The Creation of Saint-Gobain Seals’ Digital Engineer
Contents

• Company Profile Saint-Gobain

• Rationale behind the Digital Engineer: the Why

• Digital Engineer architecture: the What

• Building Blocks explained: the How

• Next steps
Saint-Gobain, key figures

- **2018 net sales**: €41.8 BN
- **Present in**: 68 countries
- **More than 80% of sales**: are made in habitat markets: construction, renovation, infrastructures and civil engineering
- **More than 180,000 employees**: and **100+ nationalities** represented
- **Around 4,100 sales outlets**: Created more than **350 years ago**
- **One of the top 100 industrial groups** in the world with around **950 production sites**
Seals, a business unit in Critically Engineered Solutions, who we are

**Our Brand**

Critical parts making THE difference

- Precise Fit
- Lifetime Confidence

**Key Figures**

- **14** manufacturing facilities
- **14** Countries
- **1,200** employees

**Our Products**

- **High temperature thermoplastics for tolerance control**
- **OmnSeal**
- **Rulon**
- **HyComp**

**Our Markets**

- Wear control in high temperature, high load & motion applications
- Leak control in extreme static & rotary conditions
- Broad PTFE formulations for wear control
Why the Digital Engineer?
Critical applications

Failure is not an option

Secure the knowledge!
Rationale

Global Standardization

Capture Know-How

Training Tool

Why a Digital Engineer?

Cost Optimization

Reduced “Time to Market”

Increase Market Share “Growth”
What is the Digital Engineer?
Non-Digital Engineer: Simplified
Digital Engineer: Overview

1. Knowledge Extraction/Update
2. Query
3. Proposals
4. Feedback
5. Data Storage
6. Machine Learning
7. Knowledge Consolidation
How is the Digital Engineer built?
Digital Engineer: Overview

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Design DB → Engineering Support → Engineering Automation

DTAI

SOLIDWORKS

OPEN RULES

Configure & Automate

HIGH PERFORMANCE SOLUTIONS
Engineering Automation: Known Solutions

- Tool for Internal Sales

- Straightforward task
  - Given input specification
  - Determine 1 standard seal (output)

- Limited knowledge of domain
  - Knowledge in model should be correct
    - Easily verifiable knowledge

→ Model decision procedure
Engineering Automation: Known Solutions

Knowledge Elicitation

- **Brainstorm sessions**
  - Design engineers (technical know-how)
  - Management (strategic decisions)
  - Multiple parties → standard solution

- **Requirements**
  - Formal representation
  - Easily readable by domain experts

- **DMN**
  - Decision tables
  - Friendly Enough Expression Language
  - Decision Requirement Diagram
  - OpenRules

![Diagram of Design Type and factors](image)
Engineering Automation: Known Solutions Implementation
Digital Engineer: Overview

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Design DB

Engineering Support

Engineer

Engineering Automation

1. Knowledge Extraction/Update

DTAI

OPEN RULES

SOLIDWORKS

HIGH PERFORMANCE SOLUTIONS
Engineering Support
Knowledge

- Extensive knowledge of domain
  - But not complete
    → Assist engineers

- More complicated tasks
  - Partial input → Partial output
  - Output → Input
  - Experiment with “out-of-scope”
  - Get explanation
  - Compare designs, materials
  - …

- Physical constraints and preferences
  - Model in First-Order logic
  - Use model generation system
    - IDP (DTAI)
  - Multiple inference tasks
Engineering Support
Knowledge: Example

- **Constraints**
  - DesignType = "Closed" ⇒ ~Spacer.
  - BackPressure ∧ Pclass > 100 ⇒ Spacer.
  - Location = "Bi−directional" ⇒ Spacer.
  - DesignType = "Open" ⇔ AbleToReleaseBP.
  - Location = "PressureAccumulating" ⇒ AbleToReleaseBP.

- **Preferences**
  - Compare numerical values
    - cost(design) = 20 ← DesignType = “Closed”
    - cost(design) = 28 ← DesignType = “Open”
  - Compare categorical values
    - Durability( Closed ) > Durability( Open )
Engineering Support Implementation

- Stand-alone tool for engineers
Comparison Systems

Decision Procedure (DMN)

- Easy to model
- Easy to understand for engineers
  - Verify correctness row-by-row
- No good representation for guess-and-check
- No distinction between physical constraints and arbitrary choices
  → poor maintainability
- Current systems only support 1 inference task
- No partial answers for unknown applications

Constraint Representation (IDP)

- More complex representation
  - Syntax + Constraint-based thinking
  - Knowledge extraction is harder
  - No trivial input-output relation
- Constraint system
  → No need for decision order
- Types of knowledge are separated
  - Constraints remain valid in other application areas
  - When circumstances change, only specific constraints change
- Multiple inference types supported
- Can handle partial input
DMN+ Proposal

- Idea:
  - Express constraints in DMN-like format → Readable representation
  - Use constraint solver as back-end → Broader useability

- Presented at RuleML
Digital Engineer: Overview

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Machine Learning on Design DB

- Utilize historic designs
  - Technical drawings
  - EPDM data

1. Search existing solutions for specific input conditions
   - Similarity search

2. Learn new constraints

3. Check data consistency
Machine Learning
Technical drawing

- Identify key objects:
  - Segmentation
  - Object identification

- Design drawing
  - Define « design identity » (NN)

- Cells
  - Perform text recognition (OCR)
  - Use cell location to link text to design properties (ILP)
Machine Learning

Search Existing Designs for Similar Inputs

- What are similar inputs
  - Distance measure (EPDM & technical drawing Info)
  - Categorical data → Category should match
  - Data with order → Equal or harsher circumstance
    - Tmax → All designs with Tmax ≥ request
    - Tmin → All designs with Tmin ≤ request

- Possibly a lot of solutions
  - Cluster solutions
    - K-means clustering
    - 1 representative design
  - Gradually filter solutions

Most similar designs:
Machine Learning

Other possibilities

● Learn new constraints
  ○ Available data
    ■ Input (circumstances)
    ■ Output (design)
  ○ Find logical consequences which are present in data (but not yet explicitly known)

● Check data consistency
  ○ Available data
    ■ Technical drawing: always correct
      ● Visual information
      ● Cell information
    ■ EPDM data: Often not reliable
  ○ Find inconsistencies in user input fields and correct/complement them
Conclusion: Status & Next Steps
Status & Short Term Goals
Where are we going?

• Automated Engineering Tools (QAD, OR & DW)
  • 1 in Production:
    PC 2500&10k Ball Valves
  • 1 in Test:
    Screw Compressor Lip Seals
  • 7 in Development:
    • PC 15k Gate Valves
    • Cryogenic Ball Valves
    • Swivels
    • Std OmniLip
    • Std OmniSeal
    • RACO Space
    • Rulon Bearings
  • Direct communication between finished tools and DriveWorks in development
    → Head start for drafting team

• Engineering Support Tool (IDP)
  • Working core functionality
  • Additional functionalities in development based on user feedback
  • Knowledge base gradually expanded
  • Prototype of system and interface by end ‘19

• ML on EPDM drawings
  • Workflow validated
  • Improving models
  • Communication with engineering support tool in development
  • Prototype by end ‘19
Thank You

Q&A

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