Creating a preventive maintenance concept for new systems considering cost and downtime simultaneously

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Introduction

- Simulation Engineer at KSE Process Technology
- Studied at TU/e
  - Industrial Engineering
  - Manufacturing Systems Engineering
- Master's thesis at Lely, Maassluis

TU/e

Content

- Introduction and problem statement
- Maintenance concept development
- Optimization model
- Case study results
- Applicability for other companies

Lely

- Farming automation solutions

Problem statement

- Availability systems important for farmers
- From reactive to more preventive, service-oriented maintenance strategy
- Maintenance schedules based on experience and gut feeling
- ➢ Not based on theoretical framework, nor explicitly defined rules
- New systems contain large amount of uncertainty

- *“How to create an optimal preventive maintenance concept for new systems?”*

Development of a maintenance concept

Involves:

1. Identifying maintenance objectives
2. Conducting technical analysis of system failure behavior
3. Selecting maintenance policies
4. Optimization policy parameters
5. Implementation and evaluation
6. Feedback

(Items 1–4: Covered in the thesis)

Source: (Waeyenbergh and Pintelon, 2002, 2004, 2009)

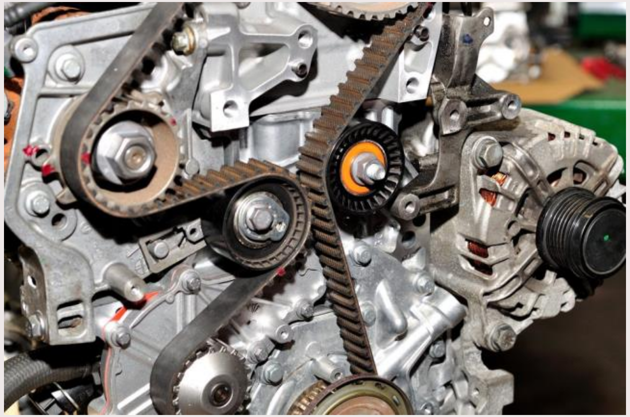
Maintenance objectives

What are we trying to achieve with the PM concept?

1. Maximize availability
2. Minimize maintenance costs
3. Minimize operational impact

Technical analysis

- Technical analysis: which behavior are we trying to prevent?
- How is our system / components expected to fail?


Maintenance policy selection

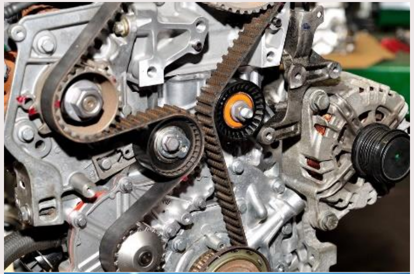
- Policy selection: how can we prevent failure?
- Can we monitor the condition?

  → Condition Based Maintenance
- Does the component likely fail after a certain time/ usage?

  → Age-Based / Usage-based Maintenance
- Does the failure have severe consequences?

  → Redesign required
- Are the consequences of failure acceptable?

  → Failure-based maintenance
- If not → redesign is required



Optimization model

- Difficult to translate downtime (availability) into cost
  - Customer satisfaction
  - Animal health
  - Product and company image

- Combination of:
  - Zhu (2015): cost optimization
  - Peng and Zhu (2017): downtime optimization

- Scheduled downs for shared PM
- Unscheduled downs for Corrective Maintenance

Model input - Setup

Setup preventive maintenance on system

- Downtime:
  - Create safe working environment
  - Perform routine inspections
  - Perform tests / calibrations before putting back in service

- Cost:
  - Driving cost
  - Labor cost

Model input - downtime

Component downtime:

- Preventive maintenance:
  - Replacement time

- Corrective maintenance:
  - Time needed to react to a service call
  - Driving time
  - Troubleshooting time
  - Replacement time
  - Extra replacements due to collateral damage

Model input - costs

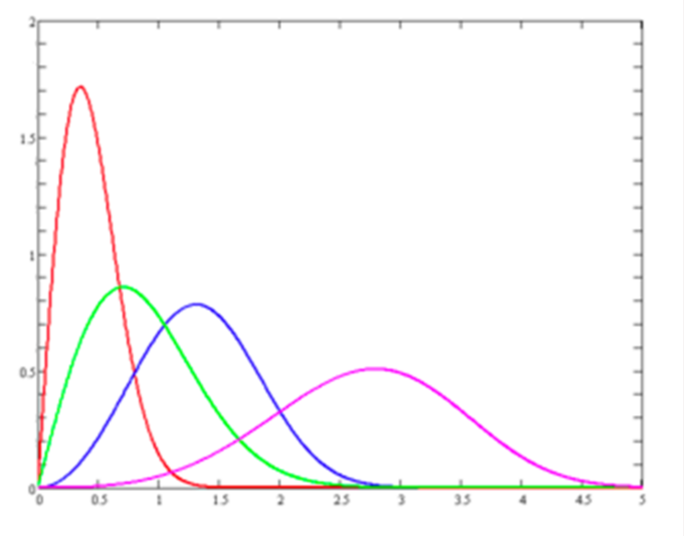
Component cost:

- Preventive maintenance:
  - Spare part cost
  - Labor cost technician
  - Production loss

- Corrective maintenance:
  - PM costs
  - + Extra driving costs
  - + Emergency shipment
  - + Possible collateral damage

Model input – lifetime distribution

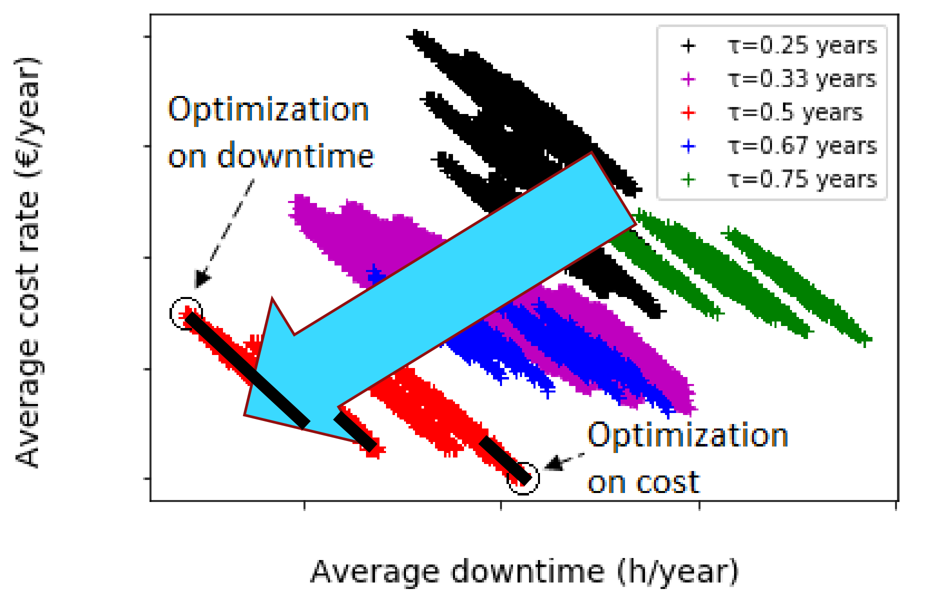
- Component lifetime distribution:
- Pool all available information:
  - Historical failure data
  - Similar components in different systems
  - Supplier recommendations
  - Test & validation phase data
  - Engineering reliability knowledge
  - Estimates experts



Lifetime (years) →

Case study results

- Each "+" represents a potential maintenance concept
- τ: Interval between two PM service visits
- Model balances PM and CM
- 6-month interval optimal
- Multiple optimal concepts > Pareto optimal

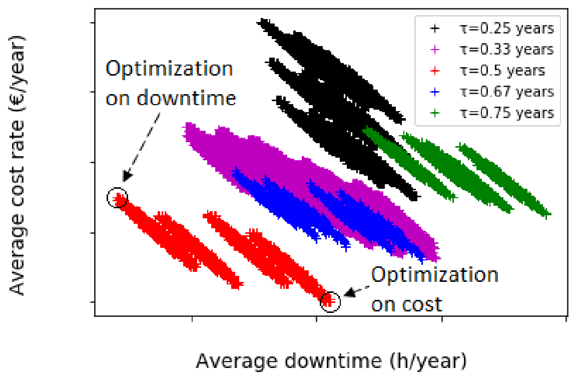


Applicability for other companies

- Decision tree can help identify component maintenance policy
- Large number of components (> 100)
- Can be extended with other single component models
- Identify and quantify conflicting objectives
- Differentiation in maintenance concepts

Summary

1. Deriving maintenance objectives
2. Technical analysis of system failure behavior
3. Selecting maintenance policy per component
4. Optimize policy
5. Select maintenance concept(s)



Thank you! Questions?