

TERMS OF REFERENCE FOR THE R&D PROJECT

1. Title: Study and Verification of ‘Powder Additive Manufacturing (3D Printing)’.

2. Background:

Additive manufacturing (AM), previously known as rapid Prototyping. Additive manufacturing (AM) is a process of fabricating objects layer-by-layer from computer-generated three-dimensional (3D) geometry models, without the constraints of conventional casting, forging, and machining processes. AM technologies have shown a great potential to reduce the energy consumption embedded in manufacturing by reducing materials wastage and eliminating machining steps.

The most popular technologies of AM are selective powder bed fusion, directed energy deposition, Materials Extrusion, Vat Photopolymerization and binder jetting, etc.

The AM process has attracted great interest in power converters due to its manufacturing simplicity, flexibility in structure design, and short prototyping period compared with traditional manufacturing methods, such as Mold casting, punching, and mechanical machining. Over the past few years, with the availability of new printable materials, increased printing accuracy, and decreased costs, this technique has gradually been incorporated into the fabrication of various power components and converters. AM technology allows for reducing weight and waste, exploring more complex geometries and improving heat transfer efficiency, thereby creating a more compact package.

As mentioned above, the powder additive manufacturing (3D Printing) has many advantages and is widely used, but there is no standard on the same. Thus it was felt that, this R&D project is important and aimed at collecting and validating data of the chemical, mechanical and physical properties for the various powders for additive manufacturing, imported and used in India and will form a basis for development of new standard on Powder Additive Manufacturing (3D Printing).

3. Objective:

To collect and verify relevant data and information from primary and secondary sources for the various powders for additive manufacturing to specify chemical, mechanical and physical properties.

4. Scope:

1. Study the available literature like national and international standards such as ASTM, JIS, EN, ISO etc. available on the subject, research papers, any study conducted by other organizations, companies’ brochures. Identify the grades, their chemical, physical and mechanical properties and any other requirements which can be included in the standard.

2. Identify the manufacturing base of the product and testing facilities of the product to collect data.
3. The project should cover on-site visits to various manufacturing units where the products are being manufactured. During the visit the manufacturing process needs to be studied and reported as follows:
 - a) Raw materials. (any Reference to Indian/international standard)
 - b) Manufacturing procedure for metal powder (specific to critical applications).
 - c) Grades (based on properties).
 - d) Designation.
 - e) Test methods. (**whichever is required specific to application**)
 - Density
 - Chemical analysis (Method of testing, in case of wet analysis is used)
 - Hardness testing, on final product
 - Strain rate, on final product
 - Porosity, on final product
 - UTS, **PSI/MPA**, on final product
 - Yield strength , on final product
 - Elongation, % ,on final product
 - Coefficient of Thermal Expansion
 - Magnetic Properties, if any
 - **Any other tests, if necessary**
 - f) Physical/dimensional limitations,
 - g) Safety requirements and Disposal of waste generated. (environmental aspect)
 - h) Packing and quantities to be packed. (Handling & Storage)
 - i) Hazards Identification and safety requirements during work. (First-Aid Measures)
 - j) Stability and Reactivity of the product.
 - k) Any other specifications, if any.
4. Visit and Collect data from testing laboratories and testing infrastructure available in the country .
5. Analysis of the data collected as above which includes collection of data on raw materials/grades mainly their chemical composition which will be used for Powder additive manufacturing (3D Printing); collection on data on chemical, mechanical and physical properties of product manufactured by powder additive manufacturing (3D printing) and other essential properties required by the product and comparative study with National/International Standard/Journals/Research papers, work by other recognized national/international organization etc; providing the guidelines/properties for selection of the powder additive manufacturing for the job by providing a comparative analysis between the grades; and also recommended manufacturing process.
6. Check the quantity of the product imported and exported and countries with which the trade for this product is occurring. Also check if any technical regulations exist for this product in these countries. Take data of the foreign specification as per which the product is being imported or exported.

7. Tests shall be conducted in BIS recognized/NABL accredited laboratories /any government lab/ Accredited to IS/ISO/IEC 17025 to validate the chemical and mechanical requirements of the grades.
8. Study and prepare a report on the effect of various alloy additions and impurities on the performance characteristics of the alloys.
9. Analysis and consolidation of data and preparation of a comprehensive analytical report of the data collected above.

5. Methodology:

1. Study the literature and analyze the findings.
2. Visit the manufacturing unit and
 - Observe the manufacturing process, examine in-process control measures;
 - Conduct focused group discussion with quality personnel;
 - Collect the data as mentioned in the scope through a questionnaire;
 - Test samples in the factory for all the possible tests
 - Draw samples from the grades manufactured and get it tested in BIS/BIS recognized/NABL Accredited/Any Govt. laboratories/ Accredited to IS/ISO/IEC 17025 for verification of the chemical, mechanical and physical properties of the products identified.
3. Visit laboratories and make report on
 - test equipment required;
 - test method being used and standards being followed for testing;
 - testing charges;
 - testing time required;
 - Witness the tests being conducted on the samples drawn;
 - Findings of the tests conducted on the samples drawn.
4. Visit the identified importers and exporters and collect data as mentioned in the scope through a questionnaire.
5. Visit the users of the product and collect data as mentioned in **Sl. No. 3** of the scope through a questionnaire and draw samples from the grades manufactured and get it tested in BIS/BIS recognized/NABL Accredited/Any Govt. laboratories/ Accredited to IS/ISO/IEC 17025 for validating the desired chemical, mechanical and physical properties of the products identified (The physical, chemical and mechanical properties for which the sample may be tested may be derived from literature survey and after discussion with the user).
6. Analyze the data and test reports from diverse sources and include the same in the project report as given in the scope.

6. Sampling plan:

1. At least two manufacturers, preferably one each from large scale and MSME need to be visited and actions as indicated in Sl. No. (2) of the methodology needs to be undertaken.

2. Three samples for each grade shall be tested preferably from different manufacturers/brands for all the properties mentioned at Sl. No. (3) of scope and any other tests as identified from literature survey/visit to manufacturer, users and importer.
3. Samples may be drawn from manufacturers, users, importers and/or markets.
4. At least two laboratories, preferably one in government and one in private needs to be visited and actions as indicated in Sl. no (3) of the Methodologies clause needs to be undertaken.
5. Testing shall be conducted in one of the Govt. /BIS recognized/NABL/CSIR accredited labs/ Accredited to IS/ISO/IEC 17025

7. Deliverables:

1. Final project report, in hard copy format as well as in soft copy, covering all aspects mentioned in the scope.
2. Questionnaire, discussion, visit reports, test reports to be appended with the final project report.

8. Timeline:

The duration of the project is 6 months from the date of award of the project. The proposed indicative timeline stage-wise is given below:

Sl. No	Stage	Time from date of award project (cumulative)
1	Literature review and identification of manufacturing base, testing laboratories, user/user industry, and discussion with BIS for the finalization of sampling plan	1 month
2	Interim/mid-term report on Visit to manufacturers, testing laboratories, users and importers and exporters and data collection	2 month
3	Preparation and submission of first draft report to BIS	2 month
4	Submission of final project report	1 month
	Total	6 months

Note: The proposer may submit the draft report to BIS without waiting for test report from independent laboratories if the test is of long duration test.

9. Support BIS will provide:

- BIS will provide any Indian/international standards, if any desired during the project timeline.
- Licensees detail manufacturing similar products.
- BIS approved laboratories testing similar products.

10. Nodal Contact Point:

Sectional committee:

MTD 25-Powder Metallurgical Products and Processes Sectional Committee

Nodal officer:

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