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# Informal and Formal Modelling of Engineering Processes for Design Automation using Knowledge Based Engineering

**Keywords :** Knowledge Based Engineering (KBE), Design Automation, Process Model, Formal Representation, Process Automation

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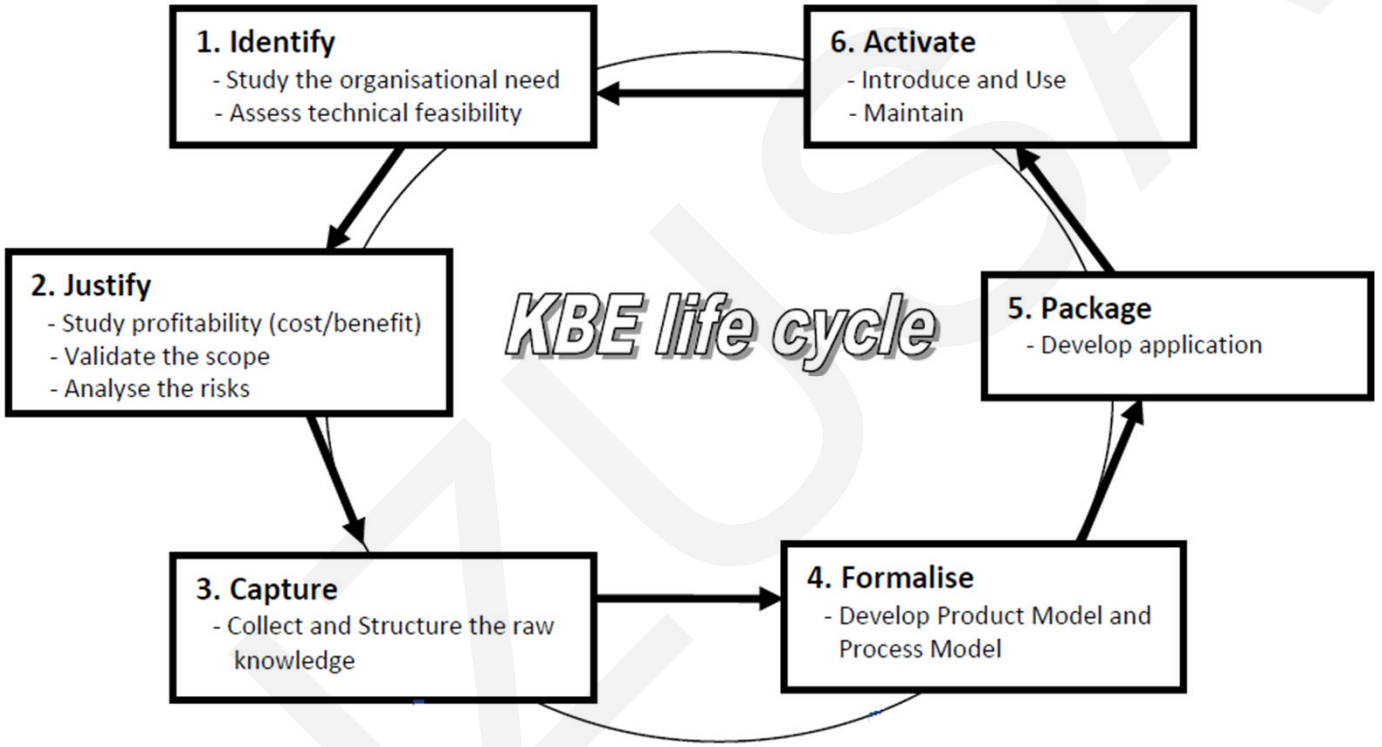
# Background : Aim of Knowledge Based Engineering (KBE)

- To preserve the engineering expertise in the form of re-usable process and product knowledge such that they are stored in intelligent, automated computer systems
- The re-usable process and product knowledge encapsulates all design and engineering information in the form of rules, requirements, product attributes and features, constraints, logic, parameters, rationale which can further be used for manufacturing analysis

## Definition

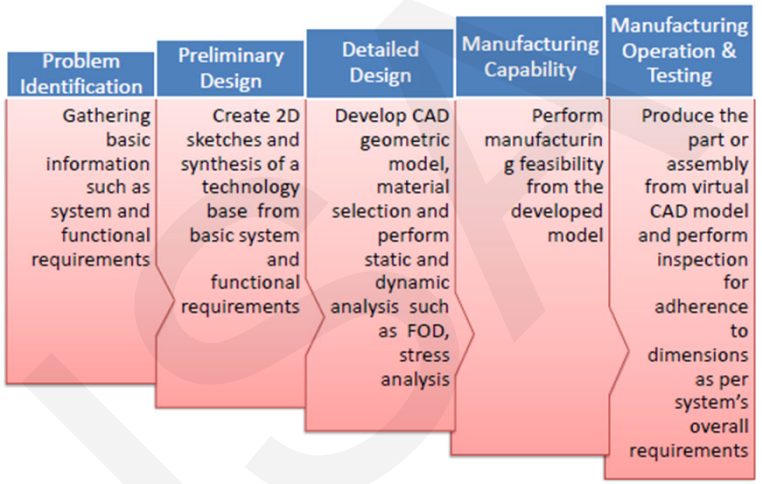
'Knowledge Based Engineering (KBE) represents an evolutionary step in Computer-Aided Engineering (CAE) and is an engineering method that represents a merging of Object-Oriented Programming (OOP), artificial intelligence (AI) and Computer-Aided Design (CAD) technologies, giving benefit to customised or variant design automation solutions'

# KBE Life cycle: 6 Stages

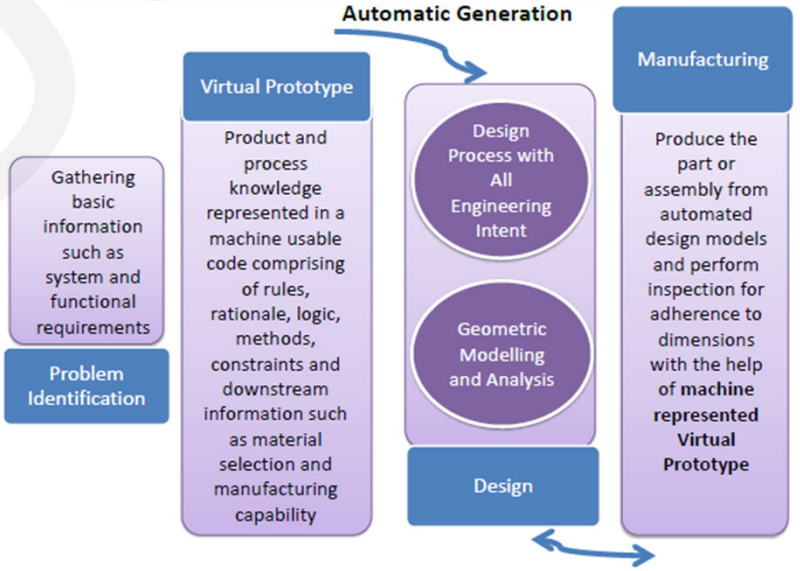


# Research Context

Traditional Product Development Process:
Geometric CAD Model directly created from system and functional requirements during design stage




Product Development Process using KBE Methodology:
Complete design knowledge which includes both geometric and non-geometric information provided as a Virtual Prototype in the form of detailed process and product repository during the design stage. The virtual prototype is in the form of a machine usable code which provides automation of the process

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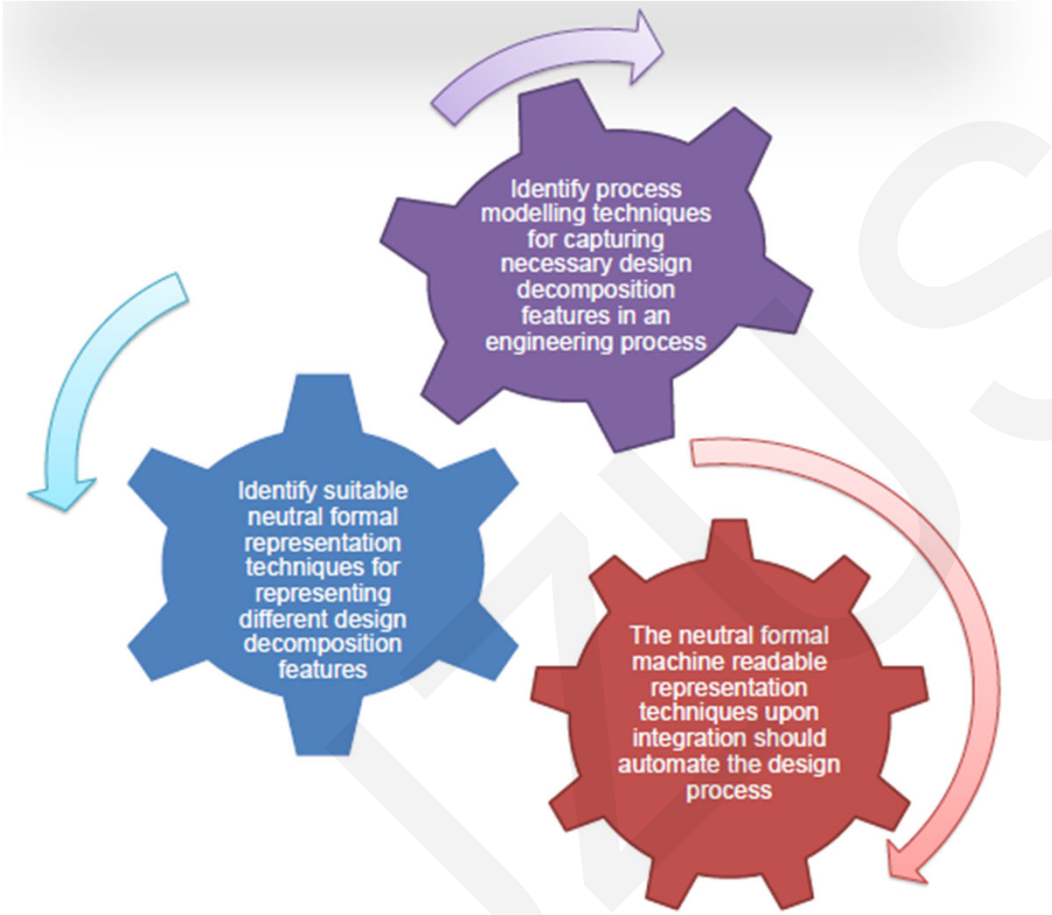
# Method Adopted




# Scope of Paper

Capture all design decomposition features in a process modelling technique. Ensure correct syntactical and semantic mapping of the informal process-based model capturing all the necessary design decomposition features to neutral formal representation techniques

**The formal knowledge representation techniques will be in a neutral (Platform Independent) format with well-defined syntax, axioms and semantics such that they can be shared across multiple platforms and enable interoperability. The formal representation techniques will also be compliant with International standards for product and process data exchange**

# Informal Modelling and Formal Representation

- Some examples of informal/semiformal process modelling techniques – Design Structure Matrix (DSM), Work Transformation Matrix (WTM), Petrinet, Coloured Petrinet, Timed Petrinet, IDEF suite consisting of IDEF0,1,2,3,4,5, Role Activity Diagram (RAD), Data Flow Diagram (DFD), Business Process Modelling Notation (BPMN), UML/SysML, Signposting, Event Process Chain Diagram (EPC)

- Some examples of formal representation techniques and languages – Process Specification Language (PSL), OWL/RDF, OWL-S, OWL DL, OWL Lite, OWL Full, IDEF5, STEP schemas, SysML/UML Diagrams with the help of tools, RuleML, Rule Interchange Format (RIF), Requirements Interchange Format (ReqIF), Common Logic Interchange Format (CLIF), Functional Markup Language (FML), Behaviour Markup Language (BML), MathML for representing mathematical rules and information

# Conclusion & Future Work

- IDEF Suite, UML/SysML, Signposting – Informal/semiformal process modelling methods narrowed down with the help of tabular analysis informally capture most design decomposition features such as objects, processes with inputs, outputs along with requirements, rules, logic, constraints, and rationale for design process automation.

- Design decomposition features exhibited in formal neutral representation techniques with the help of cited example-

  Process inputs, outputs and parameters, objects – Process Specification Language (PSL)

  Textual rules, constraints, logic and rationale – RuleML

  Requirements – SysML Requirement Diagram

- Other design decomposition features and neutral representation techniques to be represented and tested –

  Process inputs, outputs and parameters, objects – STEP (Part 49), OWL-S, IDEF5

  Textual rules, constraints, logic and rationale – Rule Interchange Format (RIF), Common Logic Interchange Format (CLIF), OWL DL

  Requirements – ReqIF

  Function – Functional Markup Language (FML)

  Behaviour – Behaviour Markup Language (BML)

  Mathematical Rules and expressions – MathML

- Development of integration method for the complete hybrid framework of formal neutral representation techniques to enable design process automation