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Application of World-Class Indicators in the Maintenance Management of 3D Printers in a Manufacturing Laboratory for R&D Projects

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INTRODUCTION & AIM

Additive manufacturing technologies have become essential in Research, Development and Innovation (R&D&I) environments, where 3D printers operate intensively and require high levels of reliability and availability. However, maintenance practices in academic laboratories often lack structured monitoring supported by performance indicators.

This work presents a methodology to apply World-Class Maintenance Indicators—such as MTTR, MTBF, Availability, Operational Reliability, and OEE—to evaluate and improve the maintenance performance of 3D printers in a university manufacturing laboratory.

Aim: to establish a measurable, internationally aligned maintenance management model that supports efficiency, reliability, and continuity in R&D operations.

METHOD

The study follows an **applied, mixed-method approach**, combining:

•**Qualitative data** → Semi-structured interviews with operators and technicians;

•**Quantitative data** → Operational records of failures, downtimes, and production.

Steps followed:

1. Selection of the most critical and highly used 3D printers.
2. Categorization and quantification of main failure modes.
3. Calculation of World-Class Maintenance Indicators using standard formulas (Mobley, 2002).
4. Comparison of the results with international benchmarks.

RESULTS & DISCUSSION

The indicators calculated from operational records and interviews revealed significant performance gaps:

•**MTTR = 1.8 h** → Repairs are relatively quick but still improvable.

•**MTBF = 12 h** → Indicates frequent failures, inappropriate for high-demand R&D workflows.

•**Availability = 86.96%** → Below world-class standards (≥ 90%).

•**Operational Reliability = 85%** → Reasonable but insufficient for continuous lab operation.

•**OEE = 72%** → Considerably below the world-class benchmark of 85%.

The main recurring issues identified include:

•First-layer adhesion failures due to improper leveling or temperature settings

•Z-axis miscalibration affecting dimensional accuracy

•Frequent nozzle clogging caused by filament impurities or thermal degradation

•Filament feeding interruptions due to traction issues or spool jams

These failures demonstrate dependence on corrective maintenance and lack of standardization.

CONCLUSION

The indicators revealed low availability, frequent failures, and operational inefficiencies largely associated with non-standardized corrective interventions.

The study concludes that maintaining high productivity and technological readiness in R&D environments requires:

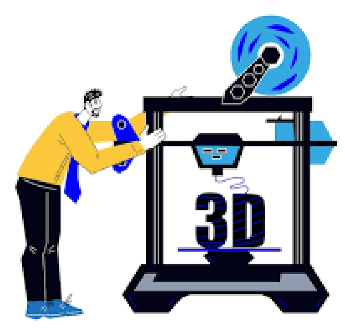
•Structured preventive maintenance,

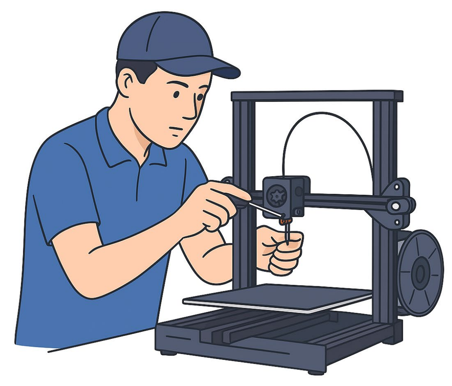
•Standardized calibration and cleaning procedures,

•Continuous operator training,

•Integration of TPM and data-driven monitoring.

By adopting these strategies, laboratories can significantly improve reliability, ensure process repeatability, and support the sustainability of technological innovation projects.





FUTURE WORK / REFERENCES

Future Work

•Implementation of predictive maintenance using sensors and condition monitoring.

•Development of a digital maintenance dashboard integrating MTBF, MTTR, and OEE.

•Expansion of the methodology to other laboratory equipment (CNCs, laser cutters).

References

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