Introduction to Research
Prof. Prathap Haridoss
Prof. Mahesh V Panchagnula
Department of Metallurgical and Materials Engineering
Department of Applied Mechanics
Indian Institute of Technology, Madras

Lecture- 32
Research in Applied Mechanics

Prof. Prathap Haridoss: We are glad to have with us today Dr. Mahesh Panchagnula. He is a professor in the Department of Applied Mechanics. He has a B. Tech in Mechanical Engineering from IIT, Madras and PhD from Purdue University in United States also in the area of Mechanical Engineering. And he has been in the Department of Applied Mechanics here at IIT, Madras. His areas of research include vecting and surface tension and liquid fuel atomization and combustion. And so he is also you know interacted a lot with industry and has a very good perspective of what industry is interested in, what academy has interested in and so on. So, with these words of introduction, we will get started in this discussion. So Mahesh, what are traditional areas of research in your department that incoming students are likely to you know have options to join?

Prof. Mahesh V Panchagnula: Thank you Prathap for having me. Our department is basically kind of structured into 3 groups. We have a group that works on Fluid Mechanics problems, another group that works on Solid Mechanics related problems and a group that works on Bio Mechanics and Bio Medical Engineering related problems. And within these areas we have; these are kind of more granular, it's in other words there is a lot of inter disciplinarily that we are very proud of in our department, we have faculty from 8 different undergraduate trainings all the way from Physicist to Aerospace Engineers, Mechanical Engineers, Civil Engineers are all represented in our department.

So we bring a very melting pot of many different sciences and engineering, and that brings a very different flavor to our department's research. I would strongly encourage all the candidates to go find the faculty profiles on the web and study them, but classically the department has focused on mechanics related problems both in the fields of fluid and solid mechanics and more in more recently we have looked at our faculty had started focusing on fluid structure interaction related problems, cell mechanics which

is a more bio mechanics interfacing with solid mechanics problems, as well as interfacing electrical engineering into mechanical engineering.

Prof. Prathap Haridoss: Of course, I think in any set of research areas even though it may be traditional clearly there are you know boundaries to a research and invariably the research is all about pushing those boundaries. So even though something may be classified as a traditional research you may, you will have you know leading edge part of that research going on. But setting that side, are there areas of research that you would consider you know more recent areas of research that people in your department have started pursuing may be let us say in the last 5, 10 or 15 years which is may be different from what people have been pursuing over the longer time frame?

Prof. Mahesh V Panchagnula: I think these 2 technological advances that I think have enabled the lot of the newer areas of research worldwide. There are extremely fast computational tools that have now become available. And there are extremely sophisticated analysis and visualization tools, electron microscopy etcetera that have now become available. So we have faculty that do experiments and computations using these tools, for example, we have faculty studying tissue properties using nano indentation and atomic force microscopy. We are faculty doing very high in computations on industry scale combustions problems during what is called direct numerical stimulation of a particular kind of a flow.

These are extremely challenging problems and these have been enabled by like I said these tools that have now become available and the insights that have been gained by the use of these tools will soon see the light of day in an industry scale deployment of a solution. I will say these are still emerging research areas, but my vision is that in a few years we will actually see these tools solving industry problems, so these are the newer areas. In the traditional areas also we must point out one difference in the way or we at IIT pursue research in general and our department as well. Using the traditionally developed research tools there are lot of India's specific problems that can be solved, whether it is an organization like DRDO or an ISRO or any of the public sector undertakings or our rural problems. They do not require the extremely sophisticated tools, but they require an India level thinking and India scale thinking that the youth that require may be traditional solutions, and we are not ready to discard those solutions because they are ready for to solve our problems.

(5.16)Prof. Prathap Haridoss: Okay I think that is a very interesting insight into what is driving research these days and how it relates to what is required in our nation. You mentioned that you know in your department you have wide range of different faculty so perceivably you also have a wide range of different students in terms of background.

Prof. Mahesh V Panchagnula: Yes.

Prof. Prathap Haridoss: Who come into your department? So, what sort of issues do they generally face when they come into their MS, PhD program here, are there some general issues that they face as they settled in and if so how would you handle it how they handle it and so on?

Prof. Mahesh V Panchagnula: Sure, I think as a research going from a class room degree program to research program is a big step up in a scholar's journey. In terms of the open-endedness that becomes available to them, that is in front of them. So, until as long as you are in a classroom environment the problems are usually well defined, you know like I say in my lectures given in equation involving 4 variables, given 3 find the fourth. That 's the classical problem solving. Once you get into the research you will still have an equation involving 4 variables, but you are only given 1 variable.

Now, you have to figure out what works for the other 3 variables and justify your own assumptions. That in a very lose definition is kind of where you are getting in to research territory and then beginning to define your own area of research is a second challenge. S So very often our faculty allows the scholar the freedom to choose their own area of research, within the boundaries of what they are interested in and what they are equipped to work in. So, this is a second challenge that the scholars usually face and these are good challenges to have because this is where we the scholars grow.

Prof. Prathap Haridoss: Positive challenges.

Prof. Mahesh V Panchagnula: These are very positive challenges and I think the way to approach these challenges is to be open-minded. Is to not think of this as a challenge like you said think of it as a positive challenge and grow in to the solution to that challenge and use the resources available, use your peer group. We have like you said; we have a very diversified peer group in our department. The MS and PhD scholars students population in the department come from many different background, so talk to all of

them and you will see a good prospective emerge of as to what the solution to these 2 questions are for your own training.

Prof. Prathap Haridoss: Ok, Great. See now, when you look at research in an academic setting and then you know there is the industrial setting, where you know people are focused on products that are supposed to come out may be are probably coming out right now or they are coming out in the immediate near future, so sometimes there is always this perception that may be research is doing something which is not directly in line with what the industry is required and may be some of it may even be true, But taking all that into account, are there specific areas of research that are there in your field that you know industry is currently very interested in and are actively looking at?

Prof. Mahesh V Panchagnula: Sure, I think being publicly funded institution we have a mandate to serve Indian industry in some way. I mean it is part of our job description and it is a part of the scholar's job description also when they come into think of what India needs and many of our faculties are involved with like I said DRDO and ISRO very actively both by serving on several expert committees as well as in specific projects. So that's a direct way in which our faculty and students are working with the Indian industry.

A more indirect way, is where we have working on industry related problems, these serve as training rounds for scholars for the industry to absorb later on when they graduate, so many of our faculty of our scholars find jobs in the Indian industry primarily when they graduate whether it is a GE, whether it is a Boeing, whether it is a Mercedes Benz they have traditionally absorbed our research scholars graduating out of our programs. I think large part of it is due to the fact that they have been trained on industry level, industry scale problems during their stint in the department.

Prof. Prathap Haridoss: Okay when you look at, I mean am sure you interact with students you know both belonging to your group, working with you, working with other colleagues of yours and so on and when you look at them going through their you know phases here of I know fresh incoming students, mid way into the research and they getting close to graduation different phases of their you know stay here and then their early part as a professional. So look at this range of time you know frame, how would

you measure you know success in research in this kind of a you know time frame, when they start from nothing and then you know move towards something significant?

Prof. Mahesh V Panchagnula: It's actually a phenomenal growth to watch. And I have had the chance to watch a few of my own students go through the process as well as my colleagues students. When they come in usually find a big change is in their level of confidence in their own abilities and I think that is with that is going to remain with them for rest of their career. The confidence they gain while here at IIT and in the Department of Applied Mechanics. A second a second add-on is their own skills set that they gain while they are here at IIT. In IIT is by any definition of world class institution in term of the infrastructure we provide the students, in terms of the peer group, the faculty group.

I think when they look at this whole this big spread of a multi-course meal in front of them, they end up the research scholars in their limited time they are here on campus end up sampling a lot of the different techniques and they add to their own skills. And at the end of the first few years they are well equipped with these skills. The last few years may be 2 years of that we have spend on campus I am looking at a typical PhD students is where the confidence grows leaps and bounds and I can see this in their committee presentation as they go forward and I think this is a very rewarding progress to watch as a faculty member and I am sure it is for them to reap the benefits of after they leave IIT.

Prof. Prathap Haridoss: Okay you already mentioned something about you know industries that are looking at areas of research here with interest because it is of you know something related to what they are working on. In general when you look at Masters Students and PhD students there is always this perception that they are specialist, which is true they become specialists in a specific area that they working on. And so when they graduate and look for positions there is always this thing that this concept that have to find something that is relevant to what they have become a specialist in. So where do you typically find MS, PhD students graduating from your department from Applied Mechanics what sort of positions do they get and what sort of organizations do they get into?

Prof. Mahesh V Panchagnula: It's a very good question; you know placement at the PhD level is nothing like placement in the undergraduate level. So yes, we are dealing with people with specific skills, but IIT has set up mechanism for industries needing specific

skills to reach out to the candidates who are graduating with those skills. I think by and large a fraction of our candidates of our scholar graduating go into industry positions that build upon the skills that they already have acquired. A similar fraction roughly about, let's say a quarter of our students go into positions where it may not be directly related to the skills they have acquired, but they have that background information necessary to grow into a position that the industry needs them to get into.

But if you look at the problem from the other side from the pull side you know as to where are the jobs for PhD students specifically. The biggest employer in India is the Academia. We now have you know about 16 IITs plus more and more getting added next year. We have several NITs; apart from these we have very good state institutions not to mention the multitude in it's private institutions. They are all looking for good faculties' members and they are all reasonably well paying positions. So a fraction of our faculty of our research scholars do go into these positions, many of them are candidates they already faculty they come gain the training here and go back to become better faculty members where ever they are.

But I will say I will encourage every graduate in PhD students to look at an academic position, because if you want to set this in other 4 as well, but if you want to be a service to the country that is 1 position where India needs you. You look at the demographics and it does not lie, the number of young men and women that are going to come into colleges in the next 10 to 15 years is humongous no other country in the world has this kind of challenge ahead of them and the PhD scholars graduating from institutions like the IITs are the ones that have to solve the training problem there.

Prof. Prathap Haridoss: Okay I think that it's a very important point for young people to look at, because the promise of the nation is also in their hands to deliver. Let me know we have spoken about various issues associated with the PhD process and as it applies to your department and the areas that they work students work in and so on. Let me ask very mundane question I mean during their stay here one of the things, one of the aspects of you know graduate students like is how much they interact with say each other and how much they interact with advisor. In this context I mean in your experience and your view, how often should students be meeting their advisor or guide and how does that know come out come out in play?

Prof. Mahesh V Panchagnula: I think I will say initially you probably want to have a fairly high frequency of meetings, just so you are getting to know each other and then typically I find that every advisor-students pair settles into their own comfort zone of you know how often they meet. Several of our faculty holds regular weekly meetings of the whole group and they may hold more frequent meetings with individual students. We have a few faculty members who, after having gained a certain level of confidence in the scholar may suggest that this scholar go about their own independent research and meet them even less frequently than weeks.

So it depends completely on the advisor and students, but I would look at that in the sense that this is something that you can define with your advisor, it's just two of you sit down you decide level of interaction that is appropriate for you. And we also have a very thriving external program, where the meetings are obviously less frequent but are just as productive in terms of research. So, I will say one last thing as whereas the advisor-student and student-student interaction go, you know we are now at IIT a predominantly PG institution and in the Department of Applied Mechanics is only a PG department.

So, we are all human beings and very often we see conflicts arise, whether it is a student-student conflict or advisor-student conflict, don't be unnerved by that, there are professional mechanism set up to handle conflicts at all levels and I will say that we are also professional beings, so I mean I don't expect to be likeable to every human beings on this planet and if there is a conflict we have a mechanism to professionally resolve it move on and still be friends.

I think, at IIT we take pride in that aspect that often we sometimes have issues with guides and students, but we have a professional mechanism that takes good care of that students graduate, they are very happy when they graduate even after having gone through some issues like this. But I must also point out there is a minuscule fraction of that 2000 odd PhD students that we have on campus that have to encounter anything like this. So, if you have these issues in mind, if you are apprehensive about trying to select a guide I will say don't be fearful go in because if something does not work out there is a

Prof. Prathap Haridoss: There are lot of options available here.

Prof. Mahesh V Panchagnula: I mean just go in with a free mind I am sure things will work out just well.

Prof. Prathap Haridoss: So to wind up I just wanted to get your words on what are the words of advice that you would give to an aspiring student in Applied Mechanics?

Prof. Mahesh V Panchagnula: I will say come in with an open mind, be ready to do interdisciplinary work because that's where world lies today. Many of the problems cannot be put in vertical silos, where I am a mechanical engineer and all I learnt in UG mechanical engineering is enough to solve this problem. So be ready to be more interdisciplinary. And I will say come enjoy the ride, you know to me the third party is to anybody anywhere in the world research is a walk through an uncharted territory, uncharted open area.

So you know you succeeded when your peers outside IIT reward you and say good, we like what you done, whether it is a publication, whether it is a pat on the back at the end of a conference presentation. We all look in the short term that is a very clear success measure, look for those measures and mind you, your peer group is not your immediate 10 students around you, it is somewhere else in the world that's why we publish in international channels. And I think look for those, look for those publications you know, aspire to be to publish in the best channels and I think you will be just fine for the rest of your career.

Prof. Prathap Haridoss: Great. Thank you Dr. Mahesh for joining us, it was a pleasure.