REVIEWER'S OPINION OF FINAL THESIS

I. IDENTIFICATION DATA

Thesis name:	**Development of an inspection system for the fast detection of topographic defects on bipolar plates surfaces by means of laser grid projection**
Author's name:	**Sara Menetrey**
Type of thesis :	master
Faculty/Institute:	Faculty of Mechanical Engineering (FME)
Department:	Dept. of Automobiles, ICE and Rail Vehicles
Thesis reviewer:	Rico Löser, Leutrim Gjakova, Alexander Pierer.
Reviewer's department:	Fraunhofer IWU – Automation and Monitoring

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **extraordinarily challenging**

Evaluation of thesis difficulty of assignment.

- Inline quality inspection of thin bipolar plates (inspection time < 1 s per plate) is a current challenge in research
- No standardized defect catalog is available
- Local necking areas are particularly difficult to detect at a plate thickness of < 0.1 mm
- Integration of a Patent for solving the thesis' task (At the beginning of the master thesis it is not known whether the presented method is suitable for solving the task)

Satisfaction of assignment **fulfilled with minor objections**

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

- The patent was applied to the example BPP
- Suitable sensor selection was made and experimental setup was implemented
- Research of suitable methods for defect detection and their implementation
- Evaluation of the methods on the basis of different sample parts
- Suitability of the grid projection was verified and a general statement about the detectability of the minimum defect size was made

Shortcoming:
Interference factors (e.g. changing illumination conditions, position deviations, random bending) were not sufficiently considered or compensated, which means that the reproducibility of the results is sometimes not ensured.

Method of conception **outstanding**

Assess that student has chosen correct approach or solution methods.

Image acquisition and preprocessing were applied in advance (HDR, perspective correction, opening, dilation, erosion, adaptive threshold).

Four approaches were applied to the preprocessed images for problem solving. Due to limited availability of BPP samples, the tests were extended to other planar parts. This allowed a general characterization of the grid projections for topographic error detection.

Of particular note is the extension of the GLCM procedure with pattern.

Technical level **B - very good.**

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

The first two chapters provide a detailed analysis of the task and the state of the art. The overview of the technological basics of BPP and image processing algorithms is substantiated by numerous literature sources. Here the student had well-founded pre-knowledge. Especially the mathematical background of the student is to be emphasized, which became apparent in very detailed derivations of equations.

Formal and language level, scope of thesis **B - very good.**

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The thesis was written in a very good academic level. The form of the work fully complies with academic requirements.

Selection of sources, citation correctness **A - excellent.**

Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

The source selection, citation style, and separation of own thoughts and work were excellently respected.

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

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III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

In the course of her work, Ms. MENETREY developed numerous approaches of her own, which are characterized by a very high level of detail and which demonstrate her great expertise. In doing so, the approaches found are always critically reflected and checked for their plausibility. Ms. MENETREY has handled the work with great initiative and expertise to our full satisfaction. This is particularly remarkable because she has acquired a profound knowledge in the field of image processing and programming within the short time of the thesis.
In summary, the work presented by Ms. MENENTREY is exemplary in terms of both content and style and exceeds the requirements for a master's thesis. The supervisors of the Fraunhofer Institute for Machine Tools and Forming Technology propose to evaluate the master thesis with 1.7 (B - very good).

I evaluate handed thesis with classification grade **B - very good.**

Apt questions for defense:

- How are the developed methods and algorithms applicable to a high-rate inline test facility? Which steps are still necessary for this?
- What scientific conclusions can be drawn from the evaluation of laser grid projection using bipolar plates as an example?
- To what extent is the applied method suitable to detect certain defects better than conventional optical inspection methods (no use of a grid)?
- From which size are defects reliably detectable with the developed method?
- How could the method be improved so that very small defects can be detected?
- How long does the evaluation take and is it suitable for integration into high rate production lines (e.g. one plate per second)?

Date: **19.8.2022**

Signature: Rico Loeser

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Datum: 2022.08.19 16:32:01 +02'00'