Executive Summary

Many scientific databases are available for materials data internationally. The data in those databases are generated in various research centres in their respective countries. China, Japan, USA and Canada have developed data stores. India is one of the leading contributors to Materials and Metallurgical data globally. However, the valuable data available is scattered in different institutional publications and reputed international journals and is not available in one place or in a quickly retrievable format. When an attempt was made to collect the already published data in the areas of mechanical and corrosion properties of materials, it was realized that the data generated within the country is of high value and very useful to the industries and scientific community if stored in one common place and utilized.

In this project, IGCAR would collect already published data and collate it into a database.

Objectives of the study

Scholarly data of an institution need to be preserved and made available to all. The Indian government and worldwide movement are for centralized repositories. In this project, an attempt was made to develop a Materials Database for India.

IGCAR had the confidence to collect data from premier institutes researching on structural materials since IGCAR has collaborations with many institutions doing research on Materials. Large sources of data on Creep, Fatigue, Tensile, Fracture and Corrosion properties on different structural materials generated in Indian laboratories will be collected.

The operation, maintenance, further developments and complete administration of the database would be by IGCAR. It was decided to host the data in an exchangeable format on the internet so that repetition of the same experiments is not done, thus saving cost & time. The extensive database will be beneficial to industries, students and research scholars.

Database Design

IGCAR collected research output data from Indian research centers and academic institutes. On studying the data, it was found, that the data essentially consists of the metadata part, which has the

same set of fields for all data records. But the experimental output is different for every material and the property tested. After many rounds of discussions, the multidimensional data model was selected to use in the design of the database. The usage of MDDB solved the problem of making changes to the database whenever a new material with different property had to be included without changing the core dimensional data structure of the database.

Detailed Data-Driven Website Design

The Indian Materials Database is designed as a multidimensional data model. Dimensional modeling (DM) is a logical design technique often used for the data warehouses. It seeks to present the data in a standard, intuitive framework that allows for high-performance access. MS SQL server is used for storing data. The web application comprises dynamic and data-driven pages developed using Microsoft's ASP.net technology.

Although the entire data deals with materials and their properties, it is heterogeneous in terms of properties studied of a specific material, material types studied with respect to a property, conditions underwent by a material before testing, and test details. The data on a property can be in tables, graphs, microstructure images, or a combination of these. Even though the research data is stored in a single database, the display of data should satisfy all users interested in various aspects of the available data.

The user's priorities in searching the data can be any of the following:

1) Search for a Material: A user may access the database seeking data on a particular material type he is interested in. For a single material, the data on various properties of the different types and subtypes of the materials obtained from multiple sources are available in the database.

2) Search for a Property: The database user may be interested only in data regarding a specific material property. The data about different material types are available in the database for any single property.

3) Search for source of data: Since the database is a compilation of data from different organizations, the user may be interested in data from a particular organization or published in a specific journal or year of publication.

4) Search for Type of data: The data on a material property is available in the form of tables, graphs or microstructure images. Sometimes, a user may be concerned about data of a particular form only, i.e. he may want to retrieve all the graphs available on material properties and so on.

Once the user views a web page with material property data, he may want to save it in an exchangeable format for future use. The application provides an option to save the data in XML (eXtensible Markup Language) format. The user's interactions with the web application are shown in the UML use case diagram in Figure. 1.

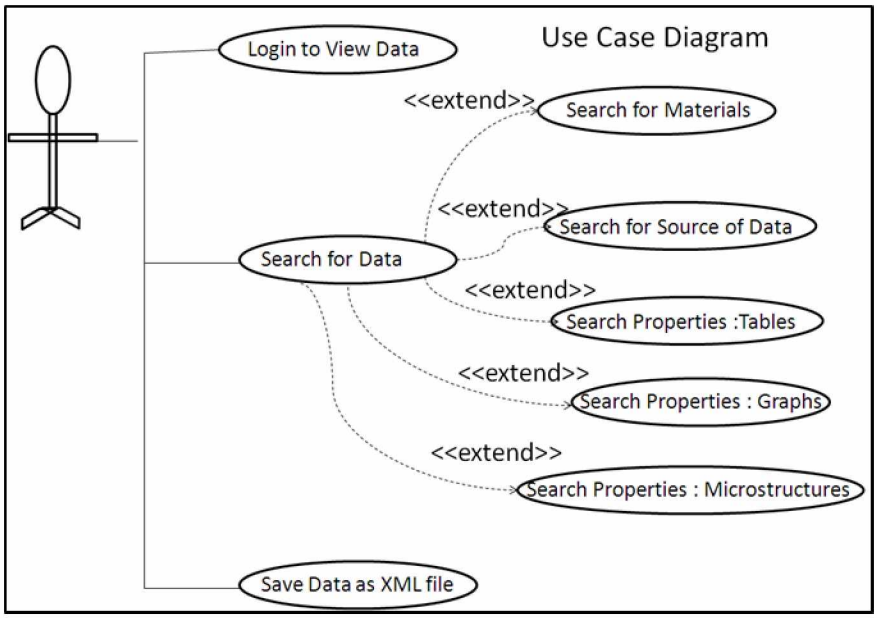

Figure 1 : Use case Diagram of Materials Database

Data Collection from Premier Institutes of India and hosting on website

This is the first pioneering work where data from various institutions are collected. Few research institutes agreed to share already published data. The participating institutes are Bhabha atomic research centre (BARC), National Metallurgical Laboratory (NML), Research and Development Centre for Iron and Steel (RDCIS), Central glass and Ceramic Research Institute (CGCRI), Indian Institute of Technology, Roorkee (IITR), Indian Institute of Technology, Kanpur (IITK), Visvesvaraya National Institute of Technology (VNIT), National Institute of Technology, Karnataka (NITK), Indian Institute of Technology, Madras (IITM) and IGCAR.

Brief Description of the data

Indian Material Database covers physical, corrosion and mechanical properties of metallic and non-metallic materials. The information is available in the form of tables, graphs and microstructures with corresponding references. In the database, the search is based on materials and properties.

Materials

Data on metallic materials cover **Ferrous and Non-ferrous alloys**. Ferrous materials include Duplex stainless steel, Maraging steels, Microalloyed steels, carbon steels, mild steel, High Strength Low Alloy steel, Austenitic stainless steel, Ferritic-martensitic steels and their weld joints. **Non-Ferrous materials include** Ni-base superalloy, Titanium alloys, Zirconium alloys, Niobium alloys, Binary alloys of Nickel, Aluminum and Copper etc. **Non-Metallic materials** include coatings, thin films, Nanocrystalline oxide multilayers, Nitrides and silica glasses. There is also information on composites such as metal matrix composites, Glass-polymer composite and nano-composite coatings.

Material Properties

The database incorporates **corrosion properties** such as biofouling, microbial corrosion, pitting corrosion, general corrosion, Sodium corrosion, sensitization and high temperature corrosion. **Mechanical properties** available are tensile, creep, various types of fatigue failure, creep-fatigue interaction, impact, hardness, microhardness, nano-mechanical behaviour, superplasticity, fracture toughness and crack growth behaviour.

Data Collection

Experimental Data from conventional and small specimen testing were covered in the material database. Data is available from the following areas like creep, fatigue and creep-fatigue interaction behaviour of various steels, studies on the influence of welding techniques on microstructure and mechanical properties of ferritic steel weldments, Zone wise creep behaviour in weld joints, application of AI techniques in weldability studies, Hot deformation studies on austenitic steel, fatigue crack growth studies on ferritic and austenitic stainless steels, Type-IV cracking problem, influence of aging on mechanical properties etc.

Data on Inconel alloys for future coal fired power plants is also included. Database also covers modeling studies on deformation and damage behaviour under creep, fatigue, tensile at different length and time scales up to atomistic simulations.

Structure-property correlations using conventional and advanced characterization techniques such as EBSD, In-situ Raman Scattering and XPS, studies on various NDE techniques including ultrasonic guided wave inspection methodology for steam generator tubes in PFBR have been incorporated.

Corrosion studies include behavior of alloys in various electrolytes, nano-metal oxide coating to resist biofouling, Materials study for nuclear reprocessing applications & evaluation of corrosion resistance of nano-nickel-ferrite and magnetite double-layer coatings on carbon steel. Phase transformations, nano-fluid magnetic sensors and interface studies are also covered.

Results & Discussions

In 2017, the website of the materials database was hosted in National Informatics Centre (NIC). To host the website in NIC cloud, application security auditing by a third party was mandatory. It was done by STQC, IT Chennai.

The database is a precious source of research data helpful to industries, students and research scholars. The worldwide open science initiative is gaining momentum. The material database of India is a standing example of open science data. Sustaining the activity by continuing data collection and updating the database would be very fruitful.