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PROPOSING A PEFORMANCE METRIC FOR AN AGILE MANUFACTURING SYSTEM

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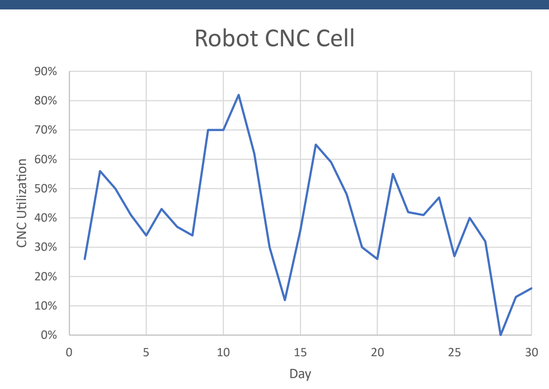
1. Introduction

For an agile manufacturing system, utilization and OEE of specific resources may not be an accurate measure for pro-duction performance as the measure does not reflect the work i.e., production preparation and changeover which is necessary to close new production orders.



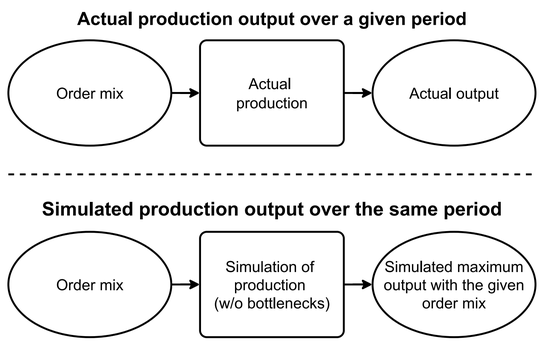
In some periods, the operators may have had the same productivity, however, this cannot be seen from the utilization of the CNC resources. Thus, upper management can have a difficult time grasping the production's productivity. Therefore, there is a need for a production metric which takes the order composition for a given period into account. Such a metric should provide a more reliable indicator of the production's performance.

2. Methodology

One important indicator of production's performance is the number of closed production orders. This number is highly affected by the order mix over a certain period. Therefore, due to the high variability in order mix, it is difficult to determine if the production's output over a given period is relatively low or high. However, if an ideal output is obtainable, then the ratio between the actual output and the ideal output can be used to predict the performance of the production's resources for a given order mix.

$$Performance = \frac{Actual\ \#\ of\ orders\ closed}{Ideal\ \#\ of\ orders\ closed} * 100$$

The ideal number of orders closed can be simulated with Discrete Event Simulation (DES). If the actual order mix and output of the production is logged for a given period, then the logged order mix can be used as input for the simulation.



Thus, if the simulation reflects the production without bottlenecks, it can simulate the maximum output for the given order mix. Once the actual output and simulated output has been achieved, these numbers can be used to compute the theoretical performance of the current system. An array of input parameters and process parameters are required to setup a DES with sufficient quality and accuracy. These parameters have been identified as the following:

Input parameters wrt. order mix:
- Order type
- Order size
- Recurring part
- Part size
- Part complexity

Process parameters wrt. production:
- CAM-programming
- Tool preparation
- Precutting of materials
- CNC setup
- CNC milling

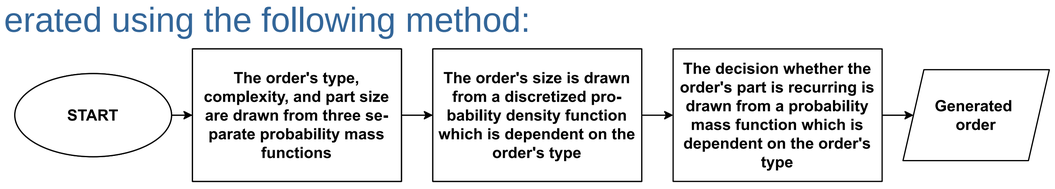
All parameters can be logged; however, part complexity has no standard definition. Therefore, a complexity value (CV) has been proposed as seen on the right.

$$CV = 1 - \frac{V_P}{V_B}$$

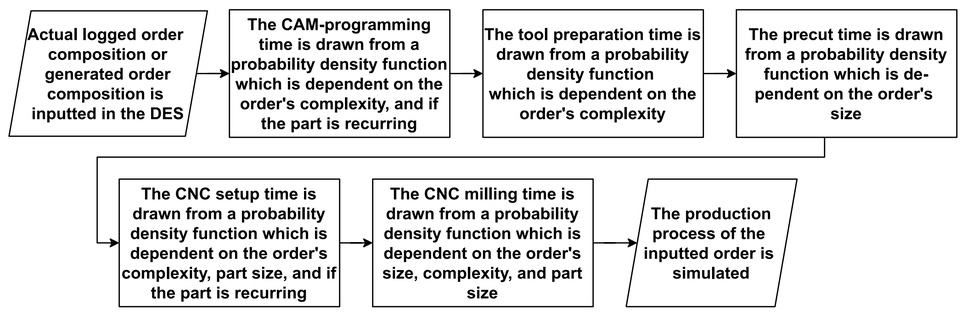
V_P = Volume of part
V_B = Volume of bounding box

3. Testing

To test if the proposed production metric is able to reliably produce a viable indicator which can be used to evaluate the production's performance, a number of scenario-based simulation were conducted. In these scenarios, input data related to order mix was generated using the following method:



The process parameters are directly affected by the currently processed order's composition. E.g., if the order's complexity level is high, then CAM, tool preparation, setup, and CNC milling is likely to require more time than orders of lower complexity. The method for generating the process parameters can be seen below:



The six scenarios presented in the table have been inputted individually into the DES for the current and ideal production.

	Planned [%]	R&D [%]	Urgent orders [%]
Senario 1:	33.33	33.33	33.33
Senario 2:	80	10	10
Senario 3:	10	80	10
Senario 4:	10	10	80
Senario 5:	45	10	45
Senario 6:	10	45	45

The results can be seen in the table below and show that the current performance is close to identical for the six scenarios. This indicates that the devised production metric can be utilized by management to estimate the performance of an agile production setup with varying order compositions. For scenario 2, the current production setup only closes 26 orders while having a CNC utilization of 29% which is contradictory as it has the lowest number of closed orders but the highest CNC utilization of all the scenarios. Therefore, the CNC utilization may provide management with an unreliable performance indicator which does not reflect the work conducted by the operators.

	AS/IS Output [order]	Ideal Output [order]	AS/IS Performance [%]	AS/IS CNC utilization [%]
Scenario 1:	31	57	54%	22%
Scenario 2:	26	47	56%	29%
Scenario 3:	31	60	52%	19%
Scenario 4:	41	76	54%	17%
Scenario 5:	32	55	58%	23%
Scenario 6:	35	66	53%	18%

4. Conclusion

A new production performance metric has been devised in this paper which can be used as an operational and development tool. The metric takes the order composition for a given period into account, and thus, it is more robust to the changes in work distribution which can be experienced in an agile production. As a result of this robustness, the metric can be used by management as a "speedometer" for evaluating the performance of the production. Further work must be conducted before the metric is ready and can be implemented.

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