



Editorial

We are delighted to bring you another edition of Sukshma. The previous edition's release was during the recent ISSS-2014 International conference in Bangalore. We are happy to note here that during the International conference, more than 100 researchers, engineers and students became members which means that Sukshma can reach more people and thereby lead to mutual enrichment. In this context of increased reach, we look forward to more quality articles and information tidbits that pertain to the broad area of smart materials, structures and systems. By this, what do we mean? Of course, several things! One of the challenges we encounter is how do we facilitate our readership to keep abreast of tremendous and fast paced developments in the R&D of this broad domain. This also is deeply linked to the very purpose of running Sukshma. Recently I had an opportunity to attend an international conference, SMST-2014, on Shape memory and Superelastic Technologies in Pacific Grove, California. Amidst very scenic and peaceful settings, I was amazed at the extent and nature of developments in this area, particularly with reference to Biomedical applications. This led me to think as to how I could help share at least a glimpse of this to our readers back home here. Hence I am in the process of writing a summary of my impressions and thoughts on this conference and would wish to share that with you in the next edition of Sukshma. I hope and also assure you that you do not need to wait too long for that to see the light of the day!

Further, I am sure that quite a few of our members would be attending several conferences and symposia. We request them to share with the readers of Sukshma salient technical developments, challenges and applications that they came across. Any eye catching piece of information that is shared would lead to our readers taking positive interest in looking up for more details on that and that would be an extremely welcome input to our colleagues working in this rapidly developing field of engineering.

I would also request our members to collectively send us an update on some recent activities in their organizations/institutions that they would like to share with our fraternity. A yearly update would enrich Sukshma and thereby its readers. Another aspect that I would like to bring to focus on is the status of 'productization' of smart applications in India. In view of the recent thrust on 'Make in India' and also Dr. Mangalgi's article on activities over the last two decades under the aegis of NPSM and NPMASSS, it is perhaps, important for us to strive towards more indigenization and local sourcing of products and technologies. I would encourage our readers to write to us their thoughts on this rather important aspect.

Lastly, but not the least, the editorial committee requests the users to send us their impressions by way of articles and letters to the editor that could be considered for publication in Sukshma.

Sukshma wishes all the readers a very Happy, Healthy and Successful 2015!



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Report on the Proceedings of 6th ISSS National Conference on Smart Materials, Structures and Systems

(ISSS NC-6)

**Dr. Makarand Joshi, R&DE,
Dr. S.A. Gangal, UoP, Dr. G.J.
Phatak, C-MET, Dr. (Mrs) A.
Murugkar, BAMU**

ISSS has been conducting a series of triennial International and annual National Conferences to provide a platform to present and share the research carried out in the broad area of Smart Materials, Structures and Systems. In this series, the sixth ISSS National Conference on Smart Materials, Structures and Systems (ISSS NC-6) was held at R&DE, Govt. of India, Pune, on 6th and 7th September 2013. Such conferences facilitate attendees steering towards more effective utilization of technologies being discussed, exploring the strengths and building the bridges across various disciplines. ISSS NC-6 was held under the able guidance of Dr. V.K. Aatre (Former Scientific Adviser to Raksha Mantri), Dr. K. Natarajan (then President ISSS) and Dr. Guruprasad (Director R&DE). We were also fortunate to receive advice from many renowned scientists in the field. Organising Committee was guided by Dr. S. Guruprasad Sc H, Director, R&DE, Pune and Shri A.K. Patel Sc. G, R&DE, Pune. Dr. Makarand Joshi shouldered the responsibility of Convener of the Conference. The topics covered in ISSS NC-6 were Adaptive/ Smart Materials and Nanotechnology, Sensors and Actuators, MEMS: Design, Electronics and Packaging, Signal conditioning & Processing techniques applied to smart materials, structures and systems, Applications: Structural Health Monitoring, Automotive sensors, BioMEMS and RF-MEMS. This conference was sponsored jointly by DRDO, New Delhi and a few local industries.

Inauguration Ceremony was held on 6th September 2013 morning in Leonardo da Vinci - Auditorium



Prof. Arun Nigavekar, Former Chairman UGC, Inaugurates the Conference by symbolic lighting of the lamp.

of R&DE (Engrs). Prof. Arun Nigavekar, Former Chairman of UGC, New Delhi inaugurated the conference by symbolic lighting of the lamp. Other Dignitaries on the dias were Dr. V.K. Aatre, Dr. K.D. Nayak (CC-R&D, DRDO), Dr. K. Natarajan, Dr. Guruprasad, Mr. N Giridhar Singh, (Scientist, R&DE) and Dr. (Ms) S.A. Gangal (ISRO Chair Professor, Univ. of Pune). Dr. Guruprasad welcomed the delegates, invitees and participants and gave a brief introduction of the conference and its theme. Dr. Natarajan familiarized the attendees about ISSS and its activities aimed at promoting smart technologies in India. Dr. Gangal, speaking on behalf of the Technical Committee, gave an overview of the technical program of the conference highlighting key aspects like the number of research papers received, the review process, quality of the research papers received and plenary and invited talks scheduled in the conference. Dr. V.K. Aatre addressed the gathering in the capacity of guest of honor and described the importance of research in the area of smart materials, structures and systems. Prof. Nigavekar's inaugural speech was quite inspiring for the participants of the conference. He also released the commemorative souvenir of the conference and the proceedings in the form of a CD.

After this inaugural function, Dr. V.K. Aatre inaugurated the Industrial Exhibition. C-MET (NPMAS), POLYTEC, Yash Enterprises, Speedfam, COMSOL, SIMCO Global, Zeth Technologies and R&DE(E), had their stalls exhibiting various products related to MEMS and other smart technologies.

Technical Program Committee consisted of Prof. S. A. Gangal, Dr. Girish J. Phatak, C-MET, Pune, Prof Siddharta Dattagupta, IIT-B, Mumbai, Dr Dhananjay Bodas, ARI Pune. The committee received a good number of abstracts (126) and subsequently received 86 manuscripts for full length contributed papers. Of these, 74 were shortlisted for either oral or poster presentations. Each paper that was presented was pre-reviewed by two experts in the respective areas. The quality of submitted manuscripts, in general, was quite good, which is reflected in the fact that there were only 12 rejections. The papers covered a wide range of topics including structural MEMS, sensors in various regimes such as bio, optical, mechanical, and electrical; smart materials, electronics backend, actuators, RF and Microwave and so on. It was heartening to note that a large number of these papers come from engineering colleges and



Prof. Nigavekar receiving the bouquet from Dr. Guruprasad.



Dr. Nayak and Dr. Guruprasad visiting a stall.

research-wise remotely connected universities. Also, it was pleasing to note that a large number of student participants contributed to these technical papers.

The committee also approached renowned scientists and academicians engaged in R&D of smart technologies for delivering plenary and invited talks. A very warm response was received from them. However, because of time constraints we could schedule only 14 invited and 2 plenary talks.

Prof. Krishnan Balasubramanian, IIT Madras and Prof. Sibani K. Koul, CARE, IIT Delhi, were the plenary speakers. Invited lectures were delivered by Dr. Soumya Mukherjee and Dr. Prasanna Gandhi from IIT Bombay, Dr. T.K. Bhattacharya, IIT Kharagpur, Dr. Natarajan Vinoy, Dr. N. Raghu, C-MET, Trishur, Prof. Rudra Pratap and Dr. Debiprasad Roy Mahapatra from IISc, Bangalore, Dr. C. Ramadas, Dr. S.K. Bhaumik, NAL, Bangalore, Dr. Patrikar VNIT, Nagpur, Dr. Giridhar Singh, R&D Engg, Pune, Dr. Amita Gupta, SSPL, Delhi, Dr. D.P. Amalnerkar, C-MET, Pune and Dr. K. Natarajan, MSRIT, Bangalore. Five parallel oral presentation sessions comprising total of 42 papers and a poster session with 39 poster presentations were held. A Cultural Program was organised on 6th September in the evening.

A delightful dance and music performance was presented by Roopak Nrityalaya, Pune. All the viewers appreciated the excellent show by all the artists.

Life time Achievement awards by ISSS were given to Dr. P.D. Mangalgiri and Dr. S.A. Gangal as a fitting recognition of their immense contribution in the areas of Smart Materials, Structures and Systems in a special session on 6th Sept. 2013.

As is customary, one session of the conference was reserved for ISSS awards and presentation by awardees. The awards were in the form of cash and certificate. This session was held in the evening of 6th September 2013. All the recipients of the awards gave a brief presentation of their work considered for the award.

Winners of the ISSS awards for the year 2013 were:

ISSS Young Scientist:

Prof. Shantanu Bhattacharya, IIT, Kanpur.

ISSS Postgraduate Student (PhD):

Pijus Kundu, IIT, Kharagpur.

ISSS Postgraduate Student (Masters):

Hrilina Ghosh, BESU, Shibpur.

ISSS Undergraduate Student (First Place):

Jagjeet Singh IIT, Guwahati

ISSS Undergraduate Student (Second Place):

Navin Anwani and Saurabh R. Anmadwar VNIT, Nagpur.

The concluding session was held at the end wherein feedback from the participants were taken and discussed for the improvement of the activity in future. The conference

ended with the customary vote of thanks from the organizers.

ISSS AGM and Formation of ISSS Pune Chapter

The Annual General Body meeting of ISSS was held on 7th September between 8-30 and 9-30 AM. The agenda included various aspects and topics concerning ISSS. In this meeting a formal announcement was made about the formation of ISSS, Pune Chapter. Following are the details of the newly formed chapter.

Name of the Chapter: ISSS Pune Chapter

Jurisdiction: Maharashtra, Goa and Gujarat

Nominated Executive Council Members:

Dr. Guruprasad (Chairman),
Dr. G.J. Phatak (Secretary),
Mr. Jaising Pednekar (Treasurer),
Dr. S.A. Gangal (Member),
Dr. Makarand Joshi (Member),
Dr. N. Giridhar Singh (Member),
Dr. Ashok Gaikwad (Member).

Report on "Five-day Workshop on MEMS Design & Simulation" held at Aurangabad

As a part of the ISSS Pune Chapter activity, a '5-day Workshop' on "MEMS Design & Simulation" was organized at Department of Physics, Babasaheb Ambedkar Marathwada University, Aurangabad between 27th and 31st January 2014. Department of

Physics hosts one of the MEMS design centers supported by NPMASS. The workshop was announced in Dec 2013. Dr. Anita Murugkar (Coordinator NMDC) was the Convener of the workshop. The workshop was organized in coordination with ISSS Pune Chapter and IEEE India SSCS Chapter. This workshop was organized primarily to create awareness about MEMS amongst students and researchers in the region. Some part of the funds was raised through the registration fee paid by the participants.

The workshop was inaugurated by Dr. S.P. Zambre, Director B.C.U.D of the University on 27th Jan. 2014. He emphasized the importance of research in the field of science and technology and appealed to youngsters to come forward for research in this field.

A total 43 participants from various Engineering and Science colleges and Universities in and around Aurangabad attended the workshop.

The participants were introduced to MEMS technology, theoretical aspects of mechanical design of MEMS, and applications of MEMS through four lectures from members of ISSS Pune Chapter scheduled on the 27th Jan, 2014. The speakers and their topics were Dr. S.A.Gangal, Univ. of Pune, 'Bulk & Surface Micromachining Techniques'. Mr. Jaising Pednekar, R&DE, Pune, 'Mechanical Aspects



Dr. Nayak visiting a stall.

of MEMS Devices'. Dr. Dhananjay Bodas 'Using Microtechnology for Biotechnology', Dr. Girish Phatak 'Integrated Sensor Systems'. These lectures were quite informative and educative. Participants enjoyed and also interacted with the speakers through question/ answer sessions.

Remaining four days were dedicated to hands-on sessions by Coventorware and Intellisuite softwares. On the second day of the workshop, in morning session Hon. Vice Chancellor of the University Dr. V. M. Pandharipande addressed the gathering and explained the basic aspects of circuit design at high frequency, in a very simple and interactive way.

On the 2nd and 3rd days, Mr. Prasanna Kumar, Application Engineer from FTD Infocom Pvt Ltd, Bangalore introduced and familiarized the participants Coventorware which is one of the important software tools used for design and simulation of MEMS devices. He explained all the modules of the software by highlighting its utilization and



Participants looking at Poster presentation.

applications. The tutorials on the cantilever and diaphragm design, simulation and analysis were performed by the participants.

On the 4th and 5th day Mr. Shripadaraja from Sri Dutt Technologies Pvt. Ltd, Bangalore gave an introduction to Intellisuite, a software tool for MEMS simulation. Tutorials on design, simulation and analysis of basic structures using this software were held for the participants.

With hands on experience on these software tools, participants were able to create their own designs. These sessions were very interactive and participants carried out the steps with zest and zeal.

Participation certificates were distributed to all the participants. Many participants suggested organizing more such workshops/ conferences on the MEMS technology in future in the region. They appreciated the speakers and trainers for their efforts. Many of them suggested increasing the duration of the workshop and hands-on training from 5 days to two weeks.

What JISSS should be and could be...

G K Ananthasuresh, IISc

We often hear that publications in Indian journals are not counted by the powers that be and hence researchers are not keen on publishing in them. Some journals administered from North America and Europe aside, most other journals are subject to this prejudice. Why are some journals respected while some aren't? The reasons for this are widely debated. Scientometrics size up a journal using impact factors, which, some say, are dubious because they can be manipulated. The number

of citations is arguably the most important metric for a journal. However, the real metric should be the readership. If a journal is read and the readers find the papers in it instructive, informative, and inspiring, citations follow automatically and reputation of the journal will grow. This may sound idealistic. But this is probably the most realistic and a proper strategy to increase the reputation of a journal. Means are more important than the end. This path may be difficult but will surely work if attempted sincerely. With

this premise, here is a wish-list that may help the Journal of the Institute of Smart Structures and Systems (JISSS) grow to be a journal to reckon.

1. Let us read it.

Papers are to be read after they appear in print. Perhaps some of JISSS papers do get read. How do we know if JISSS is being read? We can invite readers to write to the journal and post them on JISSS website. An e-mail can be sent to all ISSS members after a new issue is

out, asking them to read and share their opinions—good or bad—in Sukshma. Authors can be given a chance to respond to critique. It is the technical work we are talking about and not individuals. So, candor should be valued. This is a harmless thing to try.

We can also set up the journal website to monitor downloads and views. This will be a litmus test for JISSS. Is this journal being read or not? If ISSS members remain indifferent to JISSS, we cannot expect anything better from anyone else. So, let us dip and see.

2. Let us try to make it attractive.

Technical content is the most important feature for a journal. Agreed. But the first impression, as they say, is the best impression. So, we should make our journal attractive. There is room for improvement in formatting and typesetting. Fonts should be sharp. Tables should be pretty and easily readable. The typeface of equations should be impeccable. Figures should be appealing in addition to being accurate. When we see a figure or a photo stretched or squeezed, our respect for it falls steeply. Above all, the language should be flawless. Rectifying all these shortcomings is easy. We just need to get it done by professionals who specialize in this craft. There is no dearth of such companies in India.

3. Let us make it discerning.

High standards for a journal are set and implemented by the Editorial team. Reviewers too play an important role in it. Let us choose reviewers who are not unduly sympathetic to mediocrity. It may be argued that a high rate of justifiable rejection of submitted manuscripts may leave very little for a fledgling journal to publish. So, let us encourage reviewers to give useful feedback and suggestions for improving the quality and presentation of the work. Instead of outright rejection, we can have authors revise, re-revise, and revise again until reviewers, the editorial team, and the authors are satisfied.

What is in it for the reviewers? It is a thankless job and individuals are not eager to come forward to share

this important responsibility until the journal gains reputation. So, selfless commitment to JISSS has to come from ISSS members and well-wishers first. A little reward to reviewers may not be out of place. A meticulous and timely review deserves to be recognized. Since some may object a monetary reward, alternatives could be explored. For instance, a detailed review, with some editorial changes, could be appended under "Discussion" when the concerned paper is published. It is a good old and long-forgotten feature. Why don't we revive it?

ISSS should also hire specialists who ensure the quality of figures, formatting, and printing. A paper should not be processed for review until the language, formatting, figures, tables, and equations meet the requirements of the journal.

We should leave no stone unturned to increase the quality of the papers published in JISSS.

4. Let us increase its frequency.

Twice a year is too infrequent to be noticed. Anything that is seen often, gets noticed. So, let us make JISSS a quarterly by trying three issues per year first. Then, the authors do not need to wait for months for their accepted paper to be published. When we are not getting enough acceptable papers for two issues, how do we achieve this goal? The answer is simple: hard work and teamwork. If we do not try, it is not going to happen.

It is important to bring the issues on time. If we do that, JISSS could be listed in popular citation indices. JISSS is already picked up by Google Scholar.

We can have thematic issues handled by guest editors. We should continue to have good review papers written by experts and experienced researchers and scrutinized by other experts. We can have fast publication of important results as short communications. All these and more can be planned to ensure enough material for each issue as the frequency of issues increases.

5. Let us publicize it widely.

Just because a journal is freely available online, it does not mean that the readers will visit / access

the journal's website and download the papers. They go there if we point it to them. Sending the URL of the journal's website is not enough. So, at least ISSS members should get an e-mail periodically with hyperlinked table of contents with the titles of the papers and the name(s) of the author(s). And, we should do this often.

We should send e-mail alerts to many others in India and abroad with "unsubscribe" option for those who may consider it spam. Those who do not want such alerts can be removed from the list if they send "unsubscribe" e-mail. This means that we need a dedicated staff member at the journal office to effect these steps.

We should publicize the journal among our research colleagues in India and abroad by sending them hard copies of a few issues. A personal letter signed by the editor might be effective. Such a letter should point out the highlights of some articles in those issues. The people to whom we send the issues should be chosen as per the technical content of the articles. We can ask authors to help us here. The authors of all accepted papers should be asked to provide five names of researchers abroad with e-mail and postal contact information. We can send hard copies and soft copies to those people.

We have many visitors from abroad and many of them are Indian-born. Some of them say that they have an urge to help India. We can tell them in no uncertain terms that they can help us by submitting papers to JISSS. More importantly, we can urge them to flip through JISSS on a regular basis. If the technical content of our journal is good, they might even find something that they might cite in their own papers.

We should display all the issues of the journal at conferences that touch upon the theme of JISSS. Doing it in India is easy. Doing it in conferences that are held abroad costs money. Here, we can tie up with other publishers and bear the cost if that helps make the deal.

6. Let us publish in it.

Some may ask: "Why should I publish in a journal that is not listed in the Science Citation Index?"

It is perhaps a valid question in today's scientometrically measured competitive academic and research world. A more pertinent question is: "Why should I publish in a journal that is not read?" Well, if we do take all measures to publicize the journal and if authors submit their quality work, the papers inevitably do get read. Then, we eliminate one prime excuse for not publishing in IJSSS.

Professor B. Dattaguru, an esteemed member of ISSS, advises us to submit 20% of our papers to Indian journals every year. One in five. This is not too much to ask for from established senior researchers.

National Programme on Smart Materials (NPSM) and National Programme on Micro and Smart Systems (NPMAS) have helped build a research community in India for micro and smart technologies. JISSS is started by the same team that nurtured NPSM and NPMAS. This connection ought to be respected by all the investigators of NPSM and NPMAS. Besides, we all should recognize that JISSS is another effort to spread micro and smart technologies in India and the ensuing impact outside India and far into the future. The power of the written word should not be underestimated.

7. Let us recognize it.

What is not valued by us is not likely to be valued by others. So, if we think we are publishing papers of high quality, let us write to the Heads of academic institutions in India. We can send them a few issues with a cover letter. The cover letter should speak about what is great about the articles that are published in those issues. The letter should also say that JISSS is a discerning journal and describe briefly the measures

taken to maintain high standards. If we do this carefully, we may be able to send a message across.

Another way to recognize is to carry the image from the best paper in each issue on its cover. A cover image overlaid in the existing cover design is easily implementable. It also makes it easy to recognize an issue. Furthermore, the authors of the paper from which the image is taken for the cover are sure to be pleased.

Yet another way to recognize JISSS, as suggested by Prof. Rudra Pratap in an ISSS meeting in 2014, is to give an annual best paper award for a paper among all JISSS papers published that year. Best reviewer award should also be considered. Good efforts must be recognized.

8. Let us be professional.

Active researchers in academic institutions and research labs are happy to do the technical job of upholding high standards of JISSS. Burdening them with administrative work of the journal will enervate them sooner or later. So, JISSS needs an editorial assistant. The communications with the authors, the reviewers, and the editorial team should be done promptly and professionally. This also applies to Sukshma, the newsletter of ISSS.

9. Let us enthuse or overhaul the team.

All the aforementioned wishes can be fulfilled only if there is a team that is willing to put in quality time and effort. All the members of the editorial board should be enthusiastic about and committed to growing JISSS. Membership in an editorial board is not an honor; it is a responsibility. So, opportunities should be created for each and every person in the editorial team to

positively contribute to the journal. The team should be overhauled periodically by giving a short, say, one-year terms. The terms of only those who perform enthusiastically should be renewed.

10. Let us nurture it and own it with pride.

We have started JISSS. It needs our support now. ISSS should also unhesitatingly invest money and time. Request to commit money always raises skepticism in ISSS administration as it is with any organization. Some might say that investment on some Indian journals of the past did not yield good results. That may be a fact that cannot be contested. But, there is a strong reason why JISSS can succeed while some other Indian journals did not. The reason is that, unlike other journals that have widely dispersed scope, JISSS is focused on two specific and rising areas, namely micro and smart technologies. So, it can be made attractive enough to be read by these two research communities in India and abroad. If we are proud of the fact that micro and smart technologies have taken root in India, we should then own JISSS with equal, if not more, pride. All good things will then happen.

- G K Ananthasuresh,
suresh@mecheng.iisc.ernet.in

PS: None of what is said here may be new. All ideas might have been tried before by one journal or another at some point of time. Some are still in practice. There are many more "strategies" that many a journal adopts these days. But all conniving strategies are deliberately shunned in this listicle. Let us take the high road.

**SMART MATERIALS, STRUCTURES & INTELLIGENT SYSTEMS (SMSS)
LAB, DEPT OF MECHANICAL ENGINEERING, IIT KANPUR, at a glance**

Bishakh Bhattacharya, IIT Kanpur

Key Projects:

DESIGN & DEVELOPMENT OF SMART ANTENNA SYSTEM

Shape Memory Alloy (SMA) wire based shape and vibration control has been widely studied by various researchers for a gamut of active structural systems composed of simple structure elements like trusses and beams and plates. In the present work, we demonstrate the shape control of a parabolic space craft antenna reflector surface with the help of SMA wire actuator.

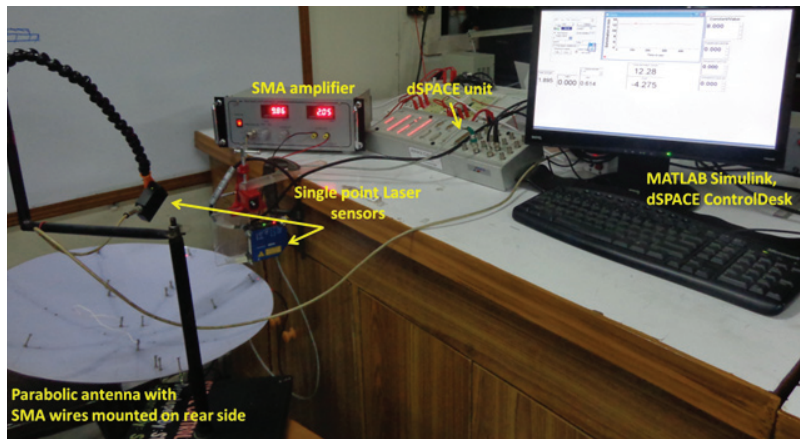


Figure 1: Adaptive Shape Control of Parabolic Antenna System

Figure 1. illustrates the antenna and the test set-up. It has been demonstrated that polycarbonate parabolic antenna surface fitted with acrylic stiffeners at the back could be actively deformed by a network of SMA wires. The active transformation of SMA wires lead to generation of end moments and forces at control points which can deform the stiffener and thereby, the antenna structures. This procedure can generate a maximum deflection >3 mm at antenna surface and can be used for macro shape control. By selectively controlling the current in the SMA wire, one can achieve both inward and outward

deflection. Different antenna configurations are generated by activating the SMA wires.

A vibration damping system comprising four bar linkage mechanism integrated with SMA wire is also developed for suppressing the vibrations of the stiffener of a 1.2 m diameter Parabolic Space Antenna. Figure 2 shows the mechanism with SMA wire as well as the system that needs to be dynamically isolated. The main idea is to incorporate the proposed vibration damper into the box stiffener. Two different configurations of the said smart box stiffener are

dynamically analyzed using Finite Element Method (FEM) in ABAQUS. Mode shapes of both configurations exhibit a combination of inflated and deflated behavior, thereby justifying the proposed vibration damping system. Experimental investigation of the proposed system is carried out to examine the transmissibility of SMA wire which is found to be feasible for the present work.

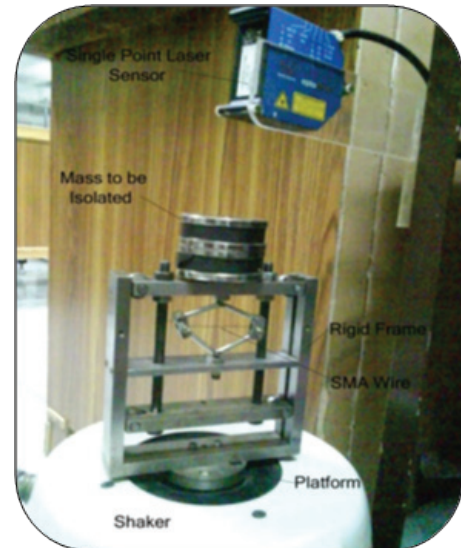


Figure 2: Conceptual Model of a Four bar Passive Mechanism for Vibration Absorption

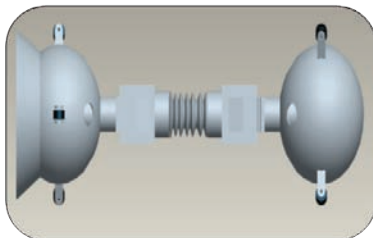


Figure 3: Concept of the pipe crawling robot.



Figure 4: Image of PVDF probe.

A NOVEL PIPE HEALTH MONITORING SYSTEM

Pipelines are one of the major means used to transport gas, oil etc. These pipelines are

often subjected to damage due to corrosive environment and other operating loads and conditions. Periodic inspection of such pipes is necessary to avoid catastrophic failure. Some pipelines run underground making human access to inspection difficult, if not entirely impossible. In this context, inspection methodologies and techniques using remotely controlled automatic/mechanized systems like robots are desirable. In our SMSS Lab, In our SMSS Lab, a pipe crawling robot is intended to be developed, which can carry necessary sensors to detect defects in pipes. The proposed robot can carry three or more sensors, and the data from these sensors are analyzed to identify the type of anomalies and their location. One of the three sensors is based on Polyvinylidene Fluoride (PVDF) film. A smart PVDF cantilever probe is

developed, which continuously rubs against the pipe wall. Whenever the probe encounters surface irregularities, its deflection is altered resulting in a high voltage pulse. Experiments were carried out on different type and size of projections and satisfactory results were found in every case. Thus, the efficacy of the proposed PVDF probe as effective sensors for analyzing health of pipelines has been demonstrated.

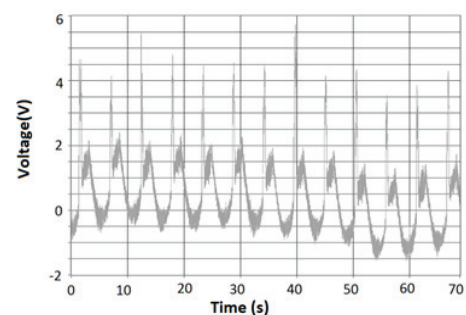


Figure 5 shows the variations of voltage when the probe is subjected to surface anomalies. Whenever the probe faces some undulations on the surface, charges gets developed on PVDF strip. These changes can be seen in terms of voltage spikes.

DYNAMIC RESPONSE BASED STRUCTURAL HEALTH MONITORING

The SMSS lab offers state of the art facility to assess the state of health of a structural component on the basis of detection and analysis of its dynamic response using 3D-Laser Doppler Vibrometer (LDV). The Laser Doppler Vibrometer measures surface motion utilizing the Doppler shift phenomenon in order to obtain the velocity of surface vibration. Any changes in the stiffness characteristics of the structure due to defects or damage due to abnormal operating loads and environment can be monitored when they induce changes in the local surface motion. In a single pass, the instrument can scan any sample from size 10 mm² to 1 m² with vibration measurement frequency up to 30 MHz from a working distance of 0.5-50 m.

It covers a wide range of mechanical and structural systems starting from turbine blades, automobile body to composite plate's modal analysis to interpret damages and also predict damping behavior.

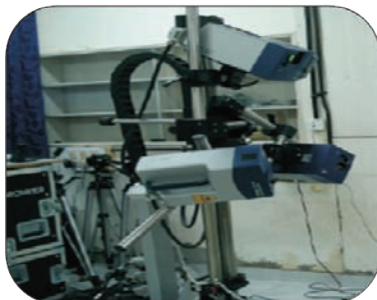


Figure 6: LDV Setup.

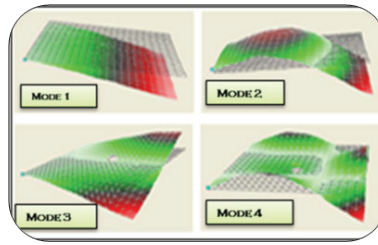


Figure 7: Mode Shapes based on Velocity Profile.

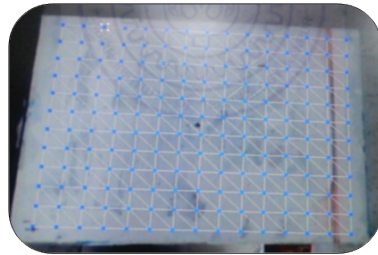


Figure 8: Grids Developed for Scanning the Surface Velocity.

Figure 6 shows the LDV system and Figure 7 shows the surface velocity plots corresponding to different surface vibration modes of a cantilever plate.

2D and 3D alignments were performed to enable the PSV software to identify any point in terms of X, Y and Z coordinates on the selected scan area on the plate with respect to the chosen coordinate system. A mesh grid of the plate is shown in Figure 8.

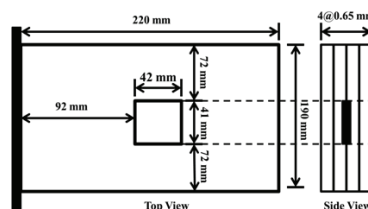


Figure 9: Schematic of delaminated composite plate.

Figure 9 depicts Schematic diagram of a damaged composite plate delaminated at the mid span. The plates were scanned and the dynamic responses were recorded in frequency domain. Figure 10 is a 2D contour plot showing the difference in health and damaged mode shape. This proposed methodology can widely be practiced in real life engineering and industrial application to detect and localize damages in laminated composite plates.

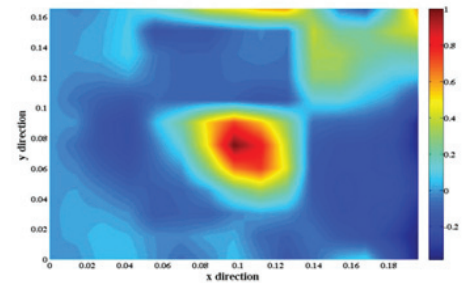


Figure 10: Difference in fundamental mode shapes.

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