Test automation in the alpha test of wafer scanners

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Integration and testing at ASML

- Tight specification
  - Many components (1000+)
  - Multi disciplinary components
  - Incomplete designs
- Time-to-market
  - Concurrent engineering
  - Incomplete test phases
- Problem characteristics
  - Large integration and test plans
  - Much rework while testing
The impact of test automation on time-to-market

- **Assumptions**
  - Test automation reduces individual test case durations
  - Other benefits of test automation not taken into account

- **Method**
  1. Model the system under test
  2. Determine the test process configuration
  3. Select a test sequence
  4. Determine the stop criterion
  5. Simulate the test execution
  6. Analyze the results
     Time, cost and quality (remaining risk)
The system under test: an example

- Possible inputs
  - FMEA/FMECA
  - Existing test sets
  - Known faulty components
  - Requirements
  - Operational profiles

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Static analysis of the model

- Un-covered faults
- Hard to diagnose

Determine the next best test case
The test process

Possible configurations:
- Test first, fix later
- Test and fix parallel
Selecting a test sequence

- Offline sequencing techniques
  - Risk based test sequencing
  - Random test sequencing
  - Result based test sequencing
    - Takes the test results into account

- Online test sequencing
  - Exploratory testing
  - Online risk based test selection
Test stop criteria

- In real life approximated by
  - Trends of reported problems
  - Test progress
  - Intuition…

- Simulation based stop criteria
  - Test duration
  - Test cost
  - Quality of the system (remaining risk in the system)
Case: A test phase in the alpha test

- System test model:
  - Test process configuration: parallel
  - Test sequence: random
  - Test stop criterion: no remaining risk

- Simulate 2000 test executions

- Faulty systems are randomly selected using the test model

- Two experiments: with and without test automation
  - Measure: total test duration

- Development/integration
  - Alpha test
  - Beta test
  - Customer introduction

- 71 fault states
  - 54 test cases
  - Average P=25.6%
  - Average TC=2.0
Simulation results – No test automation applied

Average: 90 [h]
Min: 53 [h]
Max: 154 [h]
Simulation results – Test automation applied
Each test case is executed **100** times faster

Average: 40 [h]
Min: 6 [h]
Max: 84 [h]
Lot production case – results

The benefit of test automation for the lot production case

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<th>Total test duration relative to the initial (non-automated) case</th>
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Main bottleneck: diagnose-fix-apply fix loop
Simulation results – Faster diagnose and fix loop
No test automation

\[ t_{D+F+AF} = 1.5 \ [h] \]
\[ t_{D+F+AF} = 3 \ [h] \]
\[ t_{D+F+AF} = 6 \ [h] \]
Lot production case – results

The benefit of test automation for the lot production case

Increase in test case duration due to test automation

- $\Phi_{t(D+F+AF)=6}$
- $\Phi_{t(D+F+AF)=3}$
- $\Phi_{t(D+F+AF)=1.5}$

Lot production case – results

- $\Phi_{t(D+F+AF)=6}$
- $\Phi_{t(D+F+AF)=3}$
- $\Phi_{t(D+F+AF)=1.5}$
Conclusions

- Methods, techniques and tools for modeling, simulation and analysis of test strategies are presented.

- A case has been performed using this method.

- In this case the test duration decreased by only a factor two.

- The main reason is the duration of the *fix-loop*.

- A combination of test automation and a decreased *fix-loop* duration is most beneficial in this case.
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