Sustainable performance: a paradigm inducing new needs of interoperability between maintenance and scheduling activities in manufacturing

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## The main focus

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<th>Balance</th>
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| • Scheduling and Maintenance  
• Study:  
  • (i) Sustainable manufacturing scheduling  
  • (ii) Sustainable maintenance for sustainable-efficiency | • Short-term manufacturing decisions/operations  
  • (i) Energy (most important drive in short-term decision);  
  • (ii) Risk of unsustainability (manufacturing processes); | • Barriers and concerns  
• Common understanding between scheduling and maintenance functions |
Sustainable performance

• Corporate strategy directions (Krechovská and Procházková 2014):
  – Integrate sustainability into the **business process management**
    • Sustainability must become an integral part of strategic management and business planning,
  – Integrate sustainability into the **measurement and performance management**
    • Quantify the effects of sustainable activities in the financial performance and its impact on the growth of shareholder value,
  – Identify appropriate **business performance metrics**
    • Identification of social, environmental and economic indicators that influence the success of an organization.

• Sustainable performance is a long term performance hinged on three dimensions: **Triple Bottom Line** (Elkington 1998 and Asselot 2011)
5th International Workshop - Advances in Cleaner Production
Academic Work

Triple Bottom Line

SOCIO-ENVIRONMENTAL
• Health & Safety
• Legislation
• Public awareness

ENVIRONMENTAL
• Compliance
• Bio-diversity mgt
• Emissions to air
• Water/chemical usage & discharges

SOCIAL
• Diversity
• Human rights
• Equal opportunity
• Outreach programmes

ECONOMIC
• Consistent, profitable growth
• Total shareholder return
• Risk management

ECO-ECONOMY
• Resource efficiency
• Energy efficiency
• Global climate/energy issues

SOCIO-ECONOMIC
• Employment
• Training & development
• Local economies
A trade-off (balance) between effectiveness and efficiency indicators is realized; (Zhang et al., 2012)

- minimizing input means consumption while maintaining the global performance as a compromise

Effectiveness is optimized under efficiency as hard constraints; (Bruzzone et al., 2012)

- a maximum peak power value to be respected

Effectiveness is maintained as the main objective, while efficiency is optimized in a second stage (Mashaei and Lennartson, 2013);

- opportunistic energy savings are relevant to this approach.
SCHEDULING with attention paid to maintenance

- Gao et al., 2006 - proposed a hybrid genetic algorithm to schedule jobs and maintenance activities in flexible job shop aiming to minimize time-related criteria (effectiveness-oriented, no attention paid to efficiency).

- Xu et al., 2015 - proposed a single-machine scheduling problem with workload-dependent maintenance duration where the objective is to minimize total completion time (efficiency-related criteria are not considered).
Few works addressed maintenance and sustainability simultaneously
- « Scheduling plus sustainability » (no attention paid to maintenance)
- « scheduling plus maintenance » (no attention paid to sustainability)

Effectiveness-oriented objectives used to design scheduling methods are by essence conflictual with the ones from maintenance
Sustainable MAINTENANCE without attention paid to manufacturing scheduling

- Industrial Ecology
  - Maintenance activity in the perspective of the whole LCP and so rarely in short-term manufacturing decisions.

- Green Maintenance
  - Eliminate waste streams associated to maintenance
  - Integration of Product Design issues with maintenance planning and execution

- Life-Cycle Maintenance
  - Consists, for a given product, in managing maintenance and deploying in an effective way throughout its life cycle
MAINTENANCE Strategies covering:

- Short-term and sustainable decisions
- TPM
- OEE
- Social dimension
- OM
- Maintenance and Scheduling

Most adapted to Lean Manufacturing

Aim to reach a tradeoff between equip. availability & maintenance cost

- Improv. Safety (elimin. Hazardous)
- Improv. Moral (employees’ knowledge, involvement)
- Social Relations (coop. production & maintenance)

We suggest to extrapolating opportune maintenance to opportune manufacturing, considering jointly prognostics on manufacturing fluctuations and on failures of equipment to adjust joint manufacturing & maintenance scheduling.
Interoperability Concerns and Barriers between maintenance and manufacturing

• In the context of Life Cycle Engineering (LCE): one of the main problems for integrating sustainability concepts is to formalize and define these concepts based on integrated data management.

• Drawbacks of integrating maintenance into enterprise systems (ERP, MES, CMMS, SCADA, CRM, ...):
  – Enterprise architectures are based on heterogeneous subsystems and different data structures
  – Models represent complementary knowledge but express redundancy and inconsistency.

• Users of the maintenance and manufacturing systems need to have “the right information in the right format in order for the right people to do the right things at the right time”.
  – During collaboration in or across enterprises, a mutual understanding between all the maintenance support systems operated by different stakeholders is required
Interoperability Concerns and Barriers between maintenance and manufacturing

- **Interoperability** means the *ability of two or more systems or components to exchange information and to use the information that has been exchanged*

- **Interoperability** in or across *manufacturing enterprises*, has been widely accepted as one of the important *factor affecting industrial efficiency*

- Different **initiatives** have arisen in recent decades in an attempt to integrate the requirements of *maintenance function into collaborative environments*.
  - MIMOSA (Machinery Information Management Open Systems Alliance)
  - PROTEUS project from the e-maintenance concept emerged
  - PROMISE (Product Lifecycle Management and Information Tracking Using Smart Embedded Systems): features related to e-maintenance capabilities
  - DYNAMITE (Dynamic Decisions in Maintenance): distributed and remote capabilities as wireless telemetry and online instrumentation.
Many studies related to interoperability have been carried out to support the exchange, transformation, discovery, and reuse of information.

– Semantic heterogeneity is a central issue.

In order to improve semantic interoperability, maintenance support systems must evolve their knowledge management capabilities in order to facilitate understanding and knowledge sharing.

To overcome the semantic barriers in industrial maintenance, ontological approaches have become one of the most important directions in research.

– IMAMO (Industrial MAintenance Management Ontology), based on MENTHOLOGY proposes a maintenance development process (specification, conceptualization, formalization, implementation and maintenance)
Motivation and Perspectives

The divergence of concerns and languages represents a central issue around a common understanding of economic, environmental, and social performances between production and maintenance managers and systems.

Giovaninni et al. 2012
Ontology-Based System for supporting Manufacturing Sustainability
Conceptual Framework

Production

Scheduling

Onto-P

Onto-M

Onto P-M

Maintenance

Sustainable performances:
- less waste (e.g., still usable consumables),
- less conflict (e.g., uncoordinated machine loads),
- less risk (e.g., emergency decisions),
- less costs (e.g., unplanned downtimes)...

OEE

TBL

Semantic Interop.

MES

CMMS
Thank You for Your Attention!