or the American prosthesis, what do you think is the reason?

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Any guess?

Student: Sir, one is that it looks like a human foot.

Sir: Very good, one sure short thing is it's exactly the human foot, but that doesn't give you that type of advantage.

Student: It's cheaper so more people can easily get it.

Sir: More people can get it. That is also a very very good point.

Student: It's customized for the person.

Sir: Very good. Hit on the nail. The top mark is for customization, what happens in the International prosthesis they make sizes: Small, Medium, Large, XL.

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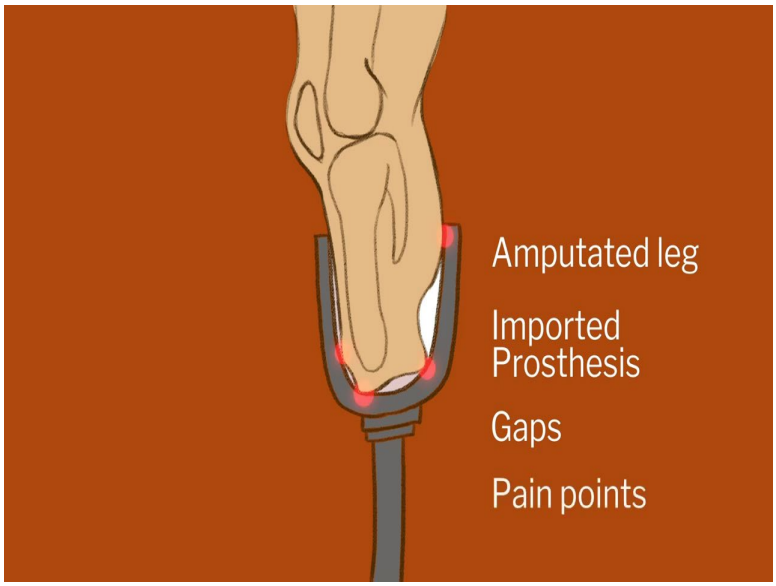

And whatever sizes you make when you put on your stump it will be loose. It will never fit exactly to the size of your stump. So, what happens. This is a prosthesis. Walking, so much of movement, so the scaling happens on your stump, you get sores on your stump. With that problem, get further component they stop using the thing. And if you get a swollen stump you cannot use your prosthesis it is extremely critical.

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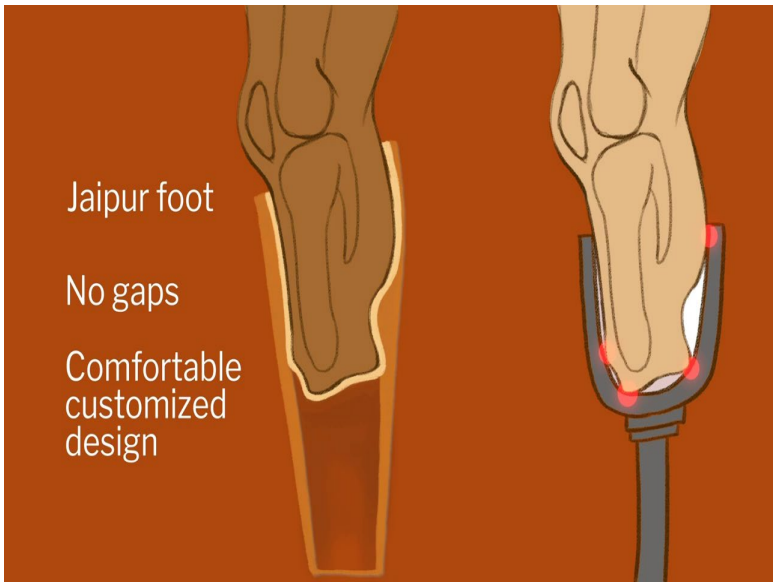

So, look at the beauty of the design. This design with the limitation and the hard work of bringing all the people together, rather than sending the prosthesis to various locations you bring the people in, right? It's completely reverse of an international, you know, supply chain activity. So, by doing that you are getting something which is highly valuable for a product like a prosthesis.

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If I trade off, I would trade off mass production to customization, got it?

Student: Sir, so you said it was custom made, so is there any part that is pre-made, the part that is not attached to the stomp?

Sir: Very good question. It is customized but the customized part only is the stump, stump. Whereas the foot parts are all readily available. Whereas the pipes are formed as per the heights of the people. So, only the customization part is the; is it pipe assembly. The formed you know stump assembly, okay?

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So today, you know, it's the most widely used prosthesis, people run, people play. In performance it is more closer to the natural foot.

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Because here when you do a standard prosthesis you cannot bend your leg. The amount of bending you can do in this leg. Okay?

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So, here we have customized fitting of the leg, better than the imported prosthesis, the biggest advantage comes that you can work in your salt pan lake, because it is completely sealed. Look at the bottom it is rubberized silicone rubber so you go in a salt pan lake nothing happens to it. The top is highly chemical resistant, polyethylene pipe so that is also you know very, very good for your use.

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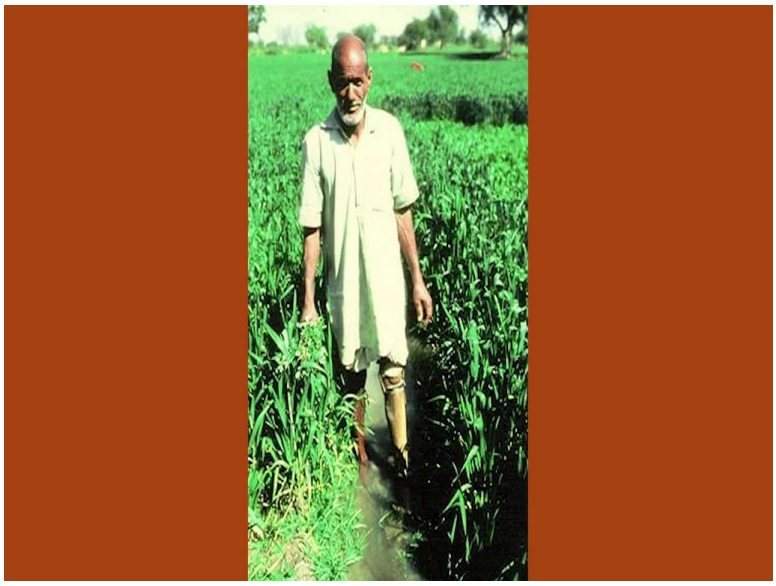

And then, you know, people can work in agricultural fields, paddy fields and there is no issue at all. And the best part is that you know you can go barefoot. So, it culturally matches our requirements of sitting on the floor, going to temples, you know and multiple aspects, which made the costs go down drastically.

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And the production happened at large scale.

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Tell me when it is nonprofit, lot of people donated, huge amount, organizations donated. Even our Minister of Welfare Government, came back and said, ‘Wow! you did a great job, can I give you money?’ So, you know, that way there was a lot of service to the underprivileged and the handicapped people. And the key to the success in all this was meeting a common goal. Remove the three disabilities, I was saying, meeting the three disabilities in the best possible way.

Tell me, how will I meet the disability of being extremely poor? What will I do there? It's low-cost but he is not spending money. So, they thought up till that level, they said ‘My god this person is already was in the hospital, he has finished all his resource, so he sold his one acre plot, he has got nothing to do.’ So they thought about all that and actually they rehabilitate them by giving them cycle rickshaws, this is most probably for the, you know, people with the hand amputation.

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They work with them also while they manufactured the Jaipur foot they would manufacture cycle rickshaws and also give them.

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They set up a separate factory to give them the rickshaws for you. Once you have mobility you could have a lot of work and you know they can pedal and take it forward.

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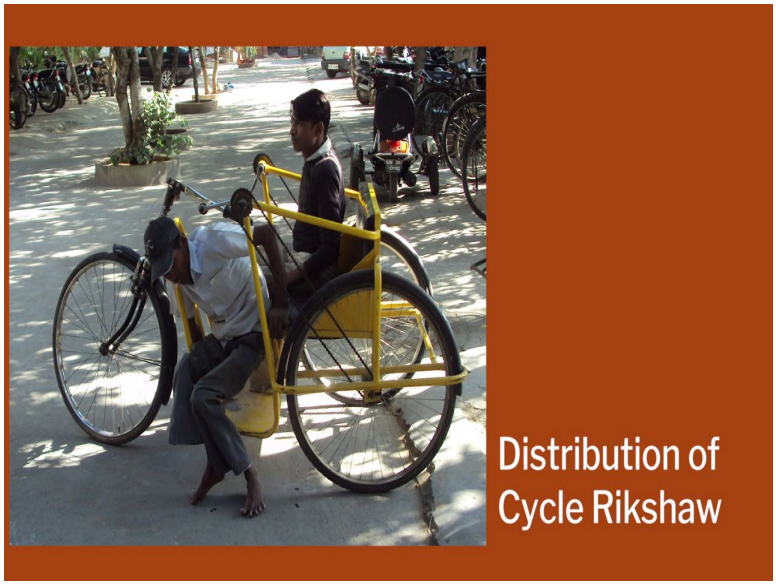

Giving them job training and women would be you know given sewing machines.

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And some of the men would be given the tea shop kit.

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I was completely sort of you know floored when I saw that while they were going out they were handed over these you know kits which just would cost 2,000 bucks or thousand rupees in the whole and you know they would go out empowered to lead the life as it is is very traumatic, the whole family is depended on this one breadwinner and you know he is now the whole family you know takes in to the next level.

Every organization like this, when I have been working with Jaipur foot for the last 10 years, a lot of IITs, a lot of large institutes, large companies start coming in very, very heavily.

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They have some of the best gait labs set up at Jaipur in the, you know, center for prosthesis and orthotics.

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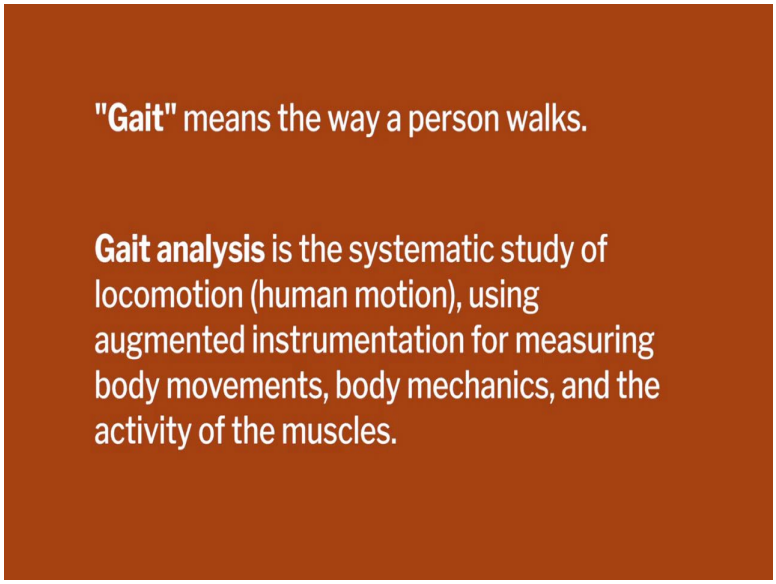

People have donated heavily for, you know, study of various aspects of below the knee and above the knee prosthesis.

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And then, as usual you know, we had lot of philanthropists you know, Ratan Tata, then then the US Secretary of State commerce: John brass

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A lot of these interesting visitors would come and because of that what happened the visibility increased and more and more technology started getting used.

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Lecture-2
Jaipur Foot - A classic innovation Part 2

Because even a small five millimeter difference in the way, you know, you work on the prosthesis can be very detrimental to the comfort and to the walking style.

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So, you know, thanks to all the visitors and the promotion which happened with the Jaipur foot.

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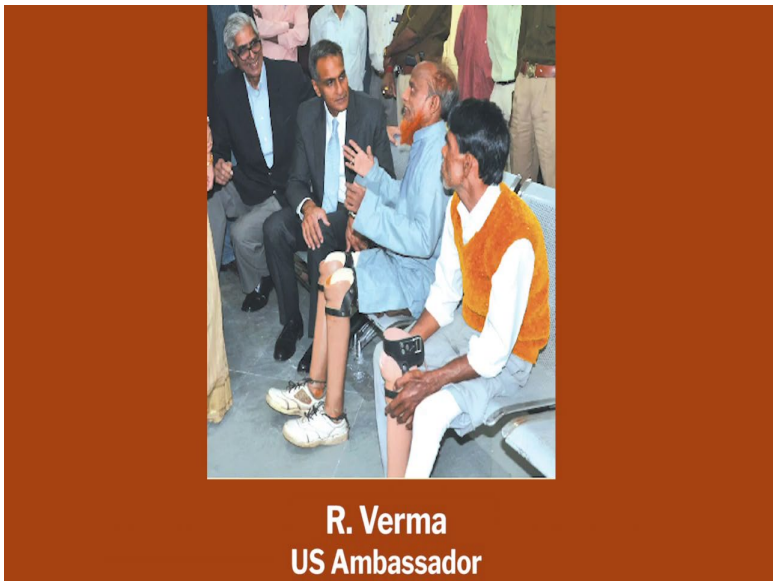

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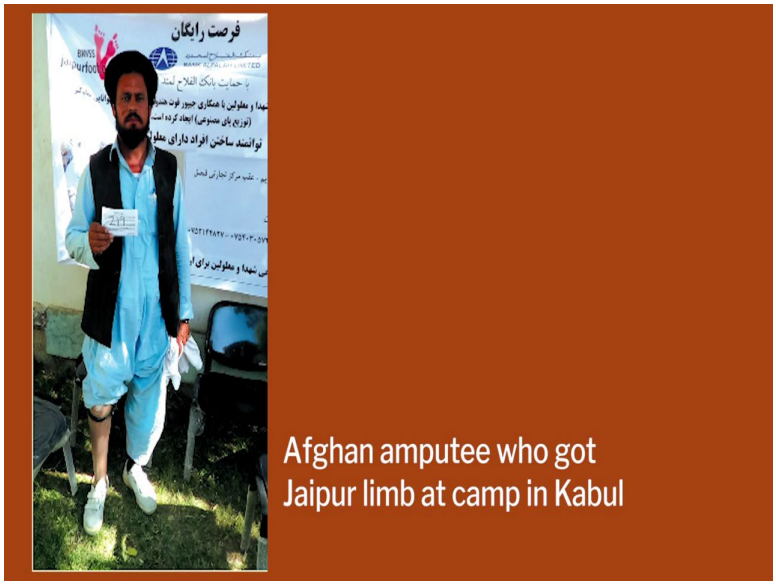

And then because of accidents in Afghanistan and other places, land mines and all, they have set up huge Jaipur foot organizations across the world now and this is the innovation part of our whole course. Till the benefit does not reach millions of users and delighted users, we cannot say innovation has happened.

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BHAGWAN MAHAVEER VIKLANG SAHAYATA SAMITI

DETAILS OF FITMENTS AND OTHER AIDS AND APPLIANCES PROVIDED TO DISABLED PERSONS

FROM 1975 TO 31.03.2016

Years	Limbs	Calipers	Others	Tricycles/	Hearing	Surgery	Total
2010-11	21943	16931	16804	4718	1426	71	61893
2011-12	23005	15453	16592	6963	1966	32	64011
2012-13	24418	15306	15127	3189	2465	9	60514
2013-14	23681	14811	15370	3951	2412	10	60235
2014-15	22848	12509	12370	5409	2619	77	55832
2015-16	26587	18652	16357	8563	5923	0	76082
TOTAL	513806	409944	462867	105774	34921	7472	1534784

JAIPUR LIMB FITMENTS IN CAMPS AT FOREIGN COUNTRIES

AFGHANISTAN	3738	PHILIPPINES	3000	PAKISTAN	987
BANGALADESH	1617	PAPUA NEW GUINEA	170	IRAQ	882
DOMINICAN REPUBLIC	500	RWANDA	500	SRI LANKA	2373
HONDURAS	400	SOMALIA	1000	SENEGAL	607
INDONESIA	1398	TRINIDAD	200	FIJI	300
MALAWI	250	VIETNAM	600	LIBERIA	271
NIGERIA	500	ZIMBABWE	250	MAURITIUS	734
NEPAL	200	SUDAN	1800		
NAIROBI	500	LEBANON	381		
PANAMA	400	ZAMBIA	121	TOTAL	23679

You can see how many countries the Jaipur foot has, you know, gone to the limbs itself has gone to more than 5 lakh 13,000 people and 20,000 people across the world have set up offices 2016 figures.

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And then, you know, lot of professors like Prof. C K Prahalad showcase this whole innovation as one of the best innovations for the bottom of the pyramid.

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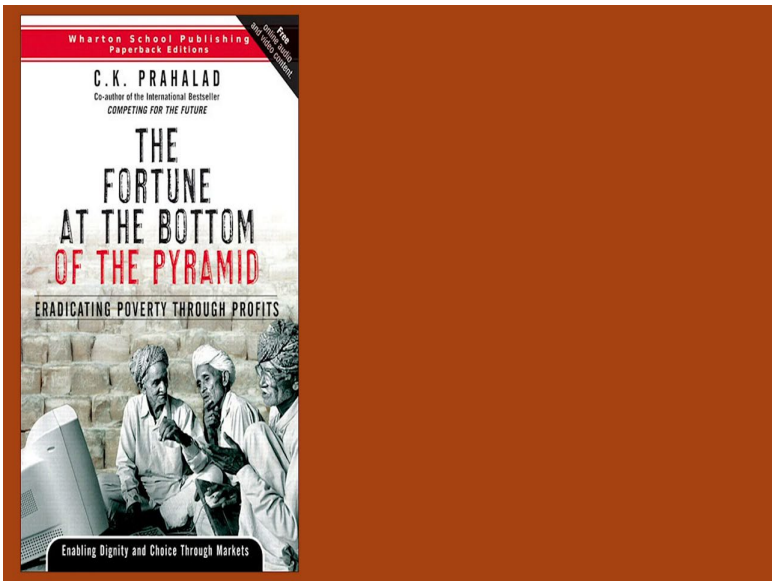

He calls his book 'The Fortune at the Bottom of the Pyramid', so here we very clearly see that every year, you know, 16000 prosthetic fittings are put in. It's a huge number to, you know, work on and take it forward. So, the video I am going to show you now is done by C K Prahalad, his student, a lot of his students and staff came down to India studied the whole phenomenon very effectively and what I like about it is it captures, in a very short video, it captures the complete, you know, whatever I have been talking till now, all the aspects of the Jaipur foot very well.

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So there we are, we you know, saw this film made by C K Prahalad and his project team. When I visited, you know, there I found one person who came with the screws which have come off.

From the shank, the screws had come off and he had nailed it. So, what happens when you nail a plastic? It will crack, this is the most important part.

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So, then we did a project in IIT. Worked for six months to design the screw. Can you now guess the screws going through how many materials? Skin colored cosmetic rubber which is, you know, the vulcanized rubber compound and the wood and the foot and the plastic shank. So, what used to happen is through the screw water used to seep into the wooden part, through the screw, through capillary action and the wood will start getting soft. So the screw get loose and it would come off.

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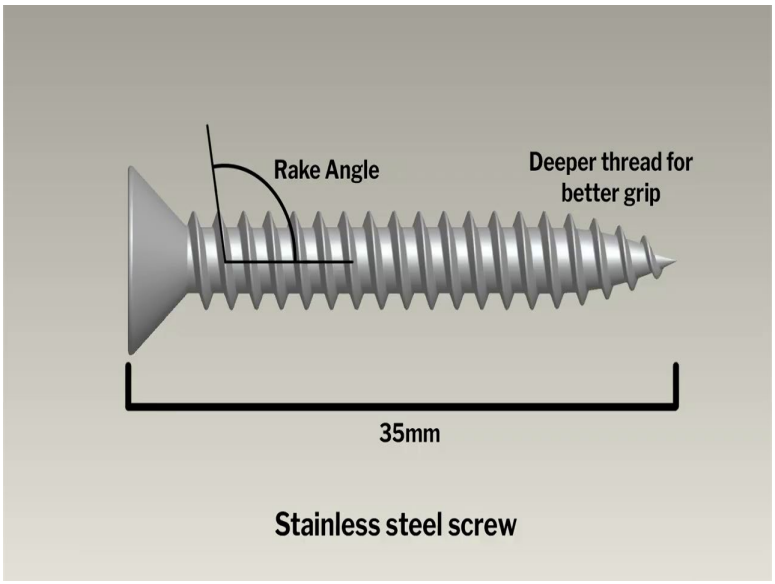

So, then we found out, you know, this best screw that we researched, we found out the correct rake angle talking to our mechanical engineering professors. We came up with a stainless steel screw. We gave the right drill hole so that the stainless steel screw will fit right into all the 3 parts and then we also gave a sealant, that is once you drill a hole you put a sealant drop so that the wood gets sealed over there before I drive the screw in.

And we supplied that to Jaipur and they tried testing 200 of these, you know, screws which we sent and if that works then we would put those screws everywhere. So, every small, you know, maintenance issue can be taken in a very good way so we need to be sending that and that is a small contribution into this large project.

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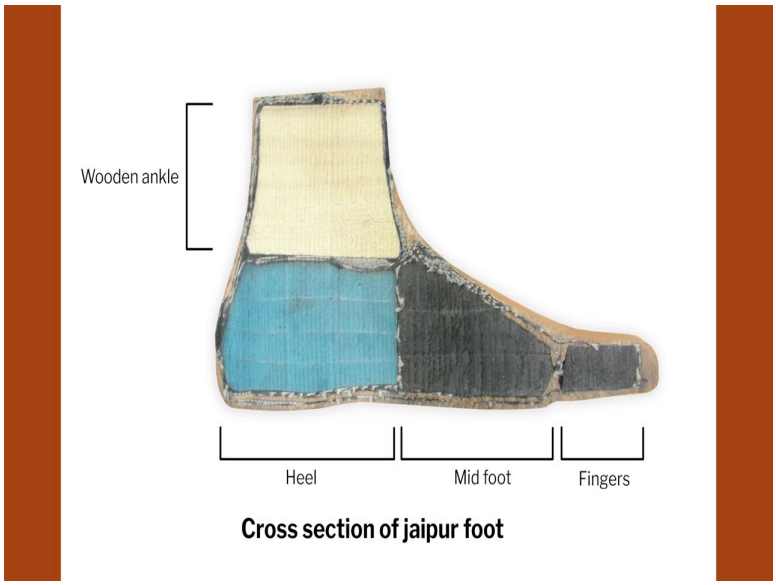

The 3 sections here: the Finger section, Mid foot and the Heel. So these 3 sections are separate where, you know, construction also is like the foot. So, the beauty of this design is it can bend. It is beautiful, the type of load, it can bend, it can take all the shocks of jumps and, see how it is bending.

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So, we saw that the affordance is happening because it is reaching, and it's the way it is manufactured, the whole structure of strategic management happened because of the, you know, officer.

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And then it is maintenance free because it is single, there 2 pieces: the single piece foot and the shank. So the maintenance is very, very low.

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You saw that stocking which is there on the stump, the stocking is specially double woven, you know, cotton stocking which actually gives all the cushioning to the stump it plays a very very vital role and that also I believe comes from Germany because of donations from German counterpart who wants to, you know, give those stockings to Jaipur.

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This is irrigation pipes most probably HDPE so these pipes are extremely strong because they use for piping water for agricultural applications, so that is a very important component of the design. Is this high-tech? What is the high-tech aspect of this?

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Very good. Material. Which material is high-tech here? Of course the microcellular rubbery is high-tech. Why? Because it went through all that research to be produced and, you know, available in large sheets which are used for large applications outside in car industries and other industries as, you know, suspension bushes and other places and here you are using the best research from automotive to use it in Jaipur foot, but you are using it in a customized way. Excellent!

What are the other high-tech things in this? High-tech materials?

Student: The socket.

Very good. The socket again is extremely critical. It comes from the best polymer, largest companies, very good strength, very good moldability. It is a thermoplastic material so you heat it and you very nicely shape it right so that is one, you know, excellent input.

But the third interesting aspect is the rubber cord and the vulcanizing paste and the rubber which is used, comes from the tire industry. And can you imagine how much research the tire industry would do to generate these raw materials? Very, very high quality raw materials. So, I am using the high tech aspect in this is all in the raw materials.

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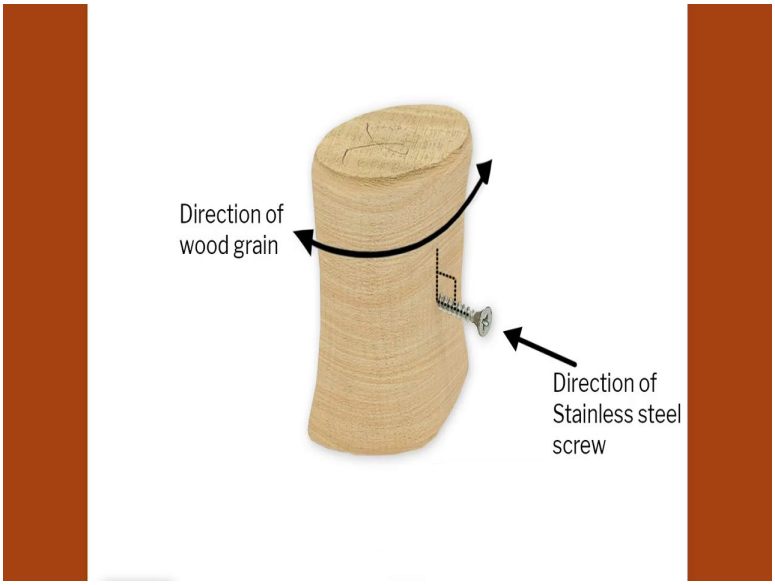

Including this wooden block, the grains of the wooden block has to be in the right orientation so that the screw will not come off. Wood can give you tremendous amount of shock absorption at that level. And what else? The joint. It can give you very good compression for putting the screws in and locking it. So, that is the beauty of putting, you know, all the aspects of the, you know, high-tech into this simple product.

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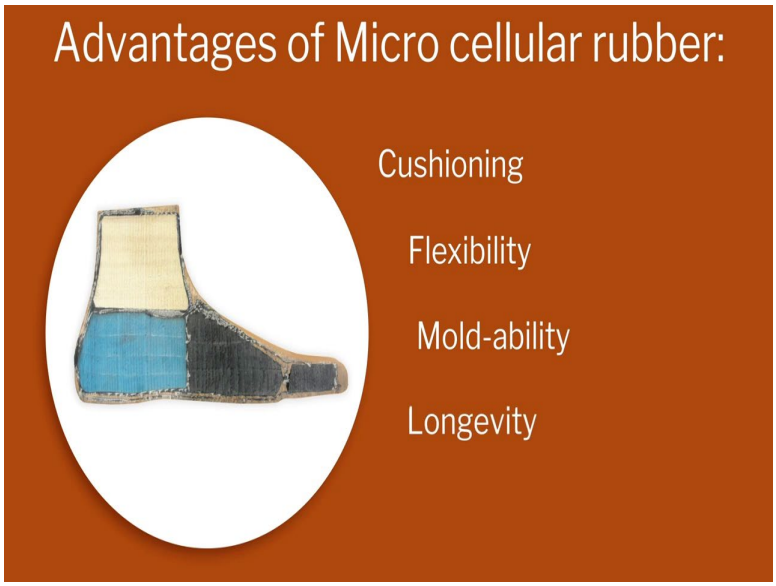

So every aspect in the Jaipur foot has multiple advantages, not one advantage. Microcellular rubber, what all it's doing? It's giving me cushioning, it is giving flexibility, it is giving it moldability, moldability now I mean building the model and it is giving me longevity, because microcellular rubber is non-perishable. Here, see it is all skill, skill of the people who are getting the job done. So, the final fitting and the final design they actually do it very customized to the people who are there.

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You saw they were actually heating on the, you know, heating on a heater to, you know, get the shank into the rubber. So, there is a joint there and it actually they fully fit it in as per design they

have an area that goes fully in and they drill the hole after they fit the shank, through and through. So, they completely fit it, drill the hole and then pull it together. So, their size is already measured. They know the sizes and they do it and that is the whole reason that they do not have too much of standardization. There is another problem of accurate design.

So they are working on that, how to modular design so that they can really close in on the, you know, inaccuracies if they crop up in the design. But this is all again hand skill which is coming into play.

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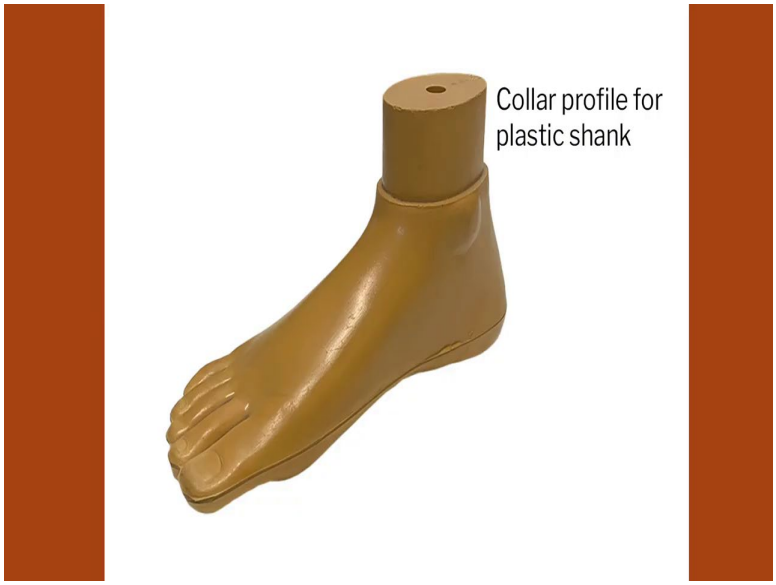

You will have to come up with some design so we came up with a design which is like a collar, so you push the pipe and it goes and rests on a collar on the foot so we made a collar here, it is still not implemented we gave that design where you made a collar, so when you put the shank it exactly goes and sits like a socket like a tiffin box.

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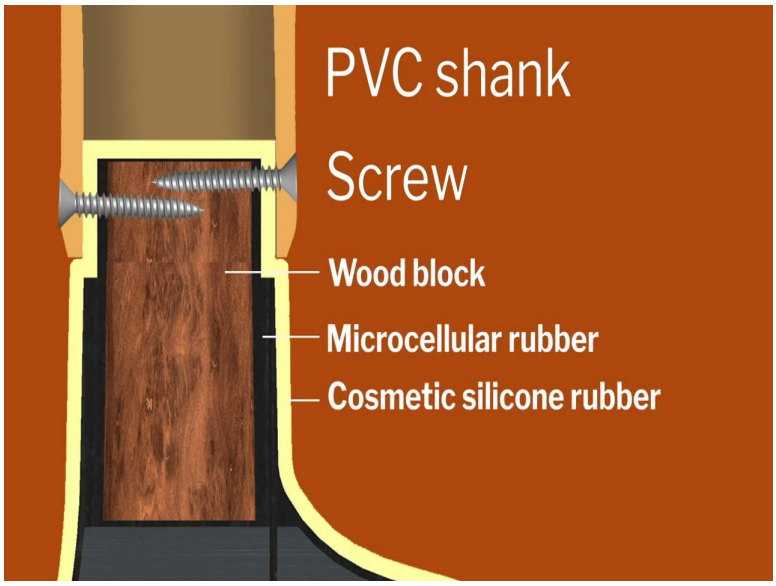

So, we made that, you know, so that there is no sort of dimensional problem because sometimes it is heated more it can't go in. So, we worked 4 months on that and we sent the design. And what is interesting in all this is, it is like again Abdul Kalam now, I sit in Bombay and send in design. Will it get implemented?

It is a large organization right? It is a large training. So, it has to be an activist mode. You have to be there, you have to train the people, you take things forward then only things get implemented. So, we are planning to take it up, you know, in the next sessions and get the whole, you know, thing implemented.

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This small finger blocks microcellular rubber, they were cutting with their hand. It's a very tedious process.

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So, we want to help them out and he said ‘we’ll give them punching machines to cut exactly the size of the fingers’ so that, you know, input was given by us so we are working on that also to support the production aspects of the design.

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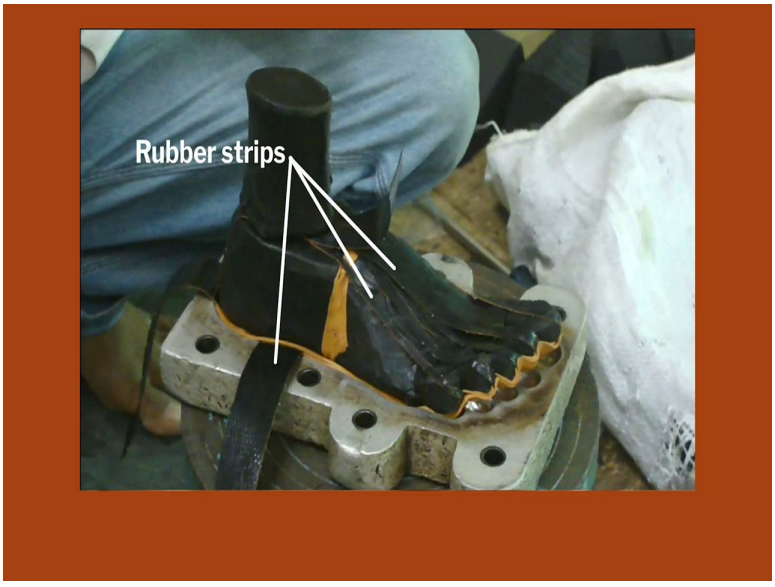

Nylon rubber cords again from tire industry provide strength and resilience. You are telling how will, by weight, it will come back? Look at the way the tire is designed, it is the same way the foot is designed, look at the strings which are, and all these are placed, you know, in the right orientation

so that you can get the type of resilience you want. They are coming, all of them are coming on top of those, you know, finger blocks so, then it gets molded with the cosmetic rubber it all gets sealed and this actually generally is 20% larger size, 10% larger size then the actual tool. So, when the tool presses it the whole thing gets compression and then the rubber flows in all the directions and you get a very, very solid piece in hand.

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And basically no skin color, now they are also trying to get little darker and lighter shades. What happens with all these organizations is when you have inventory becomes very difficult to control, and the type of population which comes over there, you know, they are happy to get a foot. They are really not bothered whether the color of their foot match, it is that type of, you know, sort of requirement. So, we have to really understand the demographics. But if we can give colors one of the best, it is quite good.

I am now coming to the last section of her lecture. So, we saw the whole innovation journey. How the whole manufacturing, how the whole materials and how each material has multiple roles, multiple advantages.

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Blade Runner' Pistorius
2012 Summer Olympics, London

And do you think there are different designs all over the world? Using blade running prosthesis which is developed in, you know, one of the best universities in the US and, you know, it's program, it's got the best materials. So, there are innovations at every level. Will you call this innovation? It is of course innovation. It uses all the ingredients for that context. It could be for one user or two users, but it is happening at that level.

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Can we apply that to our context? It is very difficult, because the whole ecosystem does not work, the cost will come too much, we do not have the type of resources. If we had the resources why not, but if the resources were not there then it is very difficult. So, we need to understand financial

implications, but if you look at the other angle of administration and cause and running, that is where your innovation can never reach scale.

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Similarly there are micro processor controlled prosthesis, and a lot of work is happening on the C leg .

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Fabulous designs, fabulous technologies, you know, very good case studies on the, you know, YouTube of how these are developed and again saved up a passion, the designers and the teams are working on for a different context which is working very well.

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These are again in integrated prosthetic legs. Surgically they have implanted. So you have one part of the prosthesis which is an implant into the bone. Then what will happen? All my outside problems remember I was talking about customization and all, that is gone right? It is already into your bone, and all your gait will be perfect. Your orientation will be perfect and that operation also has to happen very effectively and then you can attach the best, you know, computer-controlled, numerical controlled prosthesis.

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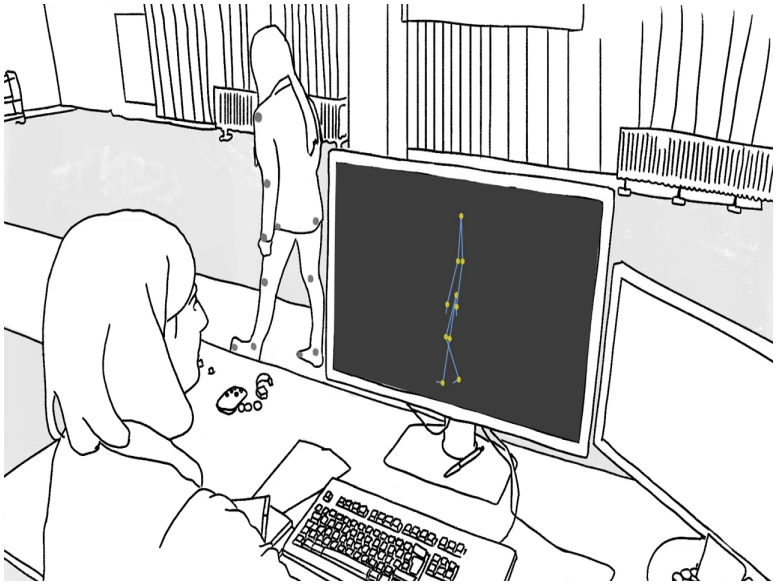

To control your gait it will learn how you walk and program itself to give you the best gait and you cannot even make out that you do not, you know, if you are having an artificial limb. So, the technology and research has gone to that level.

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And we have a lot of examples of this, you know, a racing driver who had an, you know, accident and he has both his legs of that caliber. And with that I'd like to close and we now very clearly know what happens in the journey of design, the technology, technology can be materials and manufacturing, and the innovation, and innovation comes from the complete domain of understanding the user, understanding the strategic implication and the whole vision of the person who is running the show which is D. R. Mehta of : What would I like to do?

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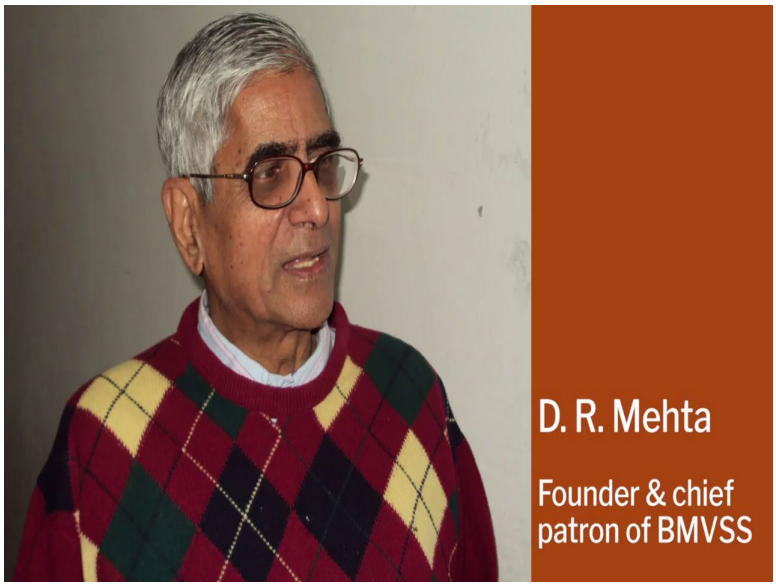

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How will I like to make it completely philanthropic? How will I like to make it a social design? And take forward the largest sector innovations? This is one of the best examples of innovation in the country. So, I thought we will start with this for our whole design and technology, you know, course.

Design, Technology and Innovation
Prof. B. K. Chakravarthy
IDC School of Design
Indian Institute Technology Bombay

Lecture-2
User Centred Helmet Design Part 1

If it is too tedious they would not buy so coming from that angle when I go and see my products which are around me a lot of products are extremely tedious to use. Because of various reasons some reasons could be that they are because of legislation. Some reasons could be because of material properties and the people are not looking at how to make these products very comfortable to the user. So, I am talking about a physical product where helmets, which are used, on two wheelers.

So, let me tell you a small story. I had the student *Mandar Kale* in 2007 I think, and he came late for a product design course. That is we have a P2 project where he was late for a week. Then I asked him, you know, 'Mandar why are you so late?' and 'What has happened?' He said that his friend died in a motorcycle accident.

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And the motorcycle helmet was strapped to the back of the motorcycle. This was in Pune, and he was very disturbed because he was saying that if only, you know, my friend would have put on that helmet he would not be dead because he had a head injury. Head-on collision with the truck in the front because the truck did a sudden break and he is going at it, you know; so then, you know, it struck me that *Mandar* if you are so concerned cannot we design a product where you encourage users? That is, you go like the way you take your key, you put on your helmet and then you go, cannot we do such a thing?

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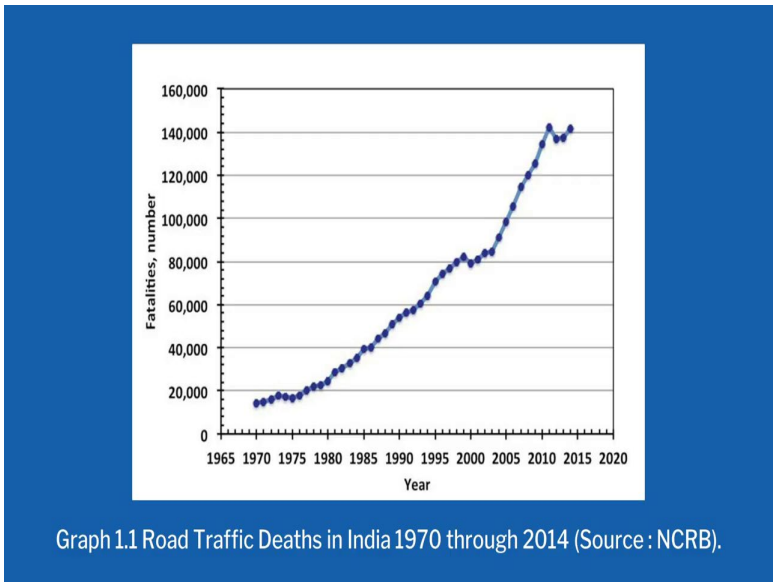

Why are helmets so uncomfortable? And then we studied. We found out so many new problems with helmets aren't so many deaths. 140,000 deaths, you know, in the year 2015 but if you go now

the increasing, you know, day by day now that we, you know, fines are much more severe people will wear helmets but I am just saying, why should the policeman ask for fines when you are saving your life? So, this is the whole challenge we started with in this, you know, journey of designing a helmet which will be extremely comfortable. But if you have an extremely comfortable helmet will it be unsafe? need not be, very good.

Will it not pass Indian standards? No, it has to pass Indian standards. Whose talking about, today we are talking about technologies, materials and processes.

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And they are, we have to make technology, we have to make materials and we have to make our engineering process suit the user right? Not, you know, give a manufacturer in specification that you to make these helmets, you know, like in this particular way and, you know, there should be no ventilation and, you know, this ventilation the helmet will crack which are not even, you know, which are not even justified from them to make.

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So, we start with that premise and we said we have to look at the situation around us. Then this is one of my, you know, project associates in our design studio Mr. *Chari.* He worked with us, he was also an M. Des designer and he said it is also complex: our culture, our ecosystem, the way we use helmet, the way we use the two wheelers, the way we use our two wheelers and he made this wonderful, you know, sketch, you know, saying that our head gears you have, you know, if you are having in head gear what will you do.

If you are having, you know, milk, if you are a guy who is taking milk around how will you handle it? So, we found it very, very challenging.

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So, from there on we started and we said let us understand our culture, let us understand the local situations and habits and let us also look at the socio-economic condition. If the helmets are too expensive nobody will buy right. The helmets have to be, you know, also looking at who is using the helmet for what purpose. So here we come down to a very important, you know, topic in design which is product planning. You need to have that variety of products which are suitable for different, different types of people.

And it is a myth when we say that I have designed one product and it will be good for everybody. I take a good example of your spectacles, everybody uses a different spectacle. Let it be style, let it be convenient, let it be, let it be a type of choice you have. Similarly, you need to have helmets which are, which are that type of variety, so that you can choose the right helmet for your requirement.

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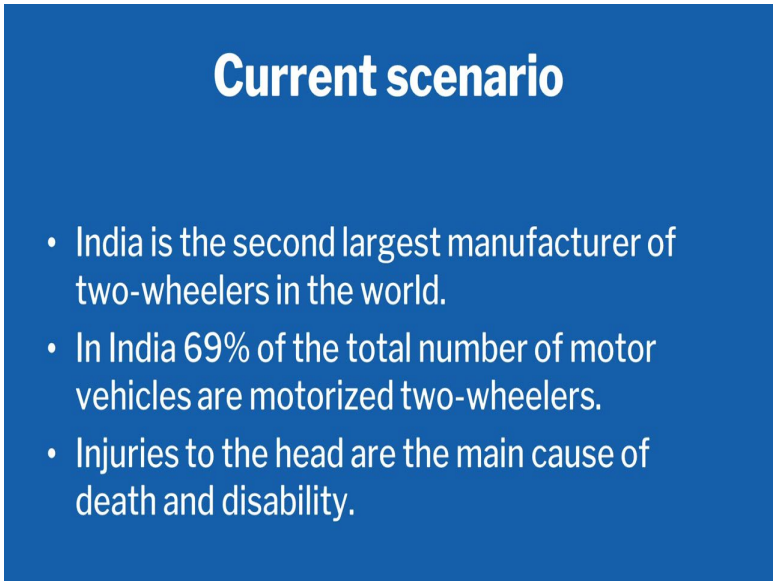

And we looked at, you know, conditions in India. Becomes the largest two wheeler manufacturer, is still growing. 69% of the total number of motor vehicles are motorized. Injuries to the head are the main cause of death. And here, for example, you will be surprised that when it is called a blunt injury.

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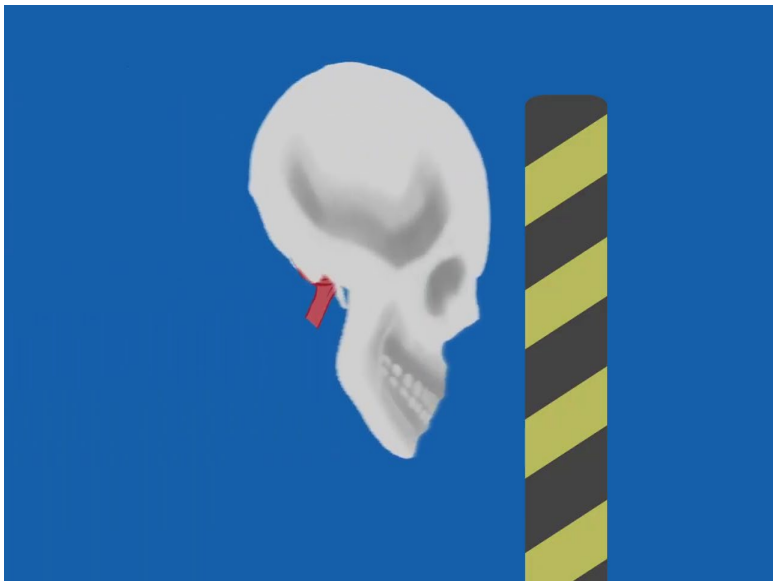

When the injury to the head happens, the brain goes and hits the skull inside because the brain is in a fluid and when it hits the skull the person is brain dead. You would not see any injury outside but the person is dead.

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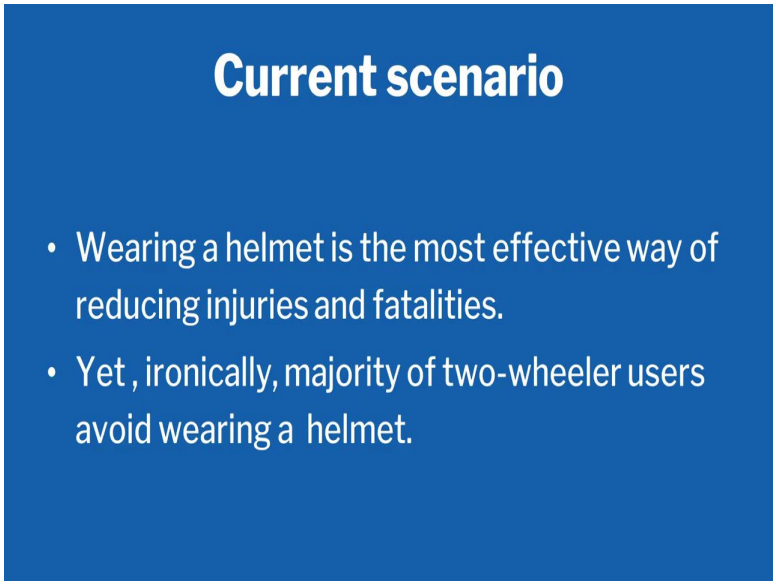

So, these are the, you know, challenging things we were facing and we are saying that anyway a helmet is the most effective way of reducing these injuries. And the majority of two-wheelers, anybody we interviewed, we found out that they just do not want to wear a helmet. Then we went and started studying our market, and our situations and people. People is a very, very important study for us. And then we were watching the type of risks on the road. Risks are too many. What is happening when you are stuck at a traffic junction the, you know, helmet gets very hot.

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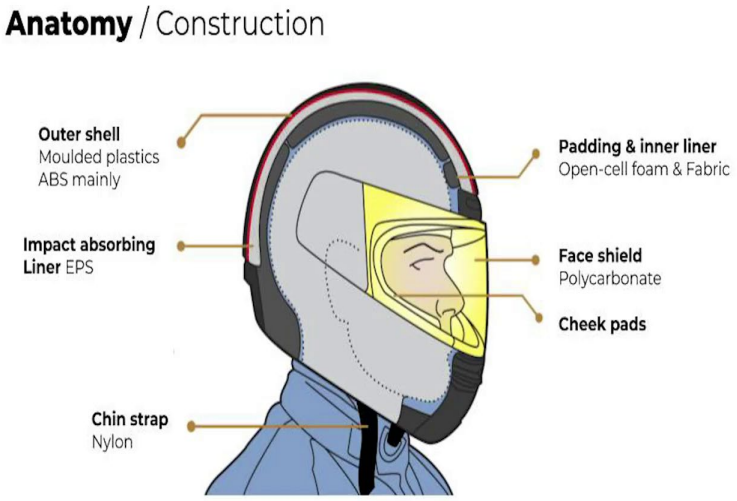

Let us look at the construction of the helmet. What do you think saves the person's life in all these three parts of the helmet: the shell, the thermocol which is the expanded polystyrene foam and the PU padding inside, out of these three, which is the one which saves the life? Thermocol. And that does not cost anything right? Thermocol is the packaging.

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This thermocol has a special property of actually reducing the acceleration of the head, the brain inside when it is going to hit the head and that type of, you know, that type of compression loading and we are not able to get in any other material till now. We tried a lot of options. We are not able

to get that type of compression where you get that type of cushioning so that the brain does not go on hit. I must tell you a nice story over here.

In Delhi we were given a big task by the transport department and they told us, you know, please check out whether these roadside helmets are good or not they selling at 400 bucks 600 bucks 200 bucks and they may be very dangerous for the people who are buying them. Then we took all the roadside helmets into our, we have a very good bio medical facility at IIT, Delhi when I was teaching there, and Professor *Dinesh Mohan* was the in-charge.

We got these Studds helmets which are the best in the grade. Then we got the other brands. Four other brands, and we bought four local roadside helmets. And we put them on the testing machine with sensors and everything and to our shock the roadside helmets were performing much, much better. 20% to 40% better than the Studds helmet. What could be the reason? More thermocol.

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And another interesting issue was that the shell which we thought was the most important would crack in the other helmets and break but save the life of a person. The roadside helmets did not use that much resin as Studds was using. So, if you use a lot of resin the shell is very hard, it takes all, when it goes and hits the floor, what happens? It absorbs less energy whereas the roadside helmet shell would go crack. What happens when something cracks? It releases all, it loses all the energy and it was much, much better. That was a shock for Studds.

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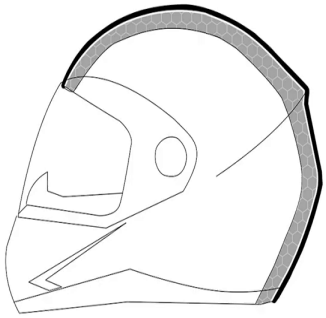

Branded helmet

Their thermocol, the Studds, you know, when the thermocol in the Studds helmet, was actually 18 to 19 millimeters and sometimes it was curvilinear because of the style and all, they had to make it with some grooves inside. Whereas, the outside helmet, no fancy design. It was straightforward round shell of 22 to 23 millimeter thick. That was the minimum, you need a minimum 20 millimeter thick for saving the life of a person, it was 20 to 24 because, it was just because of lack of, you know, things and you want to make a simple element there EPS form which is the expanded polystyrene was thicker and a uniform cross-section, so it did very well in them in the field.

So that gives us the impetus that we need to, you know, do something very drastic in, you know, making people aware of this as well as see to that, you know, people wear helmets.

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So then we said let us study all the materials available. Where will we use Kevlar? Bulletproof. Very, very high-end and then we also checked out other materials like lexan, lexan is a polycarbonate material. Polycarbonate is very strong again. Why should I study these high-end materials when I am designing a helmet for a two-wheeler rider? I am not going to use them but by studying the materials we study the properties. We are studying the properties I can come up with ideas for better use of material in my context also.

So we always do that whenever we have some study we will study parallel products whatever materials they are using, so we can come back and do multiple work.

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So, here then, we also looked at an ABSPC. This is a styrene material which is used in all plastic scooter parts and abs is a very good, you know, ABS is acrylonitrile butadiene styrene which is very easy to paint. It is injection molded.

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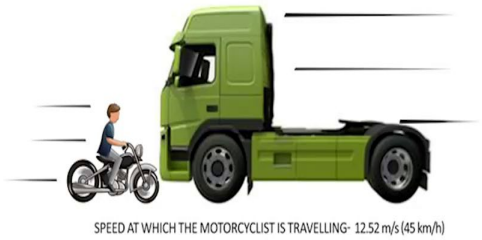

So, just to, you know, give you a little illustration of what happens if you are traveling at, say, 45 kilometres an hour and you have a head-on collision.

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It is like falling from the second-floor balcony head down. that is the type of impact and it is pretty severe we do not realize it, and for 45 kilometres an hour is nothing. Most of us go ahead at 60 to 80 kilometers an hour and if that is the speed you should be like falling from the terrace of this

five-story building there is no chance of survival, but after the collision it drops. Here it is adding on but if I come with this, you know, standstill truck then my 45 kilometers will become around 25 to 40, by the time I go and hit the, because some amount of deceleration happens when I hit.

Because some amount of shock gets absorbed by the vehicle and then the movement of the body, all that, so it reduces a little bit. So, but then you just if can imagine that if the speeds are much higher it could be very, very fatal. And that is what we see outside, so many deaths because of that reason and that perception is not there. That is a challenge for us.

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And then we went and studied the standards, and a very interesting cartel happens in the standards. In the standards we have people. We have professor's, we have visual experts and we have also industry representatives and unfortunately they are completely biased towards manufacturing. We are biased towards technology, and they are not having any context of user convenience. And then all the helmet standards are coming from cold countries.

They take in the British standards and they brought it down, and all in Europe, where do they use motorcycles? Racing, mountains, going, so for them and what type of weather? Very cold. So what happens if you borrow the standards from them? Your head will get cooked in India. Literally. And that is what happens in Delhi. When the temperature outside is of 47 degrees and you are wearing a helmet on your head you just cannot survive.

It is so hot inside. So we went and told, we then met the Indian Standards and we told them this is not right. You have to have a person who is responsible for the comfort of a person in your committee so that they look at the comfort and then introduce all the new norms. Then we did lot of observations of people's problems of, you know, how they store their helmet. How difficult it is to buckle and why people do not buckle their helmet.

You know, that they do not buckle the helmet. Then what happens? Tell me. The helmet flies somewhere else and you hit the head, head hits. So it, and we found out that this 20% accidents are happening, people are wearing helmets and not buckling, it is happening because of that. That is also very, very, you know, serious concern of buckling up.

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So, here we are looking at, you know, gets very hot and muggy there was, you know, people use a cloth inside carves and, you know, lot of people, you know, drive with the visor up though it hurts their eyes, so the air is blown inside the, inside the face.

Or interaction between two people, extremely difficult when you wear a helmet. So that is a serious issue or will you improve that?

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There is no, it restricts vision is a very, very clear thing. Your helmet sizes are so big sometimes it restricts the vision from the side.

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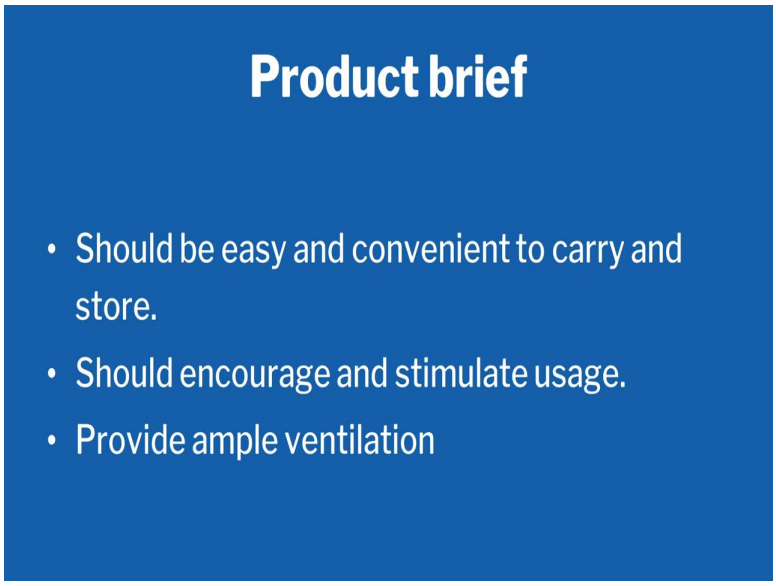

So, this is the most important thing of our design process. The product brief. Here we are saying that the helmet should be easy and convenient to carry and store. Should encourage and stimulate use. Provide ample ventilation. Should be lightweight, helmets are very heavy, that was a very important component which people did talk about. Should fit, you know, aptly on the head without wobbling. Lot of helmets will be loose.

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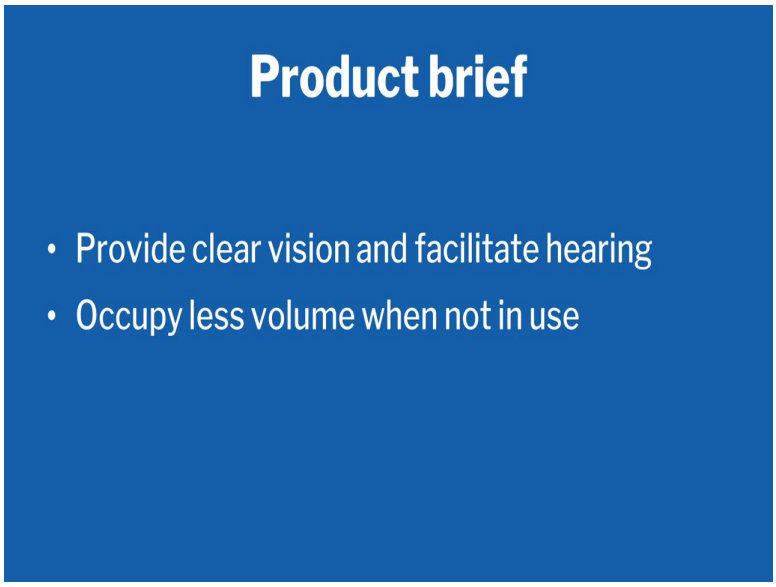

And then provide clear vision and facilitate hearing and occupy less volume when not in use. So, these are the briefs. So, when you have a brief points you want to, you know, sort of, work on this brief and make multiple ideas. Each problem should have an idea right? Multiple ideas together

will make a concept right? Multiple concepts will compete with each other to get selected as a best concept and the criteria of a selection will be the product brief, got it?

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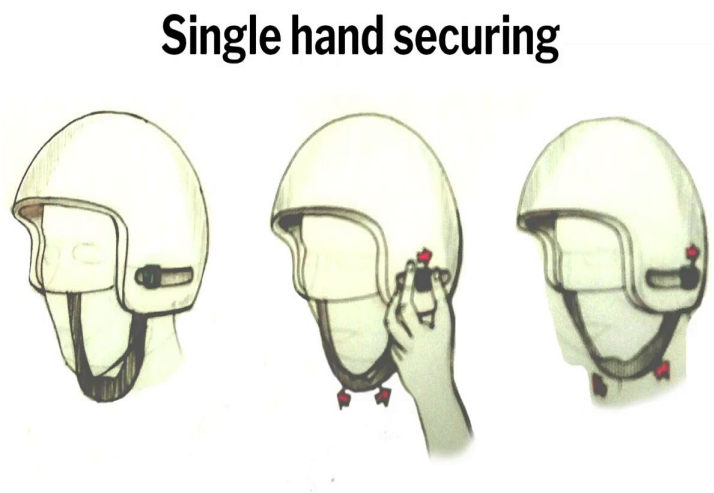

So, let us see how this whole journey went. What is this doing? Buckling, because buckling by the side. You just move these levers and the helmet is not coming out anymore. And when you are doing ideas remember, no questions asked. Right? You did that creative brainstorming. So the idea is there, respect the idea, 'Yeah good solution'.

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Wow! I love this idea. This is the scarf idea and a lot of pillion riders, women riders would say that they are much more comfortable scarfing rather than buckling. With a buckling a lot of people

have fear that the buckling will not come out. Sometimes it rusts and the buckles are very difficult to pull out. So, scarfing is a very common way of tying. And then tell me if I put a scarf what will Indian standards say? It is not secure enough. Very good and what will they do? They will test the knot in the testing machine.

They will pull and check. Right? All that can be done by getting the type of fabric but if you want to have an idea to go to the next level you can always do whatever you want.

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This is interesting, Sweat ring on the top, because too much of sweat is coming, so there is a, you know, ring on the top for sweat.

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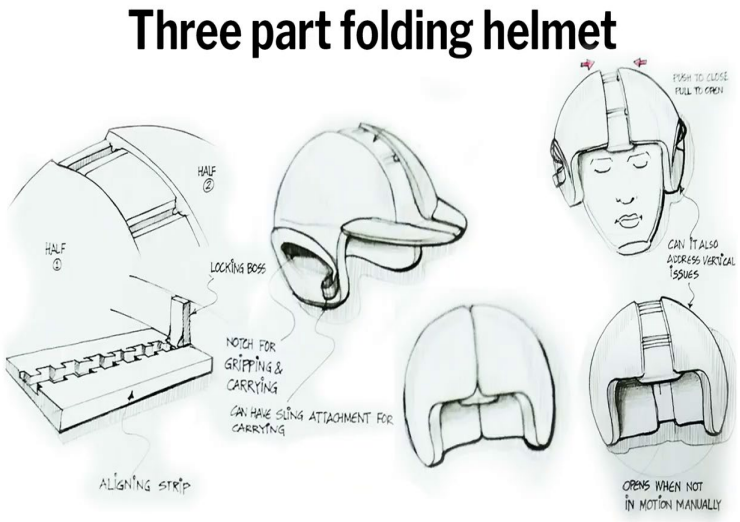

Another idea again *Mandar* only made all these ideas, where you are receding sideways to make the helmet very slim and small.

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Again, you know, two part receding helmet. You pull them out and put them inside so it becomes like, very narrow like a small file.

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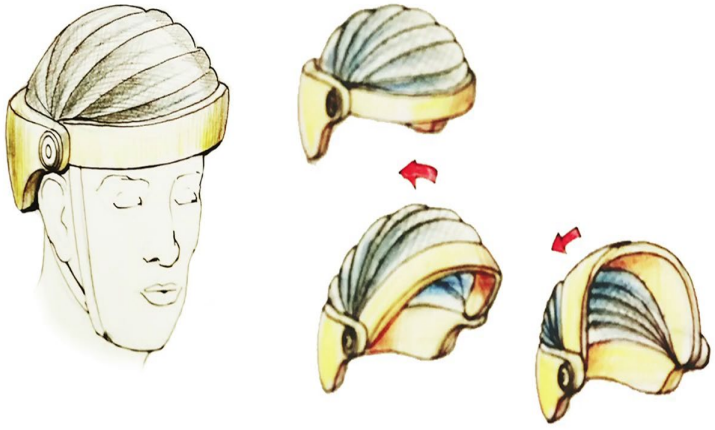
A self collapsing helmet



This is again a collapsing, you know, self collapsing helmet. It is like all around, on the top it has got a net. Most of the protection happens on the side.

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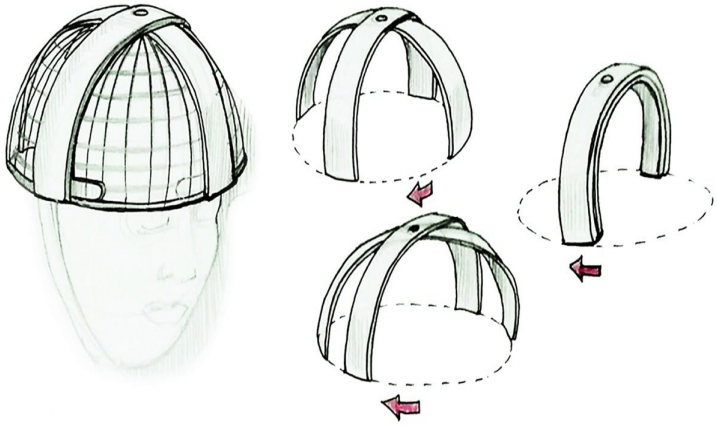
Swiveling helmet



This is again an interesting idea of swivel. You have two shells you swivel and you lock, becomes very slim. All storage ideas. Right?

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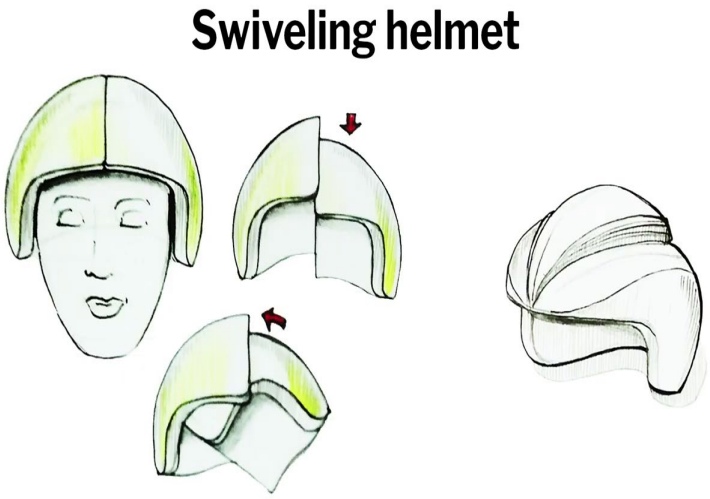

Side folding. Right?

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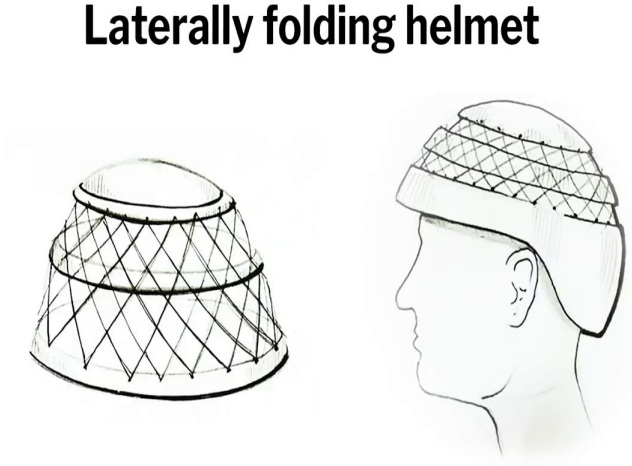

This has been inspired by the sheikhs who wear this, you know, round ring cap with the cloth, so it is inspired by that and it is like, you know, ease of wear idea of it. Just it should be as easy as wearing a cap or just, you know, with a ring on the top.

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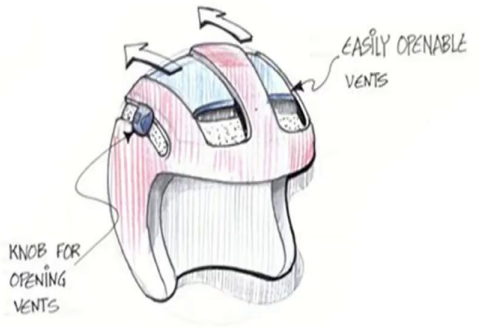
Opening up when stationary



So, this is windows on the helmet for letting air inside. So when you are the signal you can actually open the ventilation ports or they can bring out the helmet so that you get the breeze needed.

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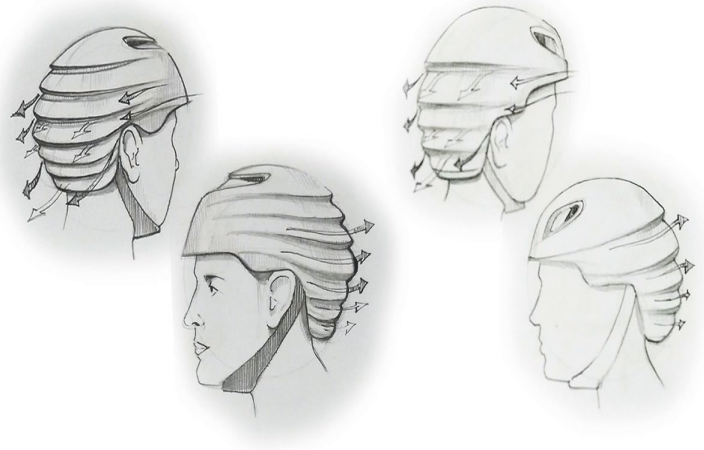
Positioning and number of vents



Then, you know, inspired by various insects. Different, different ways of sort of air ventilation. So, that your air, you know, is the; you are very, very ventilated inside.

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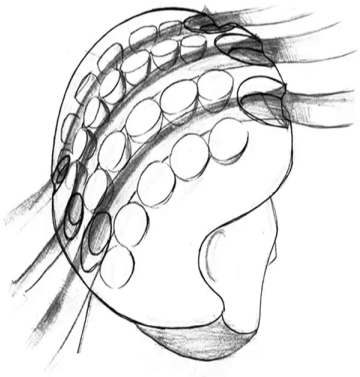
Dimple shaped foam - air channels



Again different types of dimples so that your air channels are formed so your head is cool because of the venturi effect.

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Slits from the sides if possible;

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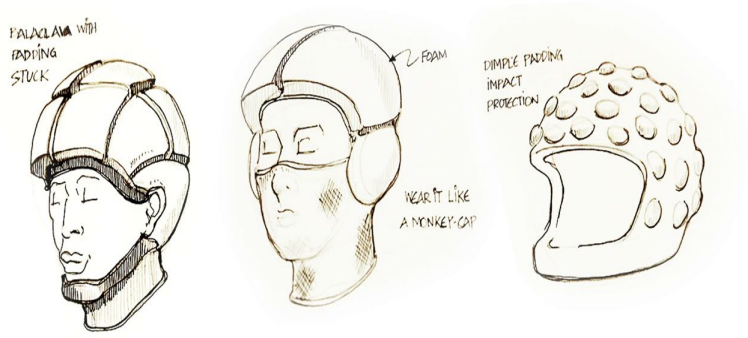
Helmet with padding on the outside



This is a helmet with padding on the outside. Remember those people sitting next to each other and want to talk. The helmet actually hurts quite a bit. A lot of people complain that they would dash against the helmet when there is a pillion rider who wants to talk to the front because of the, very easy, so the padding on the helmet. So, each problem you will come with an idea.

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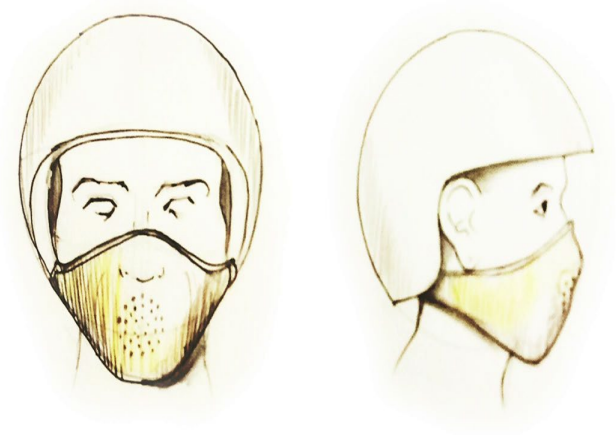
Integrated pollution mask



Biggest challenge is pollution, so much pollution that if it is an integrated helmet with a pollution mask it can be fabulous.

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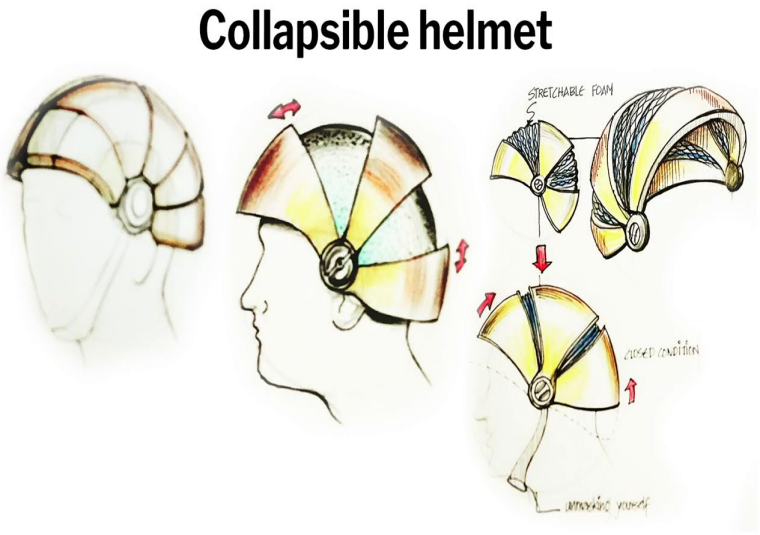

Again if it is easy to store very good, so we can think of a collapsible helmet. And then these are only very few ideas we showed. We had some 150 ideas. I will show you some of the clusters. So what happens when you have a lot of ideas like this, you know, you very clearly we are coming down to the first three points which is talking about comfort of use, encouragement of use and regulation, right? So, automatically when you cluster ideas these types of situations will come forward to you.

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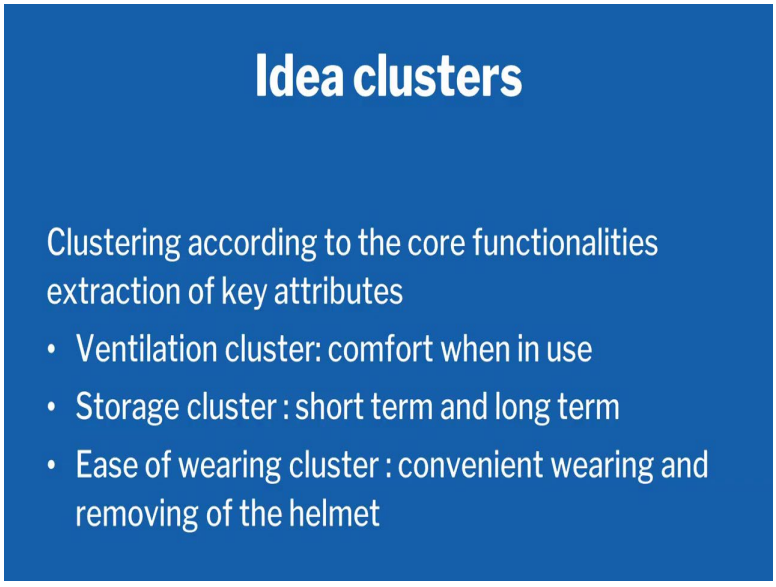

So, we had a ventilation cluster that is I put all the ideas which talked about ventilation as a ventilation cluster. I put all the ideas on the board, we actually do allotting, which was the storage cluster, easy to store cluster. And all the ones where it is easy to wear. We talk about motivation

and, you know, less resistance to use a helmet that we put in the ease of wearing cluster. Look at this ventilation cluster. This is put in this cluster because it has a chance of ventilation also. This was going to the folding cluster.

So you can actually bring a couple of ideas together. Look at the window idea, look at the gaps, look at the ventilation. Lot of ideas are put together and then what you do is, you actually use all those ideas. For example these split ideas were also used; the lure ideas also were used inside for the thermocol. The ideas where you are opening, remember that side openings were also used. So when you build an idea you use the other ideas as your inspiration. Because you cluster them together. Then we chose that as the champion idea.

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So, how will that happen that is called amalgamation and building up of an idea into the concept.

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So, you are building this idea into a concept now. So, this idea then you start working on this it is too open so I need to close it in.

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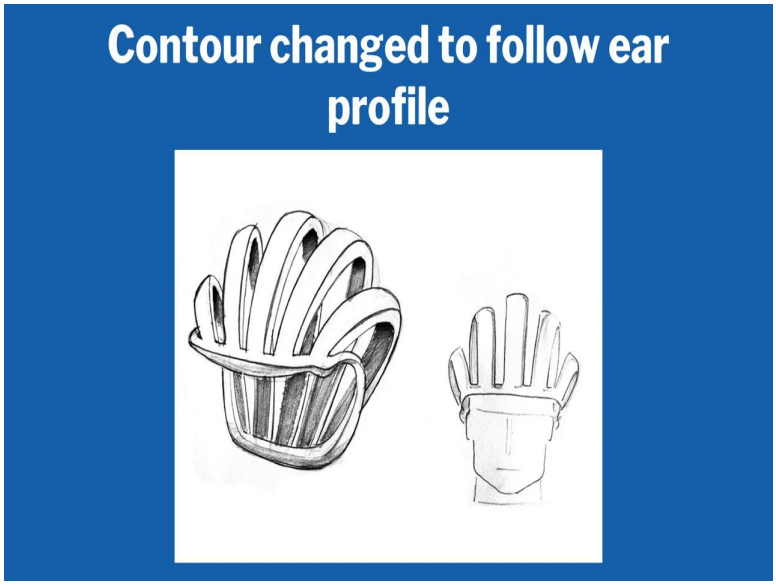

In and to close it further in.

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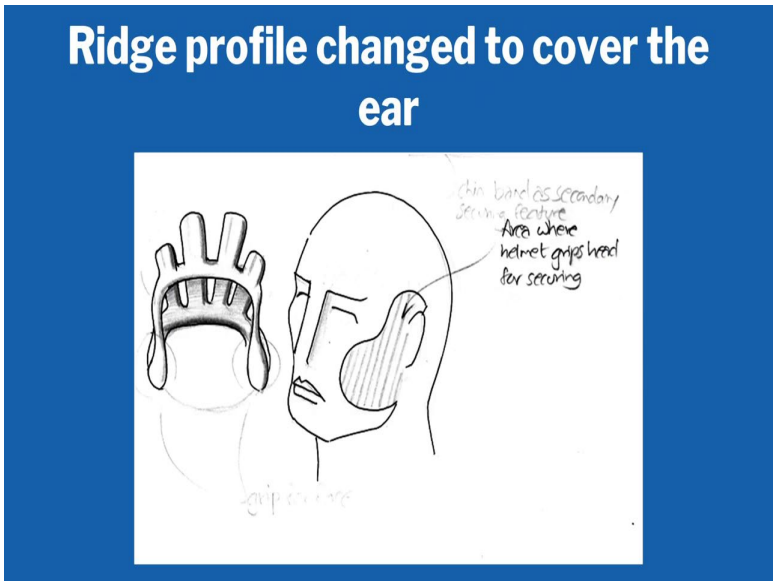

And, you know, please check out the areas which is not covering. Bring those areas in and then you make a helmet which is all the features.

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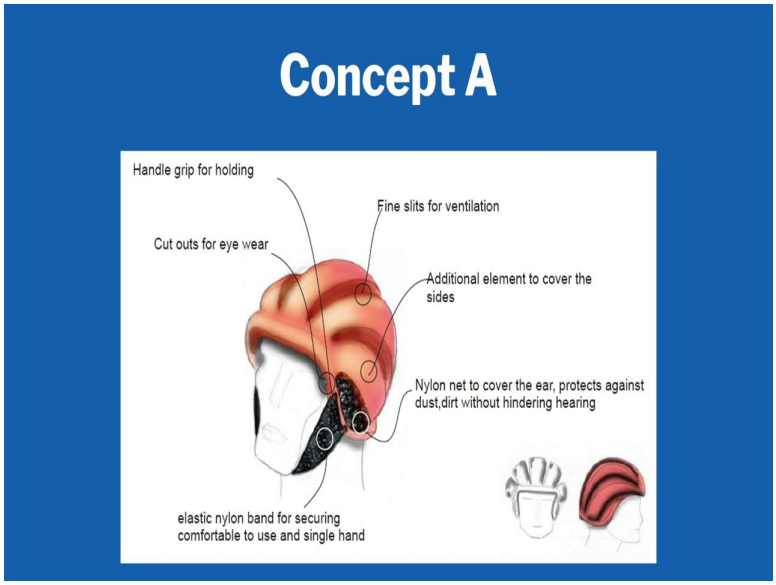

And look at this strap, there is no buckle there. That is the most innovative point: the strap is done using an elastic. Okay? So here we have concept A and the concept A is personifying ventilation. Right? But it is a full concept. It is got all the features which are built in.

Design, Technology and Innovation
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Lecture-4
User Centred Helmet Design Part 2

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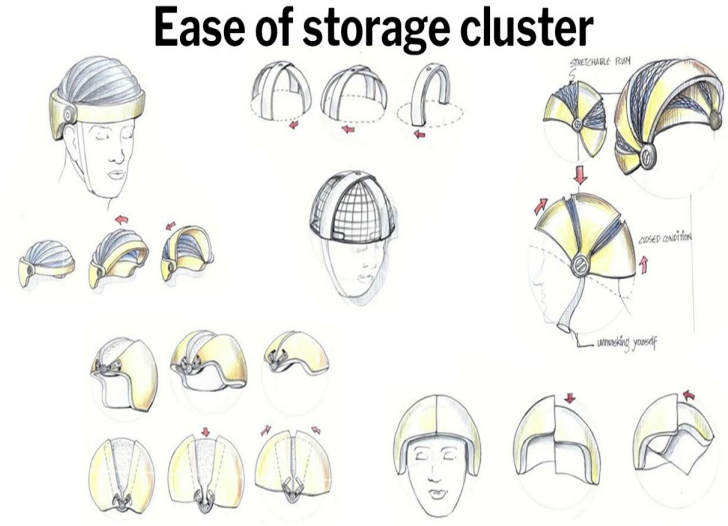

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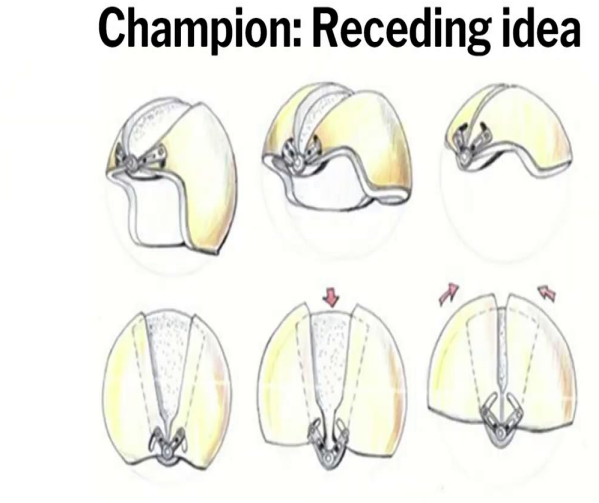

He said that I would like to make it very slim so he started with this which is part of the receding idea.

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He choose that as a champion and then took it forward from here.

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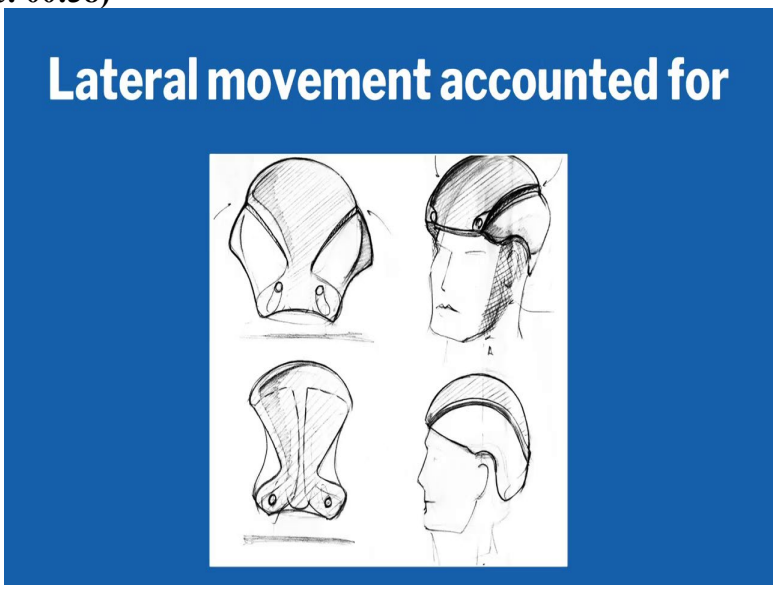

See, how did the ideas were developed by using other ideas putting together and then came up with this where you press and you push the both cells inside and it becomes very narrow. This is the Ease of Storage idea.

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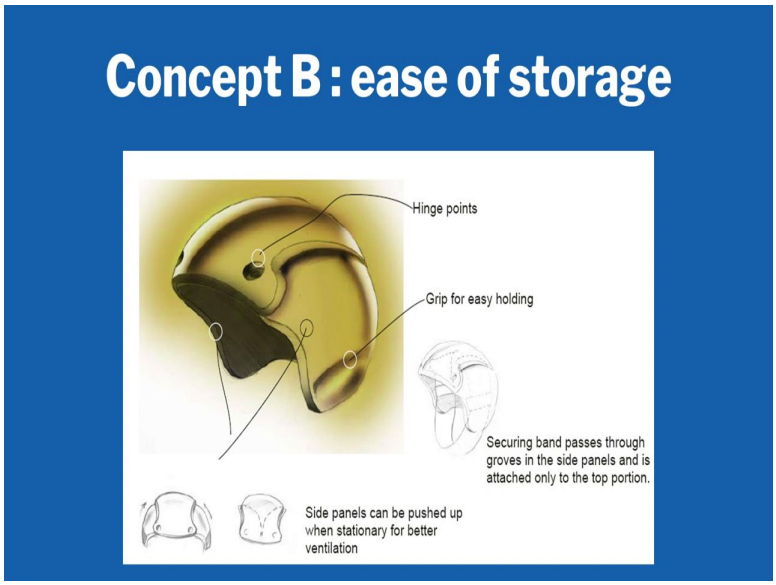

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And then, comes the Ease of Use cluster. Remember the ideas. These ideas, those ideas, all put together and finally this was taken as a champion. This idea was taken as a champion because this has with, you just have to wear it as a cap and push it down. Right?

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It was much more easy to wear so that was considered as the main idea.

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So this further developed because the net is too large. There were a lot of gaps. It won't, you know, it won't be acceptable as a helmet.

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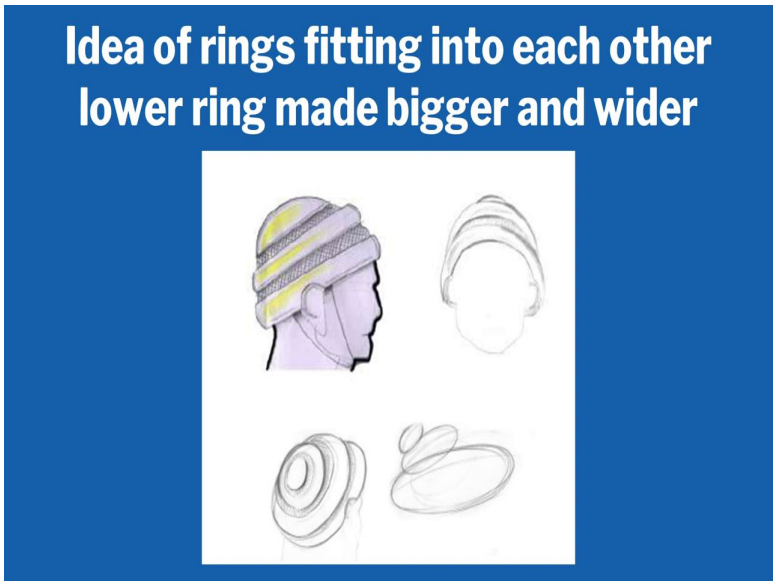

So those gaps were reduced and here you can see how the net is becoming smaller and helmet cells are becoming larger, but still that whole idea is going inside.

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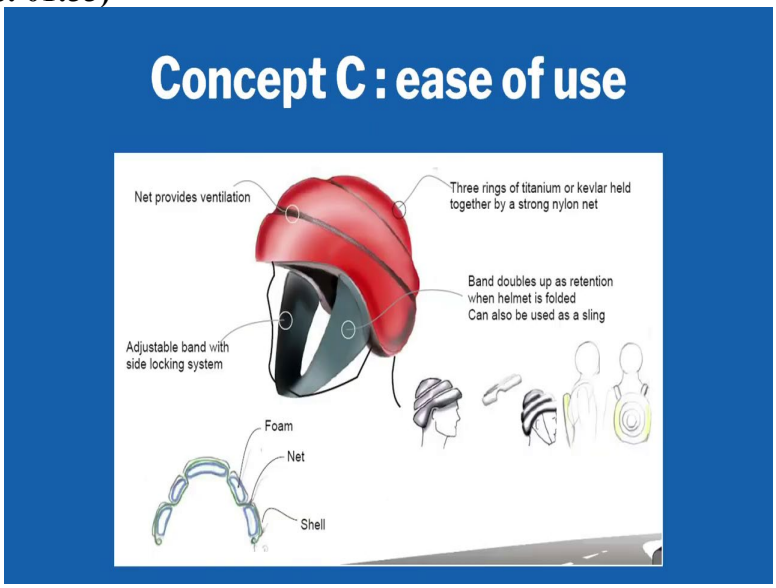

And finally you can see the concept building into a Concept C which is the use of Ease of Use. So you have 3 concepts.

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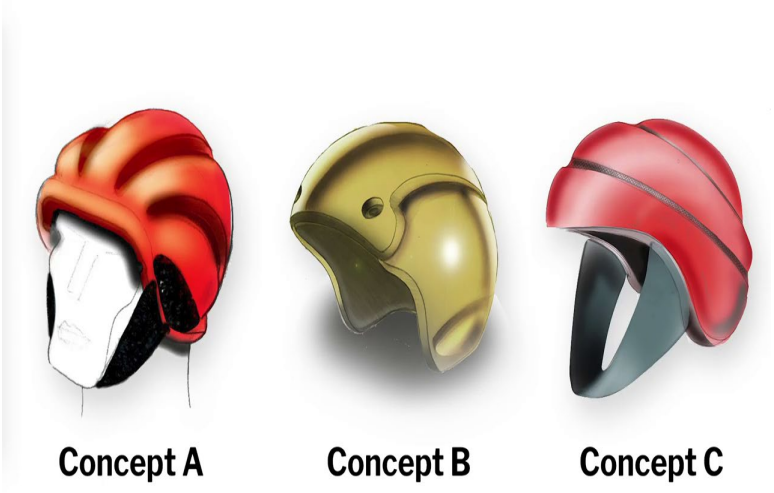

The competition between the Concepts is a very, very critical thing and from these three concepts now we need to find out which one will be used for the current product brief.

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Concept	Advantages	Disadvantages
	Good air circulation Multiple ways of gripping Light weight Strong style statement	No reduction in volume Difficult to manufacture in frp Rare chance of pierce injury Problem of dust
	Reduction in volume Ventilation on sides Easy to carry and hold	Moving parts add to complexity Projects a weak image
	Reduction in Volume Good ventilation all around	Three part manufacture Does not look robust Loose parts

The product brief was very, very clear. You would have encouragement of use. You should have, you know, basically good storage and you should have good ventilation also. So, all the three can have, all the three have three different degrees. Right? First one is very difficult to store, it is still large. Whereas this one it is easy to store. It is ventilatable also. This one is easy to store, it is ventillatable and easy to wear.

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So, automatically the last one got selected as the concept to go forward. And then we went to experts and asked them. 'What do you think about this helmet?' They said 'It's horrible'. Who would want to wear a helmet which is broken from the beginning. Isn't it an interesting perception? And this was the first reaction from the scientists and the engineers that it is like a broken helmet. You are designers should have the perception to make it look strong and not broken.

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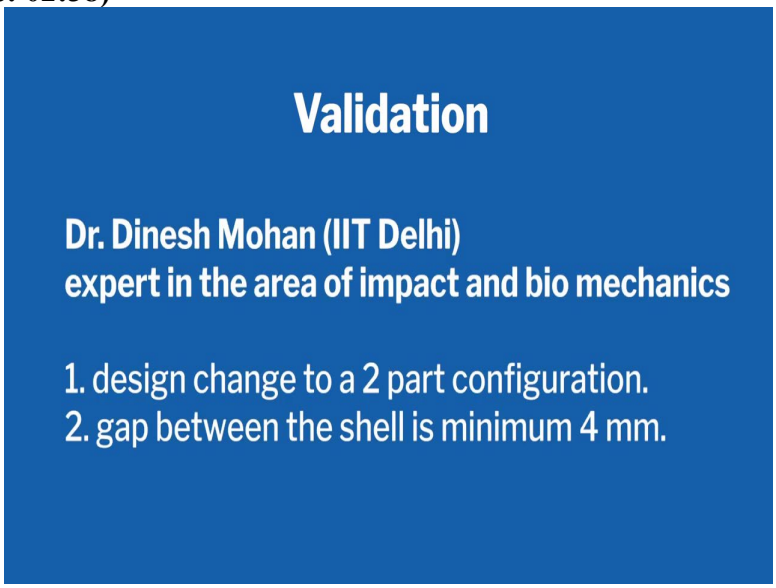

So then then, you know, Dr. *Dinesh Mohan*, again a professor, said 'This is not going to work. At least make it two parts receding then the, you know, we reworked the whole design.

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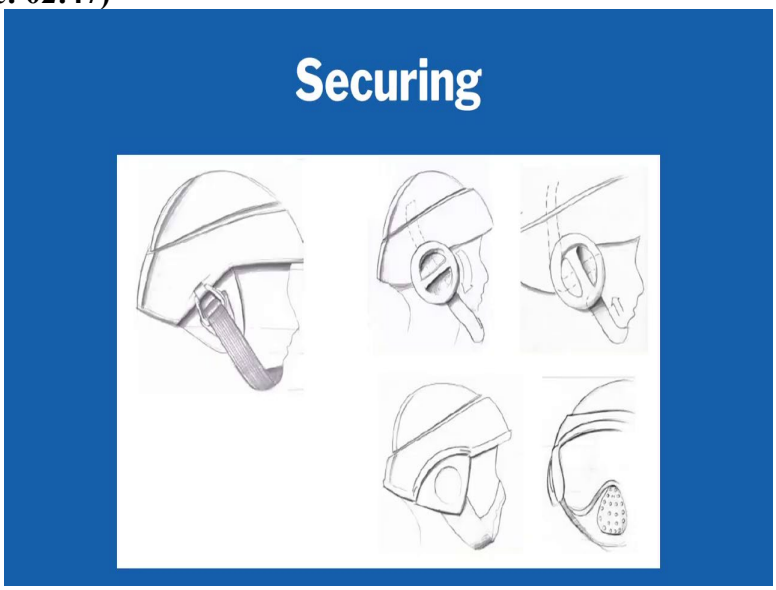

Made it two part receding. So that gap is also hidden and it only collapses when you need to store and you do not, you know, see the, you know, break very clearly and different sketches were made.

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And this is how the first conception came up about what the helmet should look like.

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(Student Professor Conversation Begins: 03:04)

Student 1: Sir, so does the break, like, structural integrity, like, in a collision?

Sir: Very good question! So just tell me, will the break compromise on the structural integrity of saving a person's head?

Student 2: Breaks (in the helmet) will like it will observe more shock.

Sir: It will absorb more shock because you are getting it closer to your head. This snug fit helmet is the best helmet for saving your life. And when the, when the hit happens it does not happen, something hitting you all around you head. Got it? Whichever side you hit, it gets closer and the fitting is also much better and you get much better, much better protection. And that is very counter intuitive. Right? So you have a much bigger task of convincing users.

That it's better than the other one and you should do, you should do evaluation by doing testing also.

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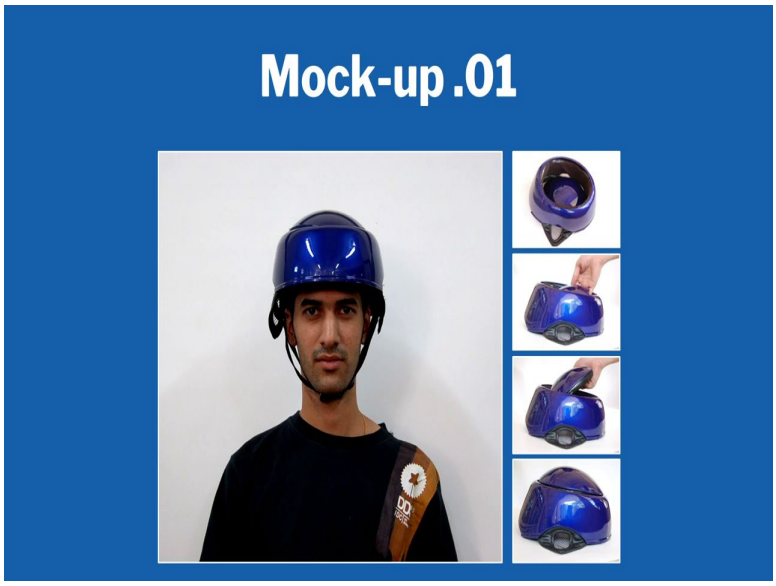

So here we have one of our *Mandar's* friend, wearing the helmet and showing, you know, how the helmet works and this is called the first working rig. Working rig will not be aesthetically pleasing. It will be built by using existing helmet parts.

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So he took a large, he took three large helmets, chopped them and created a helmet which will collapse. Right?

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He does not have the, yoo know, and then showed us how the thing works. He used the same buckle, he did not even use the elastic buckle. it is supposed to be elastic. Right? That is just a rig. It is not a mockup. When you use a mock up what will happen? It will not work but I can wear (it). It will not collapse, but I can show. I will show you a mock up also. This is a mock up. When it is full, this is the helmet when it is collapsed, this is the helmet.

It does not work and the volume becomes nearly reduced by two third, one third, sorry. So your mockups, this is a scaled mock up. You can have a full scale mockup which I have some in the lab. We actually have an Innovation Studio. When the student finished this project we wanted to carry this project forward, and we took it up with the Shenoy Innovation Studio and we started working on this by now experienced designers experienced engineers to take this forward.

When the student does their juries during their final presentation they have to show one photo realistic rendering.

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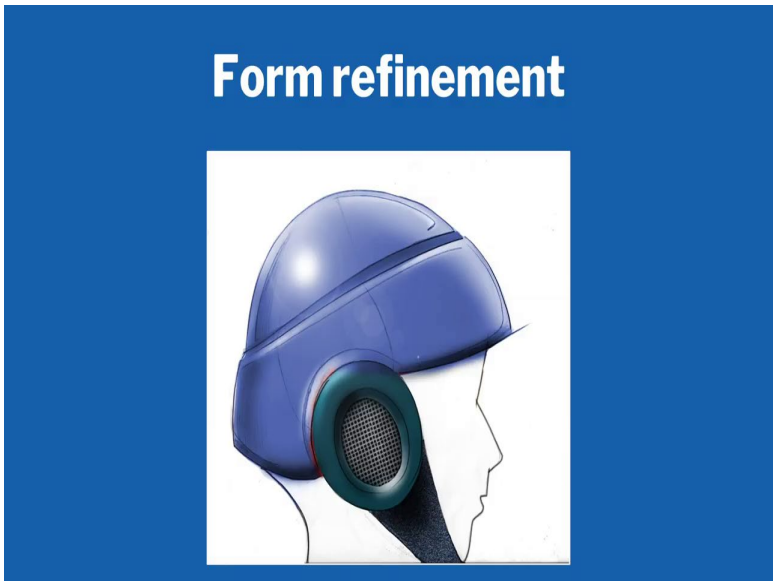

Which is the actual shape of the helmet, the form and style. Either show a working rig or a mockup model. Full scale mockup model. Please make a very good photo realistic mockup also which is as close to the mass manufactured product because nobody should be able to change your design intent later on. Now we are back to the Innovation Studio. So, Innovation Studio is a professional organization. Right? It is, it is not a student body anymore.

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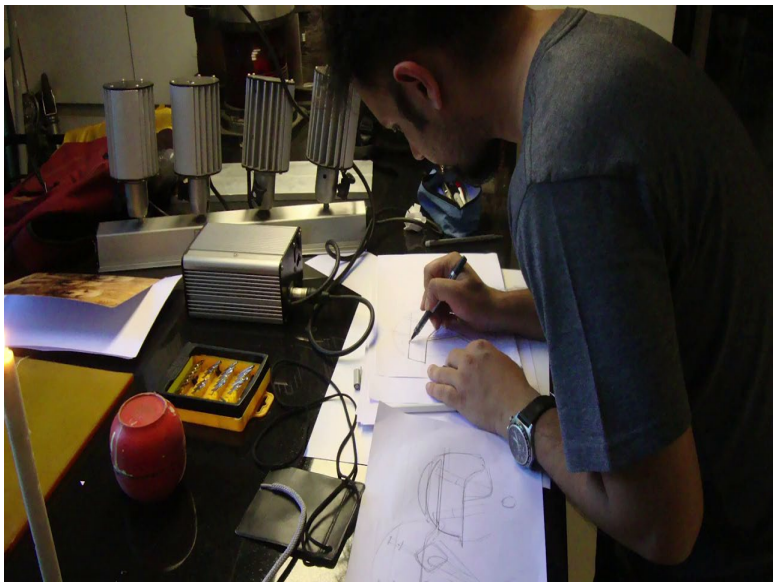

We got experienced designers with 4-5 years experience. We got engineers, we use a lot of consultants from outside to work with us whenever we have problems, you know, any of the materials and manufacturing and tooling.

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Remember I was telling you one helmet does not fit all, so we said whom are we working for, So we came up with a persona: an office going person that has a largest population of people who are using two wheelers.

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And they have, you know, the maximum problems and we chose that persona and this is that persona and then we found their daily routine, the average distances they travel, the type of vehicle they use, type of shoes they use, to get whole demographic information about this persona. So you are now clear about your segment of the user.

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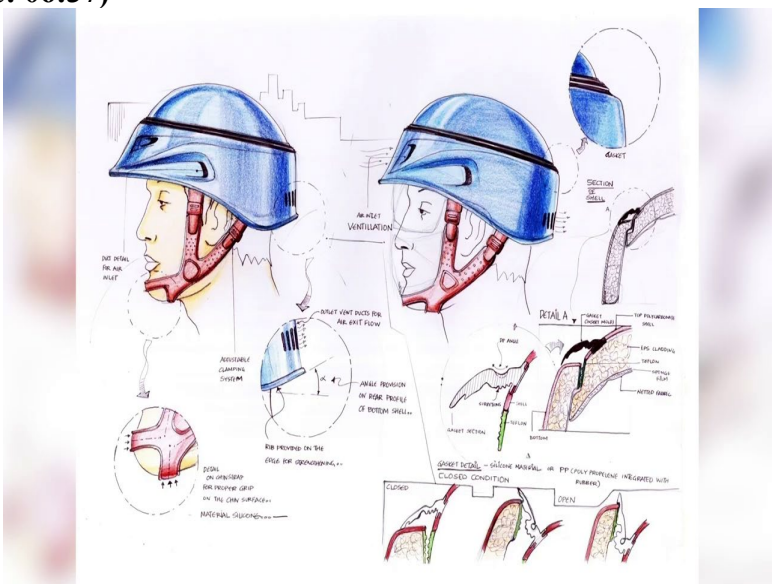

So with that segment of the user comes the very important task of showcasing the features of your helmet. So remember we were telling that the helmet will have a very good strap, which is elastic in nature with no buckling. It has a duck detailed so that the breeze will go in. Remember each concept has to have all the features, the breeze goes in and comes out and it keeps the head cool. This is an adjustable clamping system so that the elastic is not too hard on your chin. So, you adjust using the clamps which will take all the details of that.

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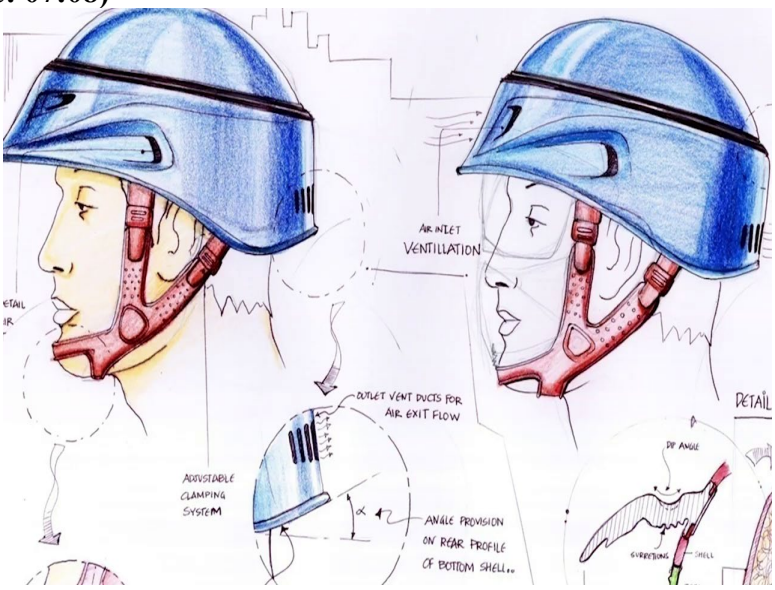

Then you have these vents which will take care of all the ventilation effectively. Then you also have this very interesting rubber.

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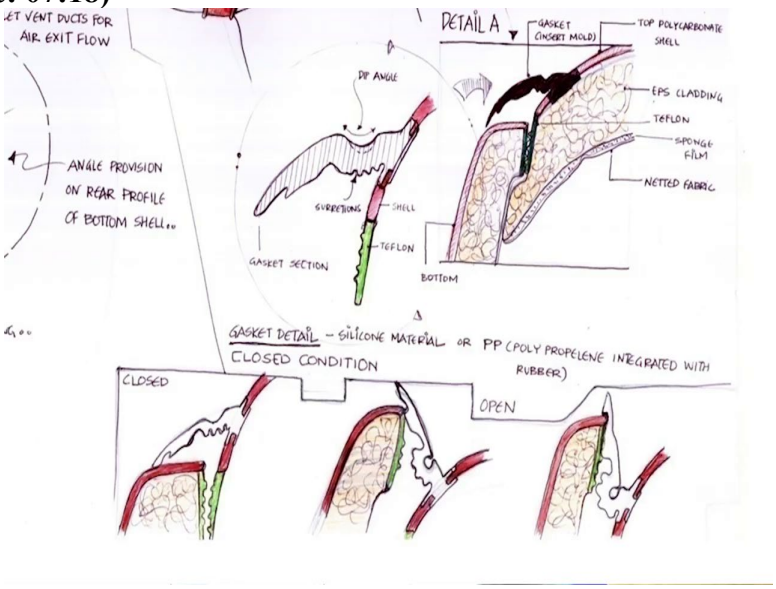

This rubber is very important, right? Because? If it is raining, the water should not go in, but it should also collapse and open up. So, the rubber detailing is very critical. So these are the initial sketches of the rubber detailing when the, you know, when the helmet goes in how will the rubber, sort of, becomes straight and helmet goes in and when I push it out how the rubber block the, you know, block the gap. So, this is a very large working, and we nearly spent 3 months working on this one detail.

It is that tough when you have any nice concept it is easy to say 'Ok it will go in and come out', but when you have a rubber detail over there, how will the rubber work? And the biggest challenge was the thermocol. Can I have a straight cut of thermocol? I cannot because that area will be weak. If there is an accident in that corner, the person will die. So we need to have an overlap and at the overlap the distance minimum 22 millimeter at all the length of the overlap. So once we did the overlap the helmet was becoming very large. So, multiple problems and these are all the features which we, you know, the helmet had to carry.

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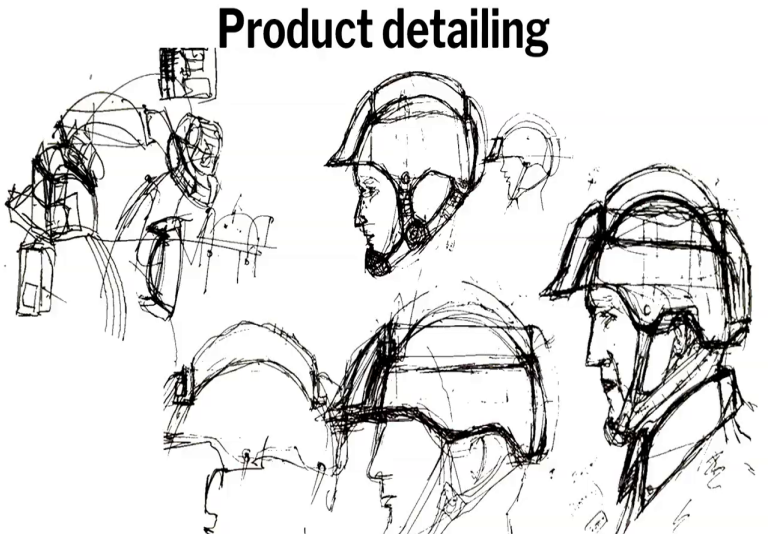

So then came all the product detailing aspects, how you detail out, how will you revit, how the shell will go in and out, the head dimensions, the control dimensions or how will the dimensions work. What are the other critical things? And these are generally, designer's doodles are very important for you to, you know, articulate, to come out of your thought process. So this is called externalizing your thought process.

When you sketch, for example when you sketch, you know, he is looking down, but when you sketch you externalize your thought process and then when you resketch again you see the number of lines, when you resketch again what happens, your internalizing and externalizing again.

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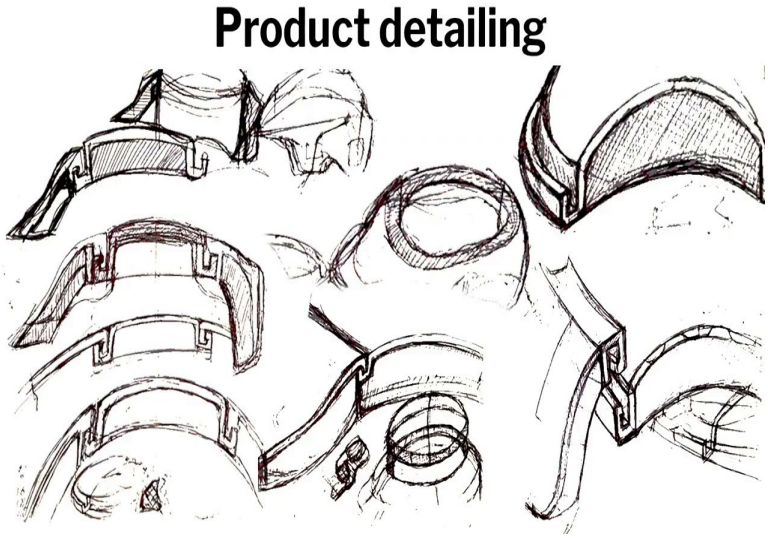

So the doodles are a very important creative journey in any design journey. So, then we did all the detailing of how the thermocol shell works, what type of shape, what type of plastic, you know, covering should come on it and how will the plastic break and lock into each other. Remember this plastic shell has to lock into this plastic shell. Right? So how will that locking happen? Will it be very wobbling or lose. Remember, one of you were saying it can be more dangerous if it is not good enough, that will go and pierce your head.

If your helmet is not, if I have too many ribs that can go and hurt the user. You're not, as per IS standards you can't have any, you know, projections inside.

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So, you have to be careful in all your detailing of how your detailing will be done, all these, you know, sketches are all about detailing and taking the markup model, remember, we had the designing solution, to the next level of product development.

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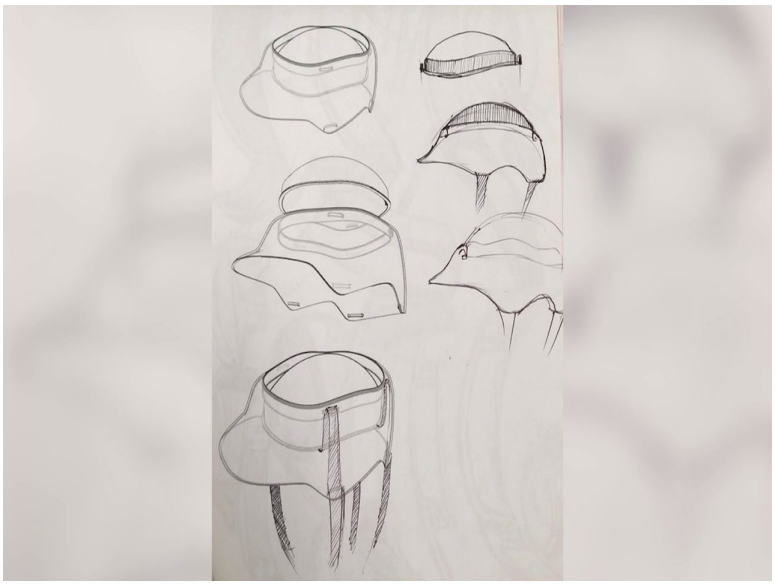

And then the biggest challenge was, you know, how will your top be buckled to your bottom? See you have the top shell and that has to be buckled to the bottom shell. This aspect was, you know, thought of multiple times. Should this shall be connected to this and then this should be connected to the chin? That was one option. The second option is the top one should be connected to the strap and this should be connected to the top. You got it?

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Because the top should be tightest so this is connected to my chin, and this fellow is just hanging over there with the top. That is one option.

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So you have multiple options of thoughts is that, this is a very very big challenge of strapping.

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How will you strap the helmet was also very, very challenging task. This also took a lot of time. Nearly how many years, took nearly 2 years to come up with, to sort out all this.

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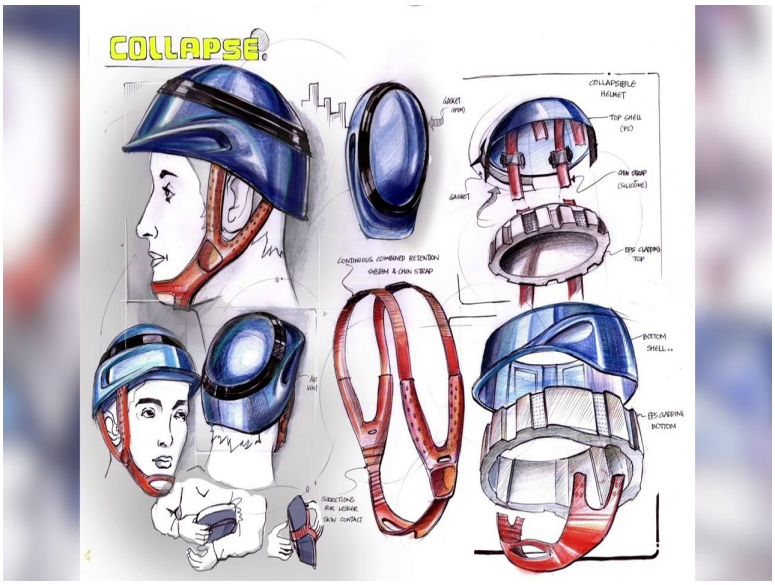

And then came the final design details.

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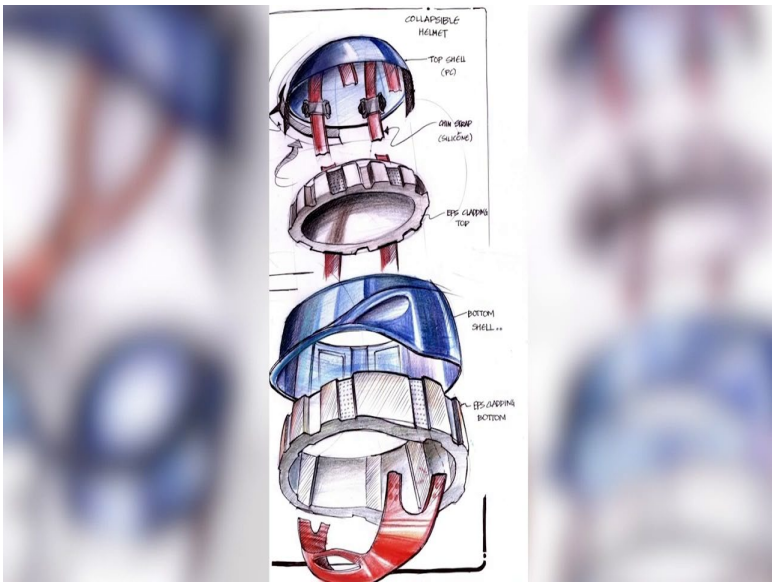

You can see how the thermocol has slots of this strapping. So, finally what we decided, we are strapping from the top, right? We are strapping from the top through that thermocol that is coming. Then it is strapping from the bottom, the bottom is hanging there and hence , you know, buckle is there. So this is one stage, there are multiple stages of development. This is one stage of development. And after this stage of development, like a, you know, Mr. *Chari* was our own aluminou with a lot of experience in the industry, you know, again, you know, went out and joined another company and then, we had another designer join this called *Ashish*.

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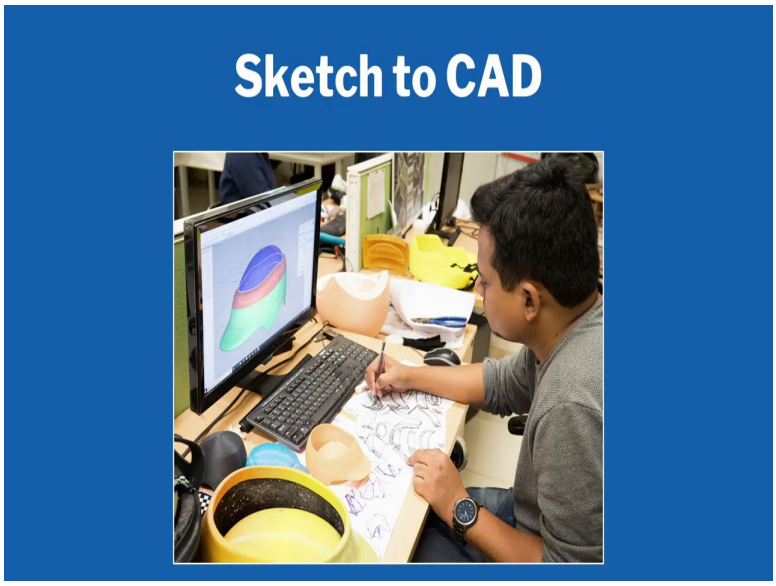

Ashish is now, you know, a M.Des from Indian Institute of Science (IISc), was sitting continuously with this product for another one and a half years. So, remember I was telling you, every idea which is creative and which is good for the user can be detailed out to become a good concept. So, that was a very strong belief in me, I said I am not going to leave this. If collapsing is going to solve my problem for both ventilation and ease of storage and ease of wearing, I am going to leave no stone unturned to see to it that this is implemented from multiple levels, the materials used, the technology used in the manufacturing technology.

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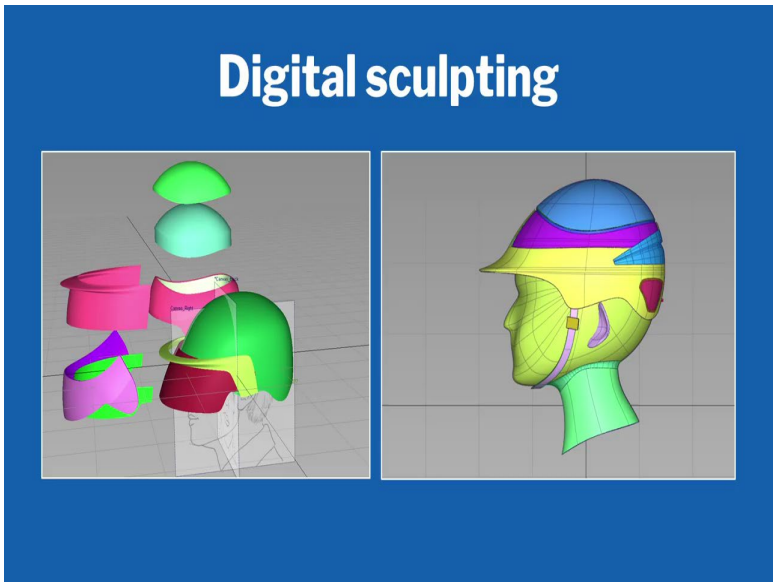

We will do everything to take it forward. So we then did the digital sculpting to get all the shapes in. Now the very important aspects started happening. Remember when you see this helmet more

on head, you will not see the break because it is on the top right, so we had to take this cut inside, it is longer out, remember the earlier helmet the cut was outside which you can see, so user perception was also a very very important aspect for us. We took that and then we, you know, got all the detailing done, we went back and did the strapping to the bottom section.

So it is strapping to this one and attached this to this one, that was a much better idea, because when you pull this will automatically sits.

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And finally, you know, this is one of the stylized versions which we couldn't fabricate because the thermocol was not fitting in this also had to be rejected.

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And then, you know, we build the final option where with the steps coming in and with that step we used 3D printing machine very creative, to vertically, to make both the shells of the product.

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And with this we came up with the option of the rib and the support structure and how, you know, for example, the volume of travel which will happen inside and you also check the thermocol how it will go in.

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So this is the final redesign option with the visor of the total design which had all the components of the collapsing, the ventilation and the visor is a very important component in every way.

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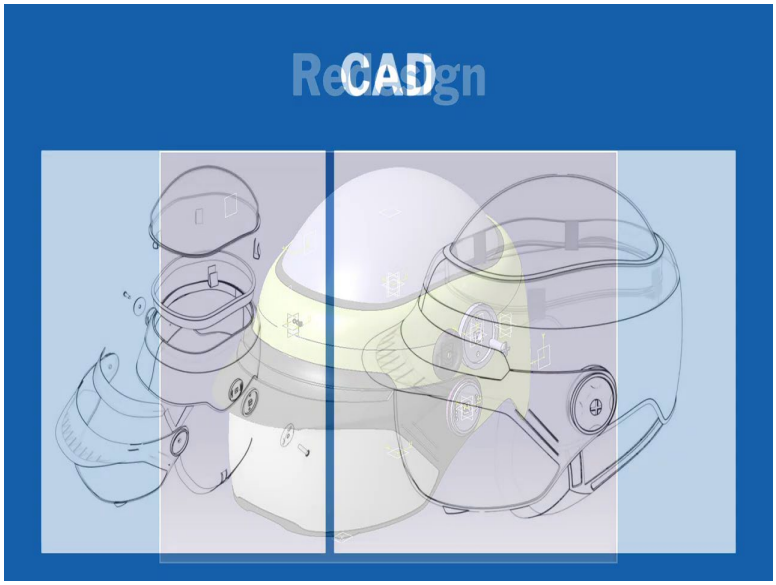

And this is the final detailing of how your whole product was made with all the clamp, buckles, rivets to put all the, all the parts together.

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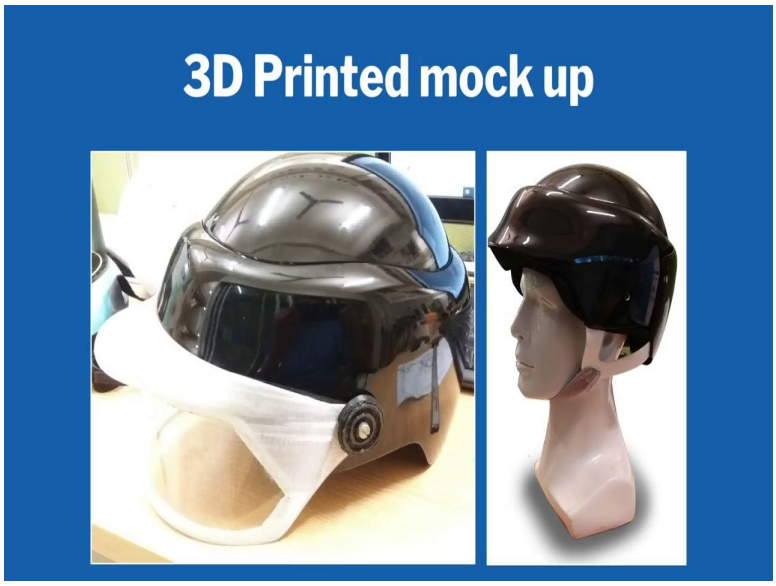

And from the CAD model we did, we did multiple 3D prints, you know, they would be an error over here so we would print again join that. So, in this case is the bottom shell and then we also have the gasket 3D printed. Unfortunately the 3D printed gasket was not very, you know, was not very good. It became very tight when we assembled it. Some other components are very difficult to 3D print because the hard components are very easy. The flexible components are generally it is good to mould them.

They are available in the market and we mold them because the molding costs is not very high. For example, the tool cost for this part could be as high as 8 lakhs. Whereas the gasket tool would be just about 2000 bucks. So it is good to, you know, do the gasket in real and do this in 3D print for your trial purposes and after that, you know, can, you know, take things to go forward.

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And then, you know, we came up with the final version of how the collapsed state, what type of volume it will occupy and you will also see that it forms like a little small rectangular space so it is easy to put in a bag. So it can go into a bag which is like a slot or we can put on a rack, so multiple, you know, advantages come in. And we also want to have ventilation on the top so if you lift the gasket ventilation ports are available for air breathing in.

So these are the, you know, designs which came up as the final design. I think, as of now in this design, we kept the visor fixed and it can be, you know, it can be actually swivelled up. But actually, you know, if you remove the skewes it is removable. So if somebody wants to buy a helmet without a visor they can buy it. So it's that kind of option that is currently available. But we thought when we did the survey, with the mock up models, everybody said that they needed it with the visor.

Student: Also, did you consider space for spectacles?
Sir: Yes, so that was a very important component. So here you can see the type of visor just coming out so much. So if you see the model, enough room is there, the visor comes out like that.
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So this is the, you know, first prototype we made and we tested by wearing. Look at the distance, pretty large the visor. So then what happened, then we integrated the little cap type design with the visor. So this is the visor, you know, where, you know, the cap was integrated. It is still under progress. Making the transparent 3D printed parts are very difficult, so we are not able to get in a single component. So we actually did this 3D printing and kept using a transparent gasket over here but it still does not exactly mimic what you want. So we plan to mould this, you know, finally to get the visor right.

So this is very critical. So we were just wondering how, because if you wear it with and elastic it has to be coming from the front, you know. So we were trying to see how we can, you know, integrate that as a convenience of wear and, you know, opening also has to happen like this.

So we were trying to block it and, you know, see to it that it is always blocked over here, so when you are wearing you have to put your fingers in and wear. So, it always lock like this, you know, locked like this. So that we are still working out. So that this one, you know, collapses inside and becomes like this much. If the visor should have been there, the visor is there, the visor would

open up a little bit and it also, because the visor is from here to here and now this has been, gone into the visor and it will open up and become this close.

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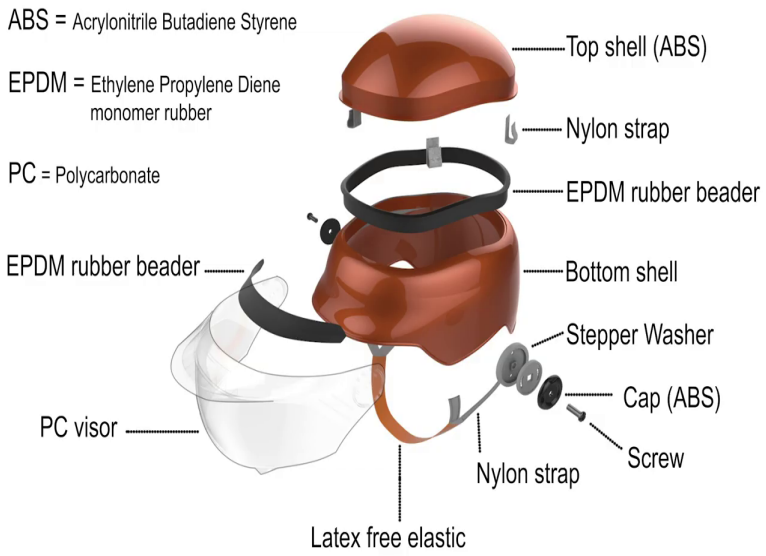

The gasket is made of either EPDM or we can use Polyurethane and this is also injection molded. You can use engineering plastics which is like polycarbonate, APS for motorcycle racing, but if you are doing a regular to, you know, regular work, which is here, it can be, you know, in a simple blend of ABS, which is much stronger. So these are all two, injection molded parts. The thermocol shells are made of expanded polystyrene you have.

So here my challenge is, you remember, the earlier helmet had only 2 dyes. Here I have four. Two plastic dyes, two thermocol dyes, one visor dye and then the elastic strap. Infact I must give you a good example over here. Did I tell you the example of the VIP Luggage Company, the VIP luggage company, there is my senior from IDC, who is the head of the, he is the vice president now, and he is based in Hong Kong to source all the components, because if you are not, if you are in the world market in luggage, you must have the components of ecosystem at level which is common in the world.

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The zippers, the plastic trims, the luggage or the polycarbonate shells, it has to be at that level. That is a very important understanding for us that to innovate, you also have an ecosystem around you which will work very effectively to take this forward.