ARAI® Progress through Research Update

Towards Safer, Cleaner & Quieter World ...

Design, Development and Testing Services at ARAI

April - June 2016

❑ Simulation Approach to Study Production Tolerances Band Sensitivity on Engine Performance and Emissions

Background:

Setting right tolerance band is important to meet stringent regulatory and customer requirements based on the combustion stability through robust analysis. Setting up wrong tolerance band may seriously affect conformity of product and field performance as well. Many times product launch happens without extensive testing of product tolerance variations influence on performance and emissions, which may lead to product conformity failures. So understanding the influence of production tolerance band of critical parameters on performance and emissions is very important to control wide performance variations and get product consistency. Assessment of production tolerances is a challenging task, which requires preparation of hardware configurations with all combinations. This assessment gives insight on system robustness on performance and emissions. However, it is very expensive to prepare hardware with all combinations for testing and also involve high experimentation cost. Entire physical evaluation process also requires lot of time to complete the process, which may lead to delayed product launch.

In general, Simulation approach reduces experimental cost and time, however, tolerance parameters interaction study is computationally expensive and time taking task. In this regard, Powertrain Engineering (PTE) of ARAI has developed cost effective approach to reduce computational expenses and time by integrating the benefits of statistical tools with 3-D combustion simulation. This method allows analyzing the effect of influence of parameters production tolerance variations on performance and emissions; and it is easy to understand odd parameter combinations without much experiments.

PTE Department has performed **case study** with an objective to assess impact of important product tolerance variations (e.g. Compression Ratio, Injection timing, spray cone angle, swirl, fueling and bumping clearance) on performance and emissions, and it is described below:

Assessment Procedure Followed

Combustion simulation is computationally expensive because of its complexity, involving second order partial differential equations with multi-fluid, multi-phase mass and energy transfer governing equations. So, realizing that execution of all full factorial cases in simulations will be computationally time consuming and expensive. Statistical approach (DOE) is used for building response model to predict results. However, quality of response model is (important to get quality and quantitative results) maintained by various check points and by cross checking sample cases through combustion simulation. Figure 1 shows R^2 value and surface model, which indicates quality of predictions.

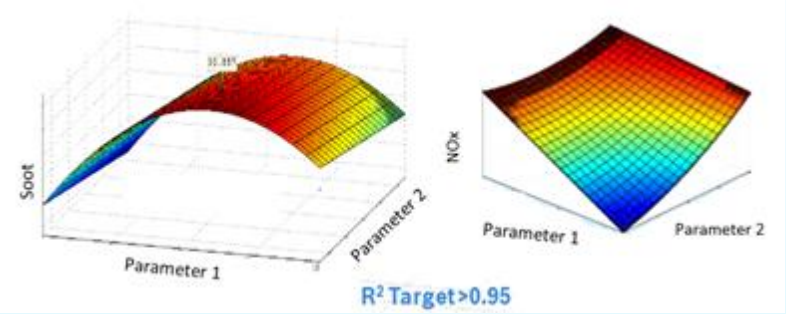

Figure 1: Critical part of this approach – High Quality Model Development

Case Study

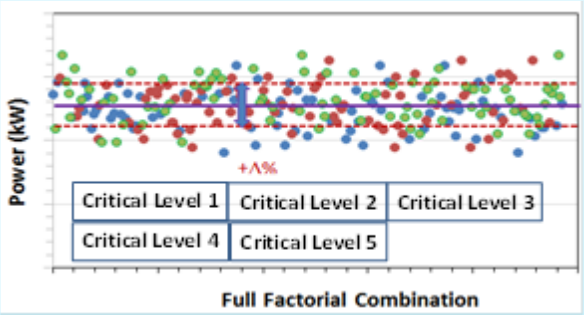

Figure 2: Engine power output will all combinations

Figure 2 shows engine power with all parameter combinations and many combinations are outside the limit zone. It means that combination of few parameters with defined tolerance band is out of target zone. Through this approach, it is possible to identify failure combinations and also possible to rank parameter's criticality level along with ranking of risk.

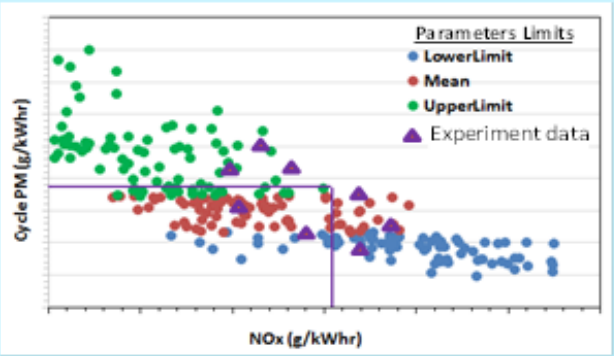

Figure 3: Cycle NOx vs. PM will all combinations

Figure 3 shows cycle NOx and PM emissions for all full factorial combinations. One critical parameter selected and results plotted with combination of other parameters. It is showing that upper limit is highly influence on emissions and 70% of combinations are outside the limits of cycle NOx and PM - indicating that selected tolerance limits are not appropriate. Triangles points in Figure 3 and Figure 4 show, 8-test results and only two are falling within limit zone. These 8-tests verified and validated in simulation and build the model for tolerance variations study.

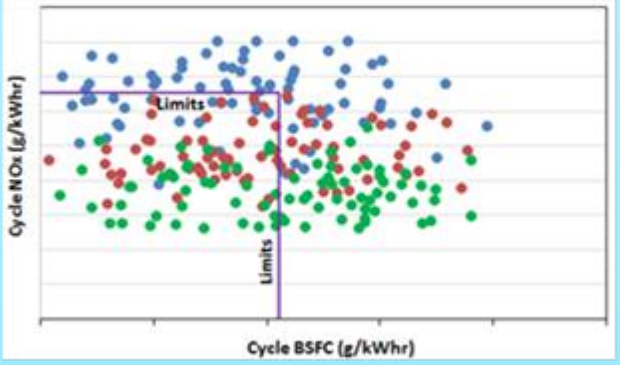

Figure 4: Cycle NOx vs. Cycle BSFC will all combination

Figure 4 shows majority of combinations cycle BSFC on higher side than the target cycle BSFC. This happens mainly due to interaction of parameters with wrongly set limits for highly critical parameter, e.g. wrong selection of pump characteristics & injectors and bowl design, etc.

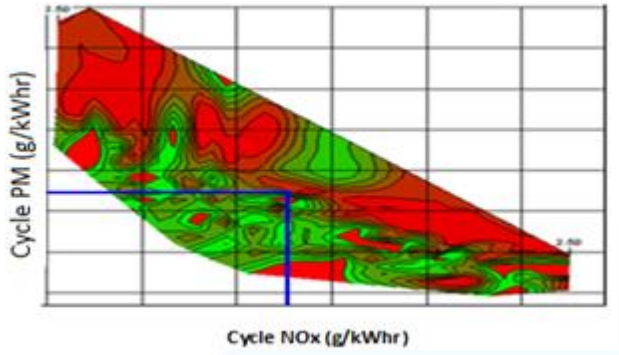

Figure 5: Cycle NOx vs. Cycle PM 2D Contours

Figure 5 shows 2-D coutour graphs for cycle NOx and PM. This analysis provide more sight to tolerance limits zone of parameters.

This approach is very useful to understand production robustness and sensitivity of design parameters for performance and emissions. This can help to relax unnecessary tightened parameters and control sensitivity to achieve production robustness for performance and emissions. This approach can used for selection of optimum BS VI package.

PTE Department of ARAI offers services for analysis of ***"production tolerances band impact emissions and performance for passenger car diesel engines, HD engines, tractor/CEV engines and genset engines",*** using statistical and computational tools in cost effective way.

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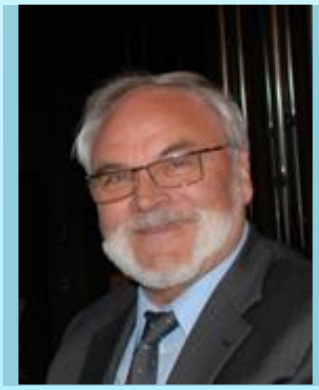
ARAI joins hands with Dr. Lothar Issler for Metallurgical Failure Analysis

Automotive Materials Laboratory (AML) of ARAI is offers various services for Metallurgical Failure Analysis. It has rich experience of more than thousand case studies, covering different sectors (automotive as well as non-automotive), variety of materials and for OEMs as well as various component and material manufacturers. ARAI has now joined hands with Prof. Dr. Lothar Issler of Esslingen University, Germany. Therefore, failure analysis reports of ARAI will also contain expert opinion and inputs of Prof. Dr. Issler.



Prof. Dr.-Ing. Lothar Issler, born in 1943, is an Emeritus Professor at the University of Applied Sciences Esslingen (Germany), Department of Automotive Engineering. He is Director of Steinbeis-Transfer Centre and Innovation Centre BWF "Strength and Safety of Components, Material and Joining Technology".

Dr. Issler graduated in 1969 in Mechanical Engineering at University of Stuttgart and completed his Ph.D. degree in "Fatigue of Metallic Materials under Out-of-Phase-Loading" in 1974. He was responsible at Material Testing Institute, University of Stuttgart, for Nuclear Research programs in the field of safety of light-water reactor components. From 1981 to 1988, he was professor for Strength of Materials at University of Applied Sciences Esslingen.

AML services in the field of Metallurgical Failure Analysis are the most sought after services in the industry. To cope up with the rising demand, one more Scanning Electron Microscope with advanced features (Tescan Vega 3) is recently installed. This will enable us serve the customers within the scheduled time frame.

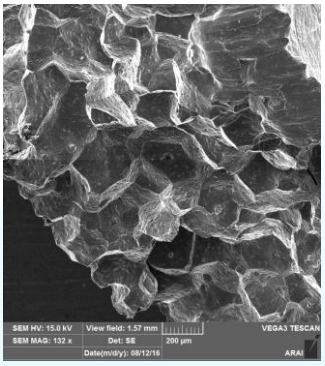
Advanced Capabilities of AML

Fractography and Failure Analysis

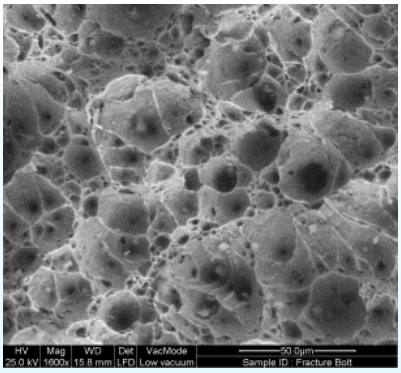
Fractography is done to understand root cause of failure, which will help in avoiding future failures. Scanning Electron Microscopy (SEM) is widely used for fractography. AML has got advanced SEM facilities where all variety of engineering materials, such as metals, plastics, rubbers, ceramics, etc. can be analyzed. These equipment are also coupled with Energy Dispersive Spectroscopy (EDS), wherein one can understand elemental composition at minute particle level or at defects. SEM analysis is complemented by routine material characterization tests such as tensile, hardness, microstructural analysis. The laboratory has vast experience of failure analysis with more than thousand case studies.

Salient features of SEM

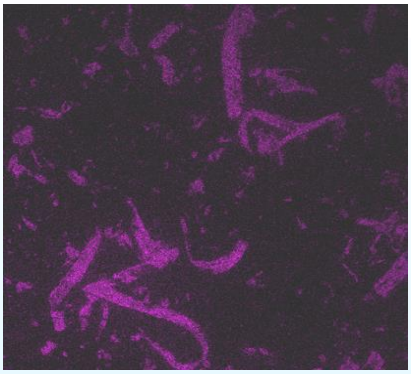
- SE and BSE detectors for **structural and compositional images**
- EDS analysis for **inclusion and defect analysis**
- **Elements' distribution** mapping
- Particle analysis such as **Particle size, shape and distribution measurement**
- **Image stitching** to build large image of local zone



Intergranular Fracture in Aluminum

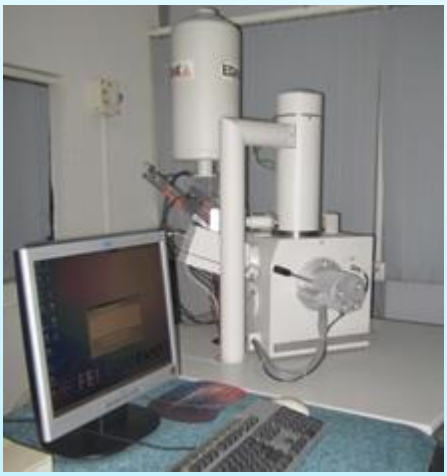


Ductile Fracture in Forged Steel



Elemental Mapping of Gray Cast Iron Showing Graphite Flakes

Vega – 3 LMU
Make: Tescan Brno, Czech Republic



ESEM Quanta – 200
Make: FEI, USA

Crystallographic Analysis (Residual Stress Analysis, Phase Analysis)

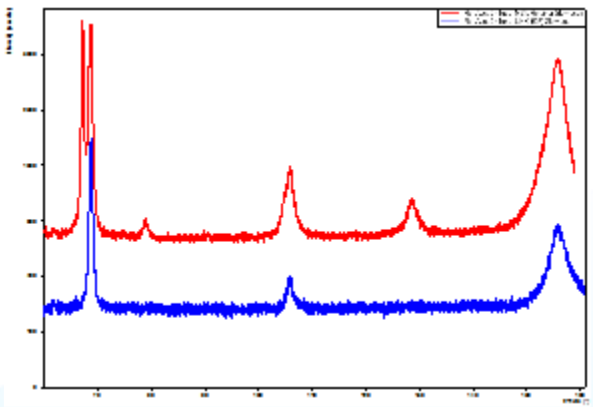
Crystallographic studies are carried out to get insight of material atomic structure. Materials may be made up of multiple phases, which govern material properties. X Ray Diffractometer (XRD) is used for correct identification of these phases and their quantification. This also enables measurement of Residual Stresses in the component, which affects its fatigue life. These tests are non-destructive and repeatable in nature.

Applications

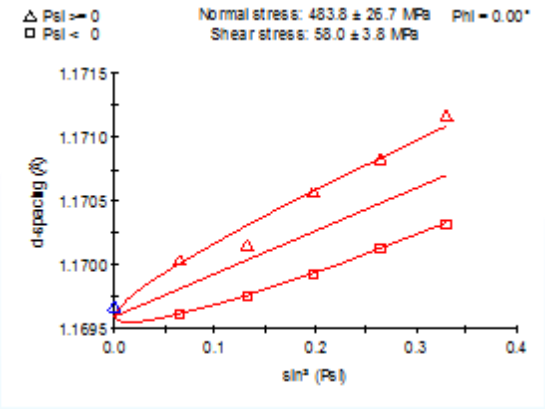
- ✓ Phase Identification
  - Quantification of **Retained Austenite**
  - Analysis of **scales and corrosion products**

- ✓ Residual stress analysis
  - **Mapping of stresses** on component
  - **Depth profiling** of stresses

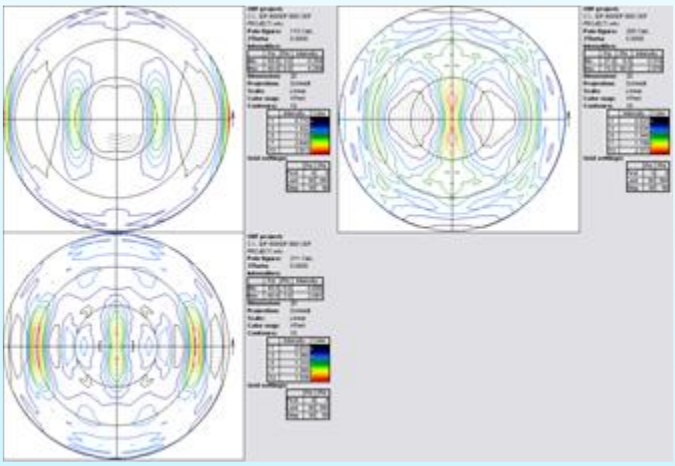
- ✓ Crystallographic **Texture analysis**



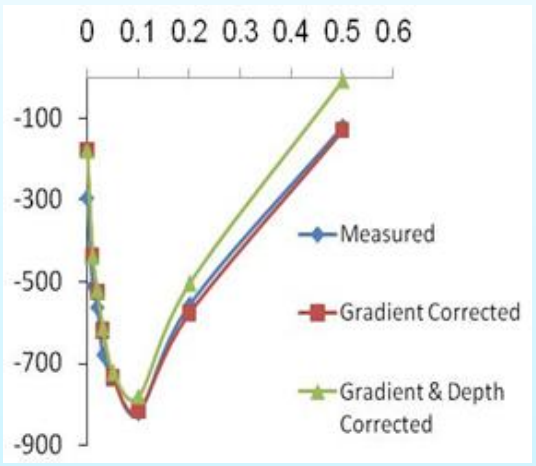
Comparison of XRD Patterns of Samples with 1 and 10% Retained Austenite



Residual Stress Measurement of Steel

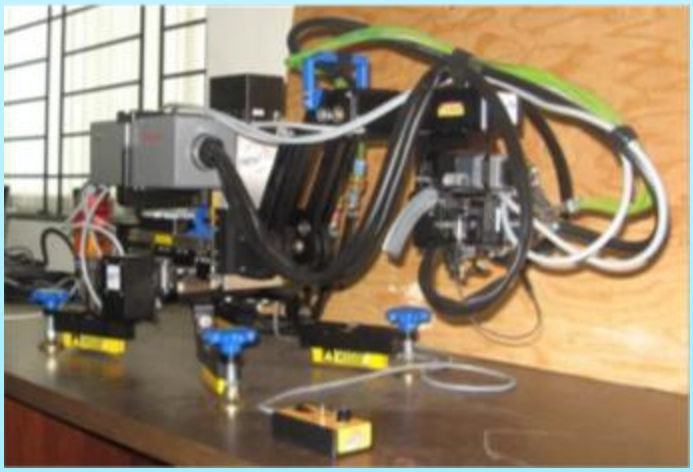


Texture Measurement (Pole Figure)



Depth Profiling of Residual Stresses of Shot Peened Component

X'PERT Pro Multi-purpose XRD
Make: PANalytical, The Netherlands



iXRD Portable Residual Stress Analyzer,
Make: Proto, Canada

AML also offers wide range of services for Material Characterization, such as mechanical, fatigue, chemical, environmental durability, etc. For more information and proposal, please Click here.

Indigenous and Cost Effective Development of Adaptive Front Lighting System by ARAI

ARAI has developed indigenous and cost effective technology solution for Adaptive Front Lighting System (AFS) for mid-segment cars. The algorithm is designed to address needs of Indian road and traffic conditions. AFS adapts headlamp beam pattern to driving conditions encountered by the vehicle. AFS operates in four different modes, viz. Expressway Mode, Country Mode, Town Mode and Weather Mode. The developed prototype, AFS ECU, has been integrated with Utility Vehicle's Electrical and Electronic architecture via CAN network to achieve these modes.

Major functions employed in this AFS ECU are:

- Town Mode
- Country Mode
- Expressway Mode
- Dynamic Swivel
- Automatic Head Lamp Leveling

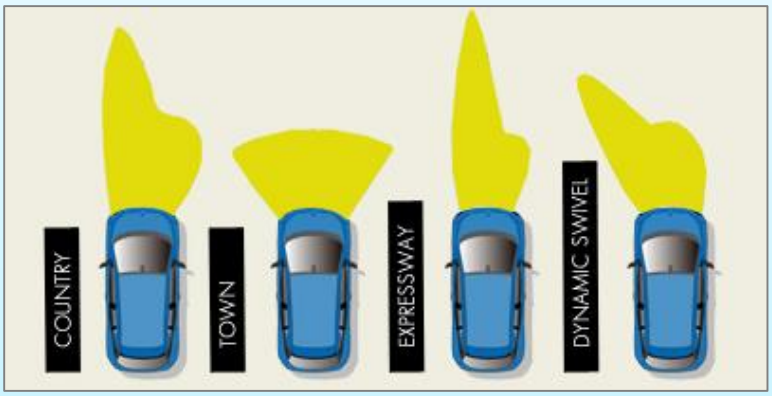


Figure 1 Adaptive Front Lighting System Modes

These AFS modes are achieved with less sensor inputs as compared to similar solutions available in the market, on existing mid-segment utility vehicle architecture. Vehicle speed thresholds are optimized to meet Indian traffic requirements. The speed thresholds to exit Town mode and enter Country mode are altered according to Indian traffic scenario. Passenger occupancy is derived by reading the chassis level sensor, which is newly added in the project vehicle. This algorithm was designed for HID-projector lamps and can be extended to LED-projector lamps or other light sources.

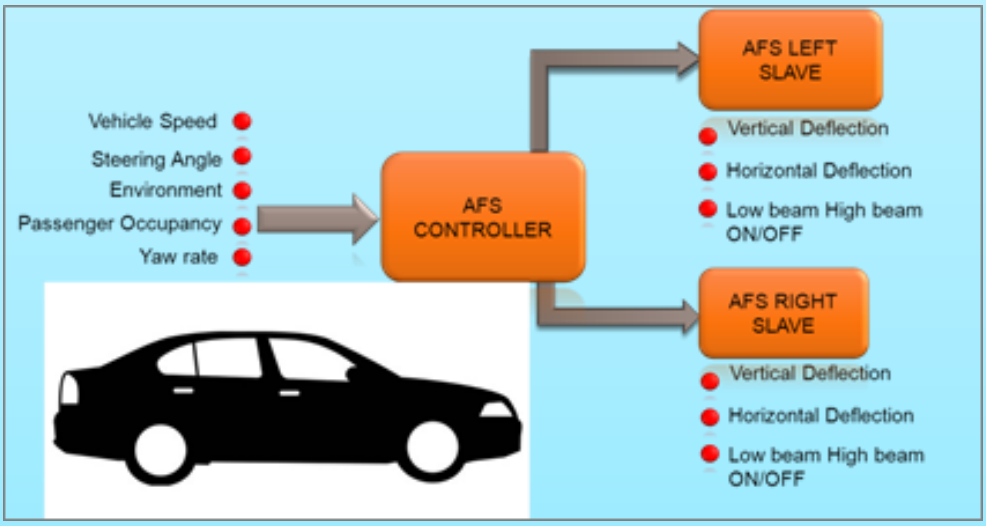


Figure 2 Input & Output Signals for AFS Controller

HID projector based headlamps were integrated with the Project Vehicle, which was driven through hilly terrain sections for verification of Dynamic Swivel and on expressway for high speed related testing. Calibration and verification of this system was carried out on test tracks and steering pad. Dynamic Swiveling was observed to be the most useful function in AFS in Indian scenario. The Dynamic swivel function encourages the driver to use passing beam over main beam. This function has market potential for mid-segment passenger cars in India, which is a part of the offered solution. These key functions can be implemented with the existing EE architecture, hence making ARAI AFS a good option to pave a way forward from the existing Non-AFS Halogen and HID lamps.

ARAI offer this solution on technology transfer basis to the industry.

With the development of AFS technology, ARAI is now able to offer following development services in automotive lighting.

- Functional Architecture Development
- Control Algorithm development for Intelligent Lighting Technologies
- Software development using Matlab and Simulink/ C
- Verification and Validation Methodologies
- Consultancy for AFS development and new technologies in the area of lighting

ARAI is also keen to develop similar AFS technologies for two-wheeler and commercial vehicle segment.

UPDATE

SIAT 2017 being organized by ARAI, in association of SAEINDIA and with the support from SAE International (USA), from 18-21 January 2017 at ARAI, Pune (India), has been receiving overwhelming response from the Automotive fraternity world over.

TECHNICAL PAPERS

Total 1445 technical paper abstracts received from various experts representing following 20 countries have been reviewed according to the review criteria of SAE International and 765 of them are accepted for further scrutiny by the experts and thereafter call for full manuscript. Review of draft manuscripts received so far, is in progress.

India	Australia	Austria	Belgium	Brazil
Canada	China	France	Germany	Greece
Italy	Japan	Malaysia	Mexico	Spain
Switzerland	Ukraine	United Kingdom	United States	Vietnam

PROGRAMME OF SYMPOSIUM & EXPOSITION

PROGRAMME SCHEDULE

		SIAT 2017	SIAT EXPO 2017
18 January 2017	Wed	Inaugural Session & Technical Sessions	Inaugural Session & Exhibition
19 January 2017	Thu	Technical Sessions	Exhibition
20 January 2017	Fri	Technical Sessions	Exhibition
21 January 2017	Sat	Technical Sessions & Valedictory Session	Exhibition

DELEGATE REGISTRATION

In view of availability of limited seats, delegate registration will be on first-cum-first-served basis. Therefore, to avoid displeasure, delegate needs to register urgently by logging on to **http://siat.araiindia.com**

Registered delegates will be entitled to participate in the Symposium, Exposition, Luncheons and Cultural Programs. They will also receive novel Delegate Kit, which will comprise of **7" Android Tablet** with pre-installed Mobile App and other data providing complete information of the Symposium. Tablet based application will enable delegates to view conference proceedings, schedule, technical sessions, papers and author details, keynote speaker profiles, Reference Technical Bulletin, exhibition details, layout, etc.

To avail early bird offer, please do register before 1st November 2016.
Details of early bird offer available on the website
https://siat.araiindia.com/registration.aspx

SIAT EXPO 2017

SIAT EXPO 2017, being organized concurrently in the premises of ARAI, providing opportunity to the auto, component and allied industry to demonstrate their products, technologies, equipment, etc. to the automotive fraternity & academia, has 180 booths. All these booths are booked by vehicle, component and system manufacturers for display of their products technologies.

ARAI – Winner of Golden Peacock Environment Management Award 2016

In the Golden Jubilee Year (1966-2016) of ARAI, yet another milestone in the history of ARAI.

ARAI's contribution towards Safety and commitment towards protection of Environment has received one more accolade in the form of GOLDEN PEACOCK ENVIRONMENT MANAGEMENT AWARD 2016. This award in Research & Consultancy category, was received by Director–ARAI in the special function in New Delhi.

Director- ARAI receiving Golden Peacock Award

Developing Technology solutions for CNG / LPG as alternate fuels, hybrid and Electric vehicles, formulation of emission and noise standards for vehicles and generators, designing lightweight materials for better fuel efficiency. ARAI assists Government of India in implementation of FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles in India) India Scheme for achieving desired objectives. ARAI is also assisting Government in establishing norms for control of in-use vehicles and recyclability / re-usability directives.

Golden Peacock Environment Management Award will stimulate and help ARAI to rapidly accelerate the pace of sustainable and effective Environment Management System. The award would inspire and align entire work force, management functions and lead to improved organizational performance. ARAI is committed to environment protection and will continue its research work in green technologies to safeguard national interest.

ARAI 50 YEARS OF BUILDING AUTOMOTIVE EXCELLENCE 1966 - 2016

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