**TRANSIENT DYNAMOMETER FOR TESTING OF SI AND CI ENGINES FOR COMBUSTION AND EMISSION RESEARCH**

IITM intends to set up a transient engine dynamometer test facility for conducting performance and emission studies on multi-cylinder automotive engines. The facility shall allow engines to be subjected to transient tests as per details given below and provide capability to measure in-cylinder combustion pressure and pollutant emissions.

**Essential Details:**

* The vendor must have supplied and commissioned at least 1 similar(transient dynamometer with measurement, control and automation) system in India and 10similarsystems globally (outside India) in reputed research and development laboratories of government funded institutions or research and development divisions of leading automobile industries during the past 3 years. The vendor should provide the details of such organizations where such systems have been installed and are operating successfully. The details must include name and address of the organization along with the brief specifications of the supplied dynamometer.
* The vendor should be the manufacturer of the transient dynamometer, automation system and the controller of the system that is to be supplied. The vendor should have their Service Centre in India and trained personnel for after-sales service. Vendor has to submit the complete details of service set up.
* The two bid system is to be followed (technical bid and a commercial bid). The technical and commercial bids should be in separate sealed envelopes. The vendors should also submit a quote for their AMC (Annual Maintenance Contract) charges and a quote for the costs of their recommended spare parts for the setup in a separate sealed envelope along with the commercial bid.
* Vendor should provide the list of utilities along with their capacity required to satisfactorily run the test facility along with the technical offer. The required civil work/ modifications will be carried out by IITM. Vendor should provide the drawings, data and manuals as per actual installation of the equipment within a month from the date of placement of the order.

**Scope of Supply**

The proposed facility shall consist of the following major equipment:

1. Transient dynamometer capable of measuring a maximum power of about 200 kW but not lower and a nominal continuous braking torque greater than450 Nm from 0 to 4000 rpm and capable of operating up to a maximum speed greater than or equal to10,000 rpm. Along with the dynamometer a digital controller which can allow it to work in both loading and motoring modes as per transient test cycles is to be supplied.
2. Test cell Automation system with all the required software modules which will allow the user to program test cycles of any nature for testing diesel, gasoline and gas engines as per Euro IV and Indian standards.
3. Base plate, Engine support/mounting system, coupling shaft along with necessary couplings and shaft guard as per the specifications given.
4. Torque measurement using a torque flange of high sensitivity along with the calibration check system.
5. Encapsulated speed encoder should be a part of the supply.
6. Throttle actuator
7. Ambient Temperature, Pressure and Humidity measurement systems
8. Engine temperature and Pressure measurement system.
9. Design and details of necessary foundation for the Engine dynamometer installation to be given.
10. The power supply system should be able to seamlessly and automatically connect with the power grid at IIT Madras during its generator/motor modes without any manual intervention of the user.

**Detailed Specifications**

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| **Specification** | **Requirement** |
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| **Capacity of Engine Dynamometer** |  |
| Maximum Speed | Greater than or equal to 10000 rpm |
| Maximum rotor inertia | Less than 0.4 kgm2 |
| Nominal continuous power braking | Greater than 200 kW |
| Nominal continuous torque braking | Greater than 470 Nm from 0 to 4000 rpm |
| Power during motoring mode | 10% lower than the generating mode |
| Torque during motoring mode | 10% lower than the generating mode |
| Overload Capability | Greater than or equal to 20% of nominal values for at least 60s in every 10 minutes |
| Nominal vibration level of the system during uncoupled operation | <3.0 mm/s |
| Operating Condition | The system should work in the temperature range of +5oC to +40oC and at high Relative Humidity of 90-95% |
| **AC Motor** |  |
| Motor type | Four quadrant operable asynchronous/synchronous motor with necessary IGBT bridges and integrated power modules for engine testing under steady state and transient conditions according to European/Indian test cycles |
| Power factor | 0.98 or better with less than 3% harmonic distortion |
| Dynamic torque response | Less than 5.0 ms |
| Bearing lifetime | At least 20,000 hours when used in the allowed operating conditions. |
| **Torque Measurement** |  |
| Torque measurement | Torque measurement shall be by means of a Torque flange. The torque flange shall be capable of meeting the dynamic responses of the dynamometer’s AC motor and the demands of the specified test cycles. |
| Torque flange range | Up to 100 kW |
| Torque flange Nominal Torque | Capable of measuring torque in the range 0-500 Nm and also withstanding the torque spikes that will occur during transient testing of a 100 kW automotive diesel engine. |
| Class of accuracy | 0.05 |
| Temperature effect per 10K on output signals | ≤ 0.05 % |
| Temperature effect per 10K on zero signals | ≤ 0.05 % |
| Linearity deviation including hysteresis related to the nominal sensitivity | ≤ 0.05 % |
| Relative standard deviation of reproducibility by reference to variation of the output signal (according to DIN 1319) | < +/- 0.03% |
| **Speed Measurement** |  |
| Speed Encoder | Inbuilt / encapsulated encoder type with direction identification |
| Minimum resolution | 512 pulses/revolution |
| **Dynamometer Controller** |  |
| Controller type | Digital |
| Dynamometer Control modes | Idle, Speed throttle position, Torque throttle position, speed torque, torque speed, user definable speed and torque modes shall be definable via software and via the operating panel |
| Torque control accuracy | 0.4% |
| Speed control accuracy | +/- 1 RPM |
| Features | Controller should allow different steady/transient test cycles to be programmed by user and provide data output for demand and measured values. It should be possible to measure up to 16 digital inputs with definable delay time and response time |
| Safety | Safety against over speed, over torque, over current and over temperature. |
| PID Controller update rate | Greater than or equal to 500 Hz |
| **Drive Shaft** |  |
| Quantity | One shaft for coupling with Mahindra mHawk120 automotive engine. |
| **Shaft Guard** |  |
| Feature | Guard should have removable cover and quick release mechanical lock. |
| Safety | Safety contact switch has to be provided which prevents test run starting with open shaft guard. |
| **Base Plate** |  |
| Type | Cast iron base plate with T-Slots and oil drain.The engine and dynamometer to be mounted on the same base plate |
| Isolation | Air dampers with automatic levelling and control unit |
| Natural frequency of system with engine running | Less than 3 Hz |
| **Engine Mounting System** |  |
| Type | Engine mounting frame of welded steel structure/screw jacks |
| Degrees of Freedom | System should have flexibility in the X,Y and Z directions |
| **Cable Boom** |  |
| Cable boom with swinging arm and transducer box | Yes |
| I/O modules | The unit should have an industry standard interface with 16 bit A/D converter built in. This bus shall enable the connection of one module to the other and also to the automation system. All necessary interfaces and cabling from the wall box to the control panel are to be provided. |
| **Throttle Actuator** |  |
| Actuator Type | Linear Motion Type, suitable for transient application |
| Control Features | Suitable digital controller capable of operating under transient European and Indian cycles. |
| Shifting travel | 100 mm |
| Max. actuation force | 100 N |
| Positioning accuracy | <0.4 mm |
| **Test Cell Automation System** |  |
| Type | PC based and user configurable. Standard cycles should be readily available. |
| Safety | Different user levels with password protection |
| Software | Software interface modules should be able to communicate with all supplied equipment. Standard Analog/Digital interfaces should be available to connect with other systems like air and fuel measurement systems (at least 8 channels each). It should be possible to start, set, shut down, control and monitor the following sub-systems.   * Dynamometer control system * Temperature and pressure measurement systems * Automation system should have interface to link for raw exhaust gas analyser. The emission test results should be displayed in different units like ppm, g/kW-hr, etc.   The software should be compatible with Microsoft Windows 7. |
| Functionalities | User definable graphical user interface necessary to monitor and control the testing process. |
| **Cabinet** |  |
| Type | 19” rack |
| Safety | Necessary safety features complying to relevant standards to be provided |
| **Pressure and Temperature Measurement System** |  |
| Universal Channels | At least 16 standard universal measurement channels for measurement of voltages, currents and resistances. |
| Thermocouple | At least 24 channels for measurement of thermocouples of type B, E, J, K, N,R, S and T. |
| Resistance Temperature Detectors | At least 8 channels |
| Pressure measurement | At least8 channels for piezo resistive transducers |
| Digital I/O | At least16 channels |
| Frequency Input | At least 2 channels |
| Analog Output | At least 4 channels |
| Sampling Rate and Resolution | Configurable up to 100 Hz with minimum16 bits resolution |
| Features | Analog input has to be atleast 16 bit ADC. |
| **Temperature Measurement** |  |
| Sensors | 12 Nos. for temperature measurement (PT100) of 0-200 oC  6 no. for temperature measurement of 0-1000 oC |
| **Pressure Measurement** |  |
| Sensors | 2 sensors for pressure of-1 to 1.6 bar  2 sensors for pressure of 0 to 2 bar  2 sensors for pressure of 0 to 6 bar  2 sensors for pressure of max. 10 bar |
| **Measurement of Test Cell Temperature, Pressure and Humidity** |  |
| Feature | A separate system indicating test cell ambient conditions such as Temperature, Pressure and relative humidity shall be offered which can be integrated with standard test cell automation system. |
| Ambient pressure measurement range with accuracy | Range 85 to 110 kPa, accuracy +/-0.1 kPa absolute |
| Relative humidity measurement range with accuracy | Range 10 to 90%, system accuracy +/-3% absolute |
| Temperature measurement range with accuracy | range 5 to 50 C, accuracy +/- 1 oC absolute |

**Electrical Connections:**

Standard electrical connections/connectors will be provided for the dynamometer and controller by IIT Madras. The vendor will be responsible for connections to the dynamometer from this standard electrical connector which will be at a maximum distance of 8 m.

**Documentation:**

Vendor should provide at least one CD of instruction manuals for operating and maintenance of the system in English language. All the documents/floppies/ CDs related to the system should be provided. This will include the descriptions and drawings required for operation and control of the equipment supplied.

**Time Schedule:**

The system should be supplied, installed and commissioned within 8 months after acceptance of Purchase Order.

**Training:**

IIT Madras may depute its two representatives for training on the transient test bed at a relevant location. Travel and stay will be taken care of by IIT Madras.

**Warranty:**

The vendor should provide a warranty for at least 12 months from the date of commissioning of the setup.

**After Sales Support:**

The vendor should have well trained engineers for after sales support in India to service the installation at IIT Madras.