Indian National Society for Aerospace and Related Mechanisms

BANGALORE CHAPTER

E-NEWSLETTER

Vol. 3, No. 3&4, August-November 2009

From the Editor

Dear Member,

The discovery of water on the moon by Chandrayaan-1 is a major milestone in the History of Space Science and Technology. This discovery will have far reaching consequences in the direction of human colonization of the moon in the future. In this regard, lunar rovers will play a key role in the near future.

This issue carries two articles. The first article is on the Systematic Conceptual Design of a Lunar Rover, which is a part of the recently completed ISRO-STC project. The second article is on Vibration Control using Active Constrained Layer Damping.

This newsletter is intended to be a medium of information exchange regarding the state of the art developments and future directions in the area of mechanisms and related fields. The editorial committee looks forward for your active participation in the form of technical articles and ideas which will certainly enhance the technical value of this e-newsletter.

With best regards,

Dr. R Ranganath, FIE
Chief Editor

CONTENTS

FROM INSARM
BANGALORE CHAPTER

For Latest Updates & Membership form please visit

www.insarm-bangalore.org

www.insarm-bangalore.org/INSARM__membership_form.pdf

Systematic Conceptual Design of a Lunar Vehicle Mobility System Using "IDEA-INSPIRE"

Amaresh Chakrabarti*, V Srinivasan, Ujjwal Pal, BSC Ranjan, Sai Prasad Ojha,
R Ranganath, BS Nataraju**
ISRO-IISc Space Technology Cell Project
E-mail: * ac123@cpdm.iisc.ernet.in, ** rrrr@isac.gov.in

1.0 INTRODUCTION

The overall aim was to develop and demonstrate the application of a systematic design process developed by us and a biomimetics software called IDEA-INSPIRE in supporting design of novel mobility systems for a challenging application like that of a lunar vehicle that could operate in similar topographic ground conditions as likely on the lunar surface.

The specific objectives of the project were:

- Formulation of a systematic design process to support design for novelty.
- Design and exploration of a wide variety of alternative concepts using various modelling resources.
- Creation of a table top model of the selected concept for demonstration.

2.0 SYSTEMATIC DESIGN PROCESS

Literature pointed out that: (a) novelty is important, needs to be supported and is likely to be achieved if a wide variety of alternatives are explored during design, (b) activity (deed of problem-solving); outcome (property of a design); requirement (what a design should satisfy); and, solution (means of satisfying requirements) should be addressed, (c) physical laws and effects are an important source for novelty in designing, (d) the conceptual design process has to be supported and (e) designing requires a systematic approach. Thus, a major objective of this project has been to develop a systematic design process that includes activities, outcomes (including physical laws and effects), requirements and solutions, and addresses conceptual design by supporting variety and novelty. A *model* of designing is defined as a *description of how designing is currently done*. A *framework* for designing is defined as a *prescription of how designing should be done to improve some of its characteristics*. The systematic design process is developed by:

(a) Developing a model of designing and based on its current limitations

(b) Developing a framework for designing.

2.1 Development of a model of designing

2.1.1 Development of models of activity-, outcome- and requirement-solution

Based on an extensive survey of literature, significant kinds of activity, outcome, requirement and solution are identified. **G**enerate, **E**valuate, **M**odify and **S**elect are identified as the activities that are common in designing and are combined together to form the GEMS activity model (Fig. 1). The SAPPhIRE model of causality [1] is identified as the model of outcomes (Fig. 2); this includes **S**tate change, **A**ction, **P**arts, **Ph**enomenon, **I**nput, o**R**gan and **E**ffect. A co-evolving set of requirements and solutions that are linked together is taken as the requirement-solution model. The above models are integrated together to create an integrated model of designing (Fig. 3) called **GEMS of SAPPhIRE as Req-Sol**. The model states that:

- All design activities can be modelled using the constructs of the GEMS model

- All design outcomes can be modelled using the SAPPhIRE model constructs
- All requirements and solutions can be modelled using the requirement-solution model

For instance, the assertion by a designer that 'a lunar vehicle must have stability' can be described as the **G**eneration activity of a **Req**uirement at the **A**ction level of SAPPhIRE. More details can be found in [2].

2.1.2 Validation of the model of designing

In order to evaluate whether the above model is inherent in 'all' design practices, it was empirically tested by checking against fourteen designing sessions that took place well before the model was developed. Results from this study revealed that all significant kinds of activities, outcomes, requirements and solutions are present in designing. However, *state changes, effects and organs are not present in far fewer numbers than expected*. This could seriously hamper the chances of enhancing variety of solutions explored and hence, the resulting novelty of the final solution. More details can be found in [2].

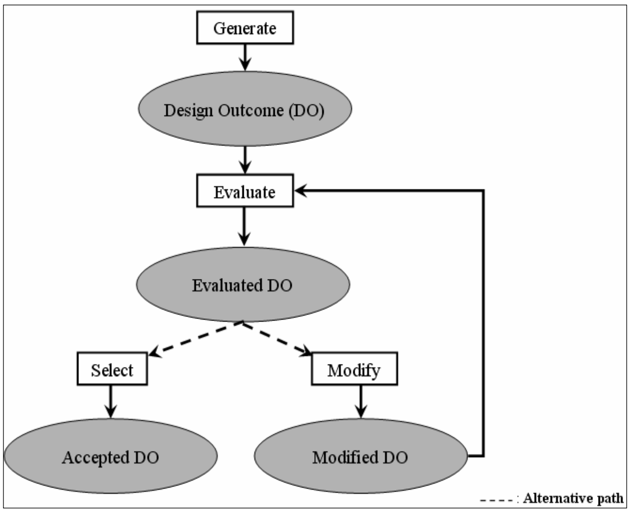

Fig 1: Activity model

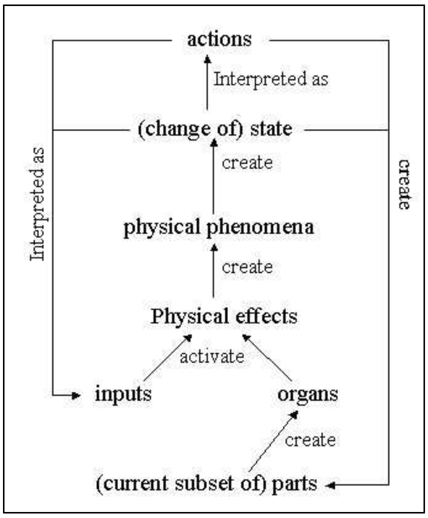

Fig 2: SAPPhIRE model of causality

2.1.3 Checking Novelty-SAPPhIRE relationship

An empirical study was carried out using existing transcripts of eight designing sessions where the SAPPhIRE model was not asked to be followed to check whether there is any relationship between novelty and the frequency of exploration of ideas at the various levels of SAPPhIRE constructs. A novelty assessment method was developed for this study. Results revealed that variety of solutions generated during a process is proportional to the number of ideas explored and the higher abstraction level of the ideas explored, the greater is the variety and novelty of the solutions developed. Refer to [3] for more details.

2.2 Development of a Framework

Based on the above observations that novelty is strongly influenced by exploration of alternatives at all abstraction levels of SAPPhIRE, and that this is currently not adequately followed, a new framework for designing is proposed. The framework prescribes that *all of GEMS activities should be carried out in sufficient detail at all levels of SAPPhIRE, for both requirements and solutions*. According to the framework, designing should be carried out in two stages: Requirement Synthesis Stage (RSS) and Solution Synthesis Stage (SSS). In

RSS, requirements at all abstraction levels of SAPPhIRE are generated, evaluated, modified and selected. In SSS, solutions in decreasing abstraction levels (action, state change, phenomenon, effect, input and organ, and part) are generated, evaluated, modified and selected. More details can be found in [4].

3 IDEA-INSPIRE

IDEA-INSPIRE is a computational tool for supporting designers to generate novel solutions for design problems by providing, as stimuli, information about natural or engineered systems that are analogically relevant for solving the problems. It uses the corpus of the diverse phenomena, that natural and technical systems exhibit, as a potent source of inspiration for solving design problems, especially in inspiring creativity and innovation of novel products and systems. The work is not about mimicking of existing natural or technical systems, but rather about getting inspired from primarily the behavioral aspects of natural and artificial systems. IDEA-INSPIRE has a database with entries from both natural and artificial systems, annotated using SAPPhIRE model of causality, so that automated analogical search can be carried out to retrieve entries that have strong likelihood of inspiring novel solutions to a given design problem (Fig. 4).

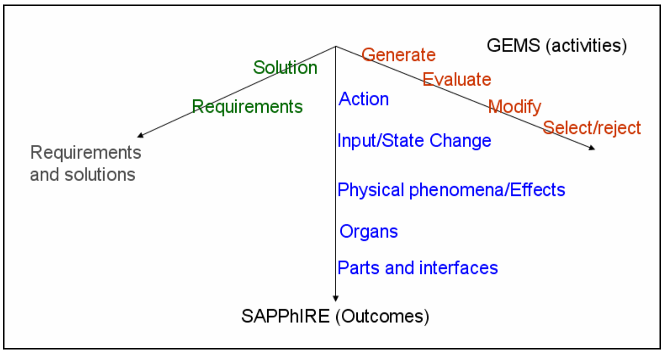

Fig 3: GEMS of SAPPhIRE as Req-Sol

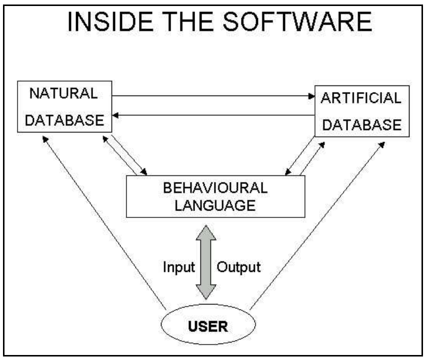

Fig 4: Internal structure of IDEA-INSPIRE

The software can be used in two different modes:

When a designer tries to solve a problem that is not yet defined clearly, the designer can browse through the database of IDEA-INSPIRE and view related systems, get interested in some of these mechanisms and may work on these selected mechanisms only, in order to use the principles behind these systems to solve the problem at hand. Browsing may also help in understanding a problem better, as a designer will be exposed to a wider variety of related yet concrete solutions. *When a designer has a well-defined problem to solve*, the designer can directly define the problem using the constructs of SAPPhIRE provided in IDEA-INSPIRE, and use the various reasoning procedures provided in the software for automated search for solutions as stimuli. In this second mode, the *design requirements at any of the SAPPhIRE levels can be expressed using a combination of verbs, nouns and adjectives or adverbs*, or *by choosing among the options provided*. Multiple requirements can be specified, either as demands (that must be satisfied by the description provided in an entry for it to be eligible for retrieval) or wishes (that, even if not satisfied, will not disable retrieval of the entry, but would reduce the value of a number that signifies how well the entry matches the requirements). The software searches databases using the requirements as search strings, and returns as result a list of entries that analogically matched the requirements, and can be inspired from in order to solve the problem at hand.

4 DEVELOPMENT OF CONCEPTS AND TABLE-TOP MODEL FOR A LUNAR VEHICLE MOBILITY PLATFORM

4.1 Applying the Framework: Lunar Vehicle Requirements

The following major requirements were identified for the vehicle platform: (a) Vehicle mass (10 kg); (b) Mass of payload (10 kg); (c) Size (600 x 500 x 500 mm); (d) Vehicle speed (10-20 mm/s); (e) Launch and land load in all directions (40g; g=9.81 ms^{-2}); (f) Gradient handling (±30 deg); (g) Mobility and steering; (h) Stability during motion; (i) Environmental protection; (i) Unobstructed view for cameras and sensors.

4.2 Applying the Framework: Overall and Specific Functions

The overall and specific functions (within brackets) for the lunar vehicle platform are identified as:

Mobility (acceleration and deceleration); Steering (forward, backward, left, right); Handling gradient (avoid obstacle, climb obstacle); Stability (prevent toppling, minimise wheel slip, maintain equal distribution of load); and, protection from the environment (protect from electrically charged abrasive dust, protect from temperature (120°C to –150°C), protect from collision).

4.3 Applying the Framework: Synthesis of Ideas and Concepts

For each of the above functions, ideas were generated using the GEMS of SAPPhIRE framework and IDEA-INSPIRE (Table 1). Ideas for each such function were then combined into alternative overall concepts for the mobility platform. 20 concepts were developed from a pool of 2000 potential concepts.

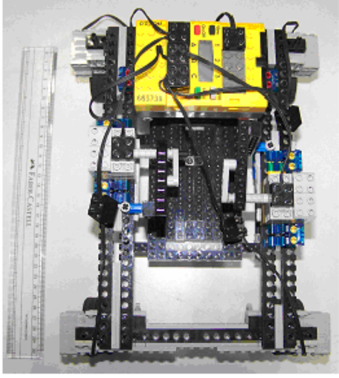
Fig 5: Physical model

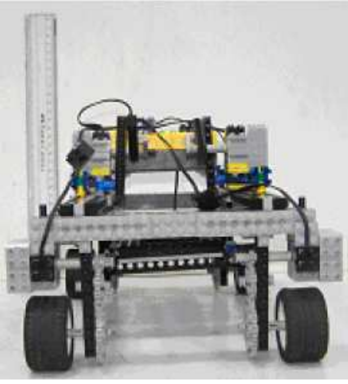
Fig 6: Physical model (back view)

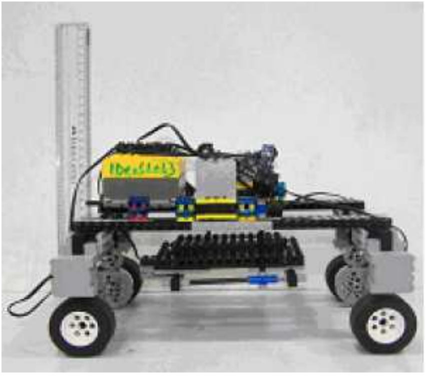
Fig 7: Physical model (side view)

Table 1: No. of ideas for each function

Overall Functions	Number of Ideas Generated
Mobility	20
Steering	10
Handling gradient	9
Stability	9
Protection from environment	17

Table 2: Specifications of the table-top model

	Parameter	Value
1	Mass of the Vehicle	1.050 kg
2	Size of the model	300x280x100 (mm)
3	Handling Gradient	(+/-) 30º
4	Coefficient of friction between wheel and terrain	0.4 ~ 0.9
5	Motors Used	9V/6.3W (x 6)

4.4 Concept Realisation and Building of a Table-Top Model

Among the twenty concepts developed in the concept development stage, one was selected for the final mobility analysis, detailing and demonstration. The 1:2 scaled physical model of the final vehicle platform concept was built using the Lego MindStorms^{TM} kit (Table 2; Fig. 5-7). Four motors were used, one to each of the four wheels; two additional motors were used for operating a platform lifting mechanism. The model was able to climb ± 30^{o} of the terrain with a motor capacity of 9V/6.3W. It was able to overcome small obstacles by lifting its platform above the obstacle and thereby clearing the obstacle. It was able to avoid larger obstacles by steering around them. It was able to carry about 1 kg of load, and climb a step obstacle of the size of half the diameter of its wheels. The physical model was, as planned, used as a demonstrator ‘table top’ model, rather than a validation of the concept, which was provided by the extensive simulations carried out using ADAMS, NASTRAN and PATRAN software.

5 CONCLUSIONS, FOLLOW UPS AND FURTHER WORK

As a result of the project, a new GEMS of SAPPhIRE model of designing and an associated GEMS of SAPPhIRE framework for design for novelty have been developed and applied, in conjunction with IDEA-INSPIRE for development of concepts for a lunar vehicle mobility platform. A wide variety of ideas were possible to be generated using the combination of the framework and IDEA-INSPIRE. Twenty potentially interesting and widely different concepts were developed and presented to ISRO experts. In consultation with ISRO, one of these concepts was selected for further exploration, and was refined iteratively during the modelling and evaluation phase to culminate into a concept that works satisfactorily.

Even after the project was formally over, the project team continued to work on several aspects of the vehicle on which the current concepts could be improved. One was step climbing ability, and the other was stability.

Using GEMS of SAPPhIRE and IDEA-INSPIRE, a new series of biologically inspired vehicle platforms were generated a few months after the project was formally concluded. Three vehicle platform variants were developed and both analytically and physically modeled and run [5]. The photographs of the vehicles and results from analyses and physical tests are given below.

In order to normalize our findings for the purposes of comparison, we have developed two measures: (a) Ratio of maximum height of obstacle climbed (H_{ob}) to wheel diameter (d_{wh}) and (b) Ratio of maximum obstacle height climbed (H_{ob}) to vehicle height (H). Table 3 summarizes our findings on the performance of the existing vehicles from a perspective of their ability to climb. Measure (a) is useful particularly for comparison of wheeled vehicles of various wheel sizes. Measure (b) provides a comparison of both non-wheeled and wheeled vehicles, an estimate of the height of payload against the height of obstacle climbed.

It was found that none of the existing vehicles were able to cover an obstacle height more than twice that of its wheel diameter or track height. Even though in literature, few other vehicles claimed to climb greater heights, the detailed specification of the vehicle or their performance details are not given.

Table 3: Existing robots and their climbing abilities [5]

Robot	LxWxH (mm)	d_{wh} (mm)	H_{ob} (mm)	H_{ob}/d_{wh}	H_{ob}/H
ROBHAZ DT	720x484x319	~ 200	180	0.9	0.56
ROBHAZ DT3	290x470x740	~ 200	180	0.9	0.24
Transformable Crawler	1600x874x305	305	203	0.66	0.66
SHRIMPIII	639x429x228	116	220	1.89	0.96
MFEX	630x480x280	130	180	1.38	0.64
MarsoKhod	1200x950x1000	350	500	1.42	0.5
Rocky7	610x490x310	130	195	1.5	0.63

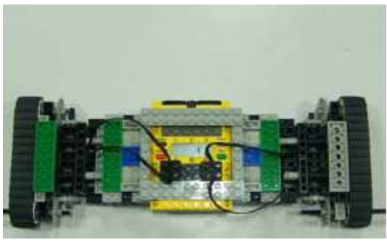

Fig.8: A model of the STV

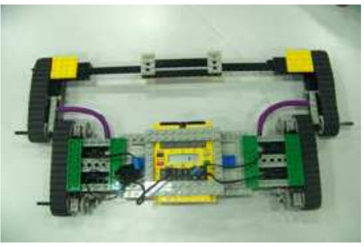

Fig. 9: A model of the DTV

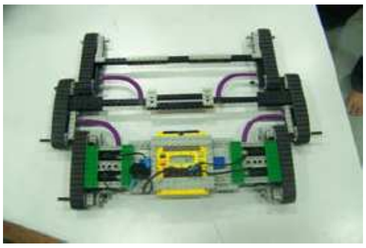

Fig. 10: A model of the TTV

5.1 Single Tracked Vehicle (STV)

The physical model of the STV developed is shown in Figure 8. The track height (including the diameter of the wheel driving the track) is 29 mm. The vehicle is run with four motors. It is powered by 6 AA Ni-Cd batteries, each of 1.5V. The vehicle could climb a maximum step height of 22 mm. The specifications of the STV model are given in Table 4.

5.2 Double Tracked Vehicle (DTV)

The physical model for the DTV developed is shown in Figure 9. The track height is 29 mm. The vehicle uses four motors. The vehicle is powered by 6 AA Ni-Cd batteries, each of 1.5V. The two tracks are serially connected with a hinge joint, whose movement is limited with the use of flexible, inextensible members that act as mechanical ‘limit switches’, in order to avoid folding of the tracks on each other. The vehicle could climb a maximum step height of 41 mm. The specifications of the DTV model are given in Table 4.

5.3 Triple Tracked Vehicle (TTV)

The TTV is shown in Figure 10. The track height (including the diameter of the wheel driving the track) is 29 mm. The vehicle uses four motors, and 6 AA Ni-Cd batteries each of 1.5V. To create the TTV, the double tracks of the DTV are serially connected with another track using a hinge joint, whose movement is limited using flexible, inextensible members, to avoid folding of the tracks on one another. The vehicle could climb a maximum step height of 84 mm – almost three times its track height. This seems to be the best traction-based vehicle in terms of its step-climbing performance (with a H_{ob}/d_{wh} of 2.90 and H_{ob}/H of 1.45 compared to the best reported vehicle SHRIMP III with corresponding figures of 1.89 and 0.96). The specifications of the TTV model are given in Table 4.

On the whole, the project led to not only an novel systematic design framework and a validated IDEA-INSPIRE software for stimulation ideation and development of novel designs, but also to a number of highly novel and potentially interesting concepts for lunar vehicle mobility platform. It would be interesting to take a further, follow-up project to carry out embodiment design in further detail for one or more such vehicles, and develop an exact model for the vehicle for more detailed functional testing.

Table 4: Specifications of STV, DTV and TTV

Vehicle type	L x W x H (mm)	Mass (kg)	Track width (mm)	Velocity (mm/s)	H_{ob}/ d_{wh}	H_{ob}/H
STV	299x126x58	0.667	20	13.66	22/29=0.76	22/58=0.38
DTV	360x222x58	0.76	20	13.21	41/29=1.41	41/58=0.71
TTV	360x318x58	0.849	20	12.5	84/29=2.90	84/58=1.45

The work is planned to be extended in the following directions:

- The software should be tested with designers at ISRO in industrial problems of interest to ISRO. This should be done in a systematic way, so as to identify how and where the software helps enhance creative potential, and how best to use it in the context of ISRO's design process. Modification to the software may have to be taken up as a further, subsequent action.
- The essential ideas of IDEA-INSPIRE could be taken up to extend the database in other areas of ISRO's work, such as sensors, actuators, and other modules related to ISRO work.
- An extended study and development of physical models associated with the serially tracked vehicles could be taken up, particularly since these show such great potential in terms of their stability and step-climbing potential.

REFERENCES

1. Chakrabarti, A., Sarkar, P., Leelavathamma, B. and Nataraju, B.S., "A Functional Representation for Aiding Biomimetic and Artificial Inspiration of New Ideas," Artificial Intelligence for Engineering Design and Manufacturing, 2005, 19, pp. 113-132.
2. Srinivasan, V. and Chakrabarti, A., "Design for Novelty – A Framework?", International Design Conference (DESIGN 2008), Dubrovnik, Croatia, 2008, pp. 237-244.
3. Srinivasan, V. and Chakrabarti, A., "An Empirical Evaluation of Novelty-SAPPhIRE Relationship," International Conference on Design Theory and Methodology, IDETC/CIE, San Diego, USA, 2009.
4. Srinivasan, V. and Chakrabarti, A., "Designing Novel Artefacts – A Novel Systematic Framework," International Conference on Research into Design (ICoRD 09), Bangalore, India, 2009, pp. 67-75.
5. Ranjan, B.S.C., Pal, U., Ojha, Sai Prasad, Srinivasan, V., Chakrabarti, A., "Exploring Serially Connected Multi-Tracked All-Terrain Vehicles for Improved Obstacle Climbing Performance", 14th National Conference on Machines and Mechanisms (NACoMM'09), NIT Durgapur, 17-18 December 2009 (Submitted).

Vibration Control using Active Constrained Layer Damping

Milind Undale,
SMG, ISRO Satellite Centre, Bangalore
E-mail id: milindu@isac.gov.in

INTRODUCTION:

There are various vibration damping and control techniques that are followed in modern vibration suppression techniques. The active constrained layer damping (ACLD) treatment consists of a viscoelastic layer known as constrained layer and a piezo-electric layer, known as active constraining layer and is augmented with efficient active control means to control the strain of the constraining layer, in response to the structural vibrations. The two-layer composite ACLD when bonded to the base structure whose vibrations needs to be controlled, acts as a smart constrained layer damping treatment with built-in control capabilities. In practice the constrained layer damping treatment is periodically cut into several segments instead of a large single layer in order to optimize the effectiveness of the damping treatment on a large structure. Such a typical segment of ACLD treatment on a plate is shown in Figure 1.

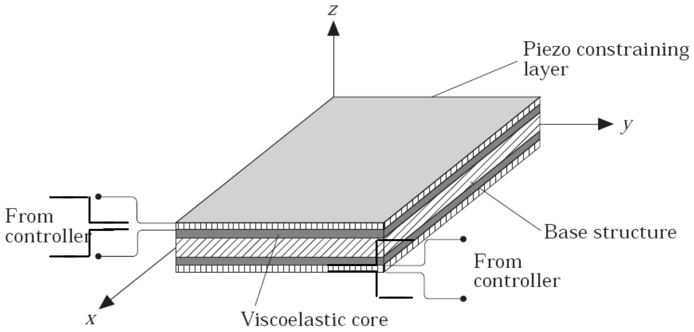

Figure 1: Schematic Diagram of the ACLD Patch

The demand for drive shafts to operate at higher speeds (near- and post-resonance) necessitates the implementation of a vibration suppression technique. Most of the study conducted was on damping of torsional vibrations. In present day's piezoelectric materials have been increasingly used as distributed sensors and/or actuators for active control of flexural vibration of high performance lightweight smart structures during the past decade and half. The flexible structures when coupled with layer/patch of these materials as distributed sensors and/or actuators are known as "smart structures". The performance of smart structures depends on the magnitude of the piezoelectric stress/strain coefficients. The magnitudes of the piezoelectric coefficients of the existing monolithic piezoelectric materials are very low. Hence, large control voltage is necessary for achieving a significant amount of active damping in smart structures. Further research on the potential use of these existing piezoelectric materials as the distributed actuators for smart structures has led to the development of active constrained layer damping (ACLD) treatment. The ACLD treatment consist of a viscoelastic constrained layer and a piezoelectric layer acting as the active constraining layer. When the treatment is integrated with a base structure (substrate) and is augmented with an appropriate strategy, the strain of the piezoelectric constraining layer can be controlled in response to the vibration of the base structure leading to the active constrained layer damping of this structure. It is well known that the flexural vibration control by the constrained layer damping treatment is attributed to the dissipation of energy in the viscoelastic core undergoing transverse shear deformation. As the constraining layer of the activated ACLD treatment increases the passive transverse shear deformation of the viscoelastic constrained layer, the ACLD treatment improves the overall damping characteristics of the flexible structures over its passive counterpart. Because the control effort necessary to increase the shear deformation of viscoelastic layer is compatible with the low control authority of the monolithic piezoelectric materials, the piezoelectric materials perform much better to attenuate the vibration of smart structures when they are used as active constraining layer of the ACLD treatment than when they are used alone as distributed actuators. Also, ACLD treatment provides the attributes of both passive and active damping occurring in unison because of the fact that passive damping mechanism is integral to this treatment. Hence, since its inception, prolific use of ACLD treatment can be noticed for efficient and reliable active control of flexible structures.

Operating Principle of ACLD:

The operating principles of passive constrained layer damping (PCLD) and ACLD is shown in Figure 2. When the base structure experiences the longitudinal displacements, u_o and v_o at the interface between it and the viscoelastic core in the x and y directions, respectively as shown in Figure 2(b), the in-active constraining layer undergoes the corresponding displacements u_{pa} and v_{pa} at the interface between it and viscoelastic core. Consequently, the viscoelastic layer is subjected to a passive shear stain, γ_{pa}, in the x-z plane as shown in Figure 2 (b). Under these conditions, the ACLD acts as a conventional PCLD where in the constrained layer is in-active. But, when the constraining layer is activated properly by the controller, the passive displacements u_{pa} and v_{pa} change to u and v, respectively. Thus an additional displacement ($u-u_{pa}$) is generated by the piezo-electric effect to increase the shear strain of the viscoelastic core to γ_1 as shown in Figure 2 (c) in the x-z plane. The corresponding increase in the shear strain ($\gamma_1-\gamma_{pa}$) enhances the energy dissipation characteristics of the ACLD and results in effective damping of the structural vibrations. Similarly, the activated piezo-layer also undergoes an additional deflection "($\nu_1-\nu_{pa}$) in the y direction corresponding to displacement 'v' resulting in increasing the shear strain of the viscoelastic core in the y-z plane to ν_1.

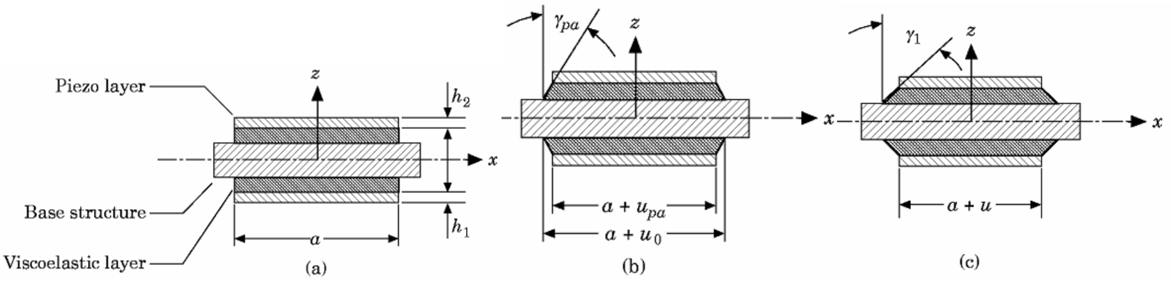

Figure 2: Operating Principles of the PCLD and ACLD Treatment
(a) Un-deformed (b) PCLD (c) ACLD

A schematic representation of ACLD treated composite shaft and piezoelectric fiber reinforced composite (PFRC) patch is shown in Figure 3. A distributed parameter model is developed using Hamilton's principle to describe the behavior of ACLD treatments of shaft. A FEM is developed based on equations obtained from the above method.

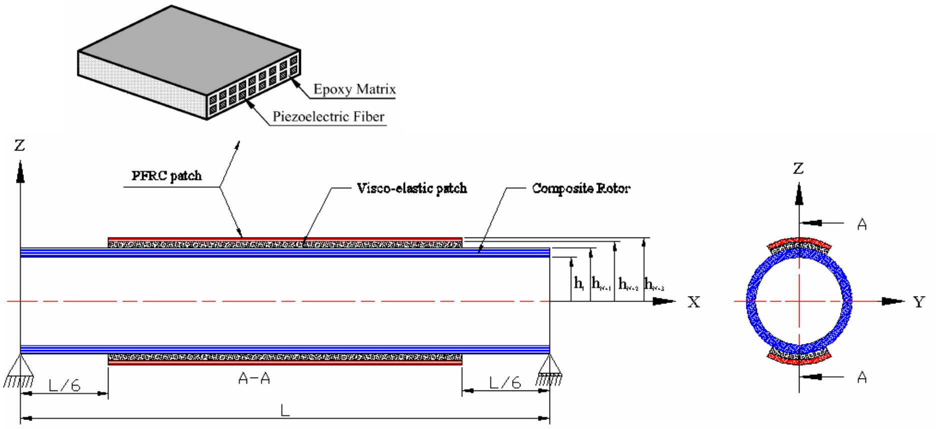

Figure 3 Schematic Representation of ACLD Treated Composite Shaft and PFRC patch

The equations of motions for the ACLD treated shaft is obtained from the Lagrange principle by finding the strain and kinetic energies of the individual layer of composite material, viscoelastic material and piezoelectric material. The equation is of the form of

$$[-\omega^2[M]+i\omega[D]+[K]]\{Q\}=0$$

Here the matrix [D] involves the contribution due to the gyroscopic effect and is dependent on rotational speed Ω of the shaft. The eigenvector {Q} is given

$$\{Q\}=[V_1,W_1,\alpha_{y1},\ \alpha_{z11},\ V_2,W_2,\alpha_{y2},\ \alpha_{z2}..........V_n,\ W_n,\ \alpha_{yn},\alpha_{zn}]^T$$

Where, V and W are the displacement along the Y- and Z-axes, α_y and α_z are the rotations about the Y- and Z-axes respectively.

In the active control strategy, the active constraining layer is supplied with a control voltage proportional to the velocity of the point (La, 0) which corresponds to the mid-point of the ACLD treated shaft. Thus the control voltage can be expressed in terms of the derivatives of the global nodal translational degrees of freedom as follows:

$$V=-k_d\dot{w}(L/2,r_p)=-k_d[U]\{\dot{X}\}$$

Where k_d is the is the controller gain and $[U]$ is a row vector for expressing the velocity of the point (L/2, r_p) in terms of the derivative of the global nodal generalized translational displacements. Substituting equation into the final damped equation of motion governing the closed loop behavior of the overall beam/ACLD system can be obtained as

$$[M_S]\{\ddot{Q}_S\}+[C_d]\{\dot{Q}_S\}+[K_S]\{Q_S\}=0\text{, Where in }[C_d]=k_d[F_p][U]^T$$

The controlled and uncontrolled frequency response for a typical antisymmetric cross ply composite shaft (0/90/0/90) obtained is shown in Figure 4. The peak response for uncontrolled and controlled shaft with 10000 and 20000 gain (k_d) is shown in Figure 4 by A, B and C respectively. Figure 4 shows the enhancement of ACLD characteristics of the rotor over the passive damping or uncontrolled damping.

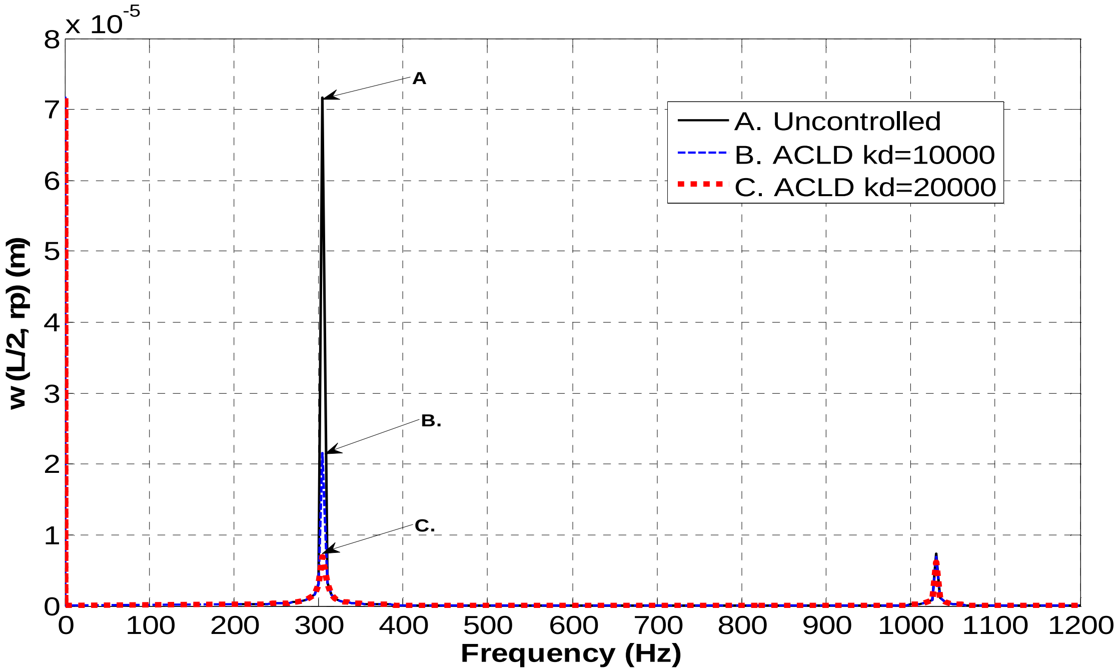

Figure 4: Typical frequency response for the transverse displacement of a antisymmetric cross-ply rotating shaft.

APPLICATIONS:

Piezoelectric composites are now being effectively used for underwater transducers, vibration control of space structures and medical imaging applications. These composites have been reported to show improved mechanical performance, electromechanical coupling characteristics, and acoustic impedance matching with the surrounding medium over the monolithic piezoelectric materials. Performance of smart structures can further be improved if the constraining layer of the ACLD treatment is made of the piezoelectric materials with improved piezoelectric coefficients

We invite you to send technology news, technical articles, members news and suggestions/comments on e-newsletter and the web contents to Chief Editor to improve the newsletter. The technical articles may be limited to 400 words only in MS Word format with two photographs. The direct extracts from references may be avoided. Kindly provide your e-mail & mail address to enable us to contact you.

enewsletter@insarm-bangalore.org
www.insarm-bangalore.org