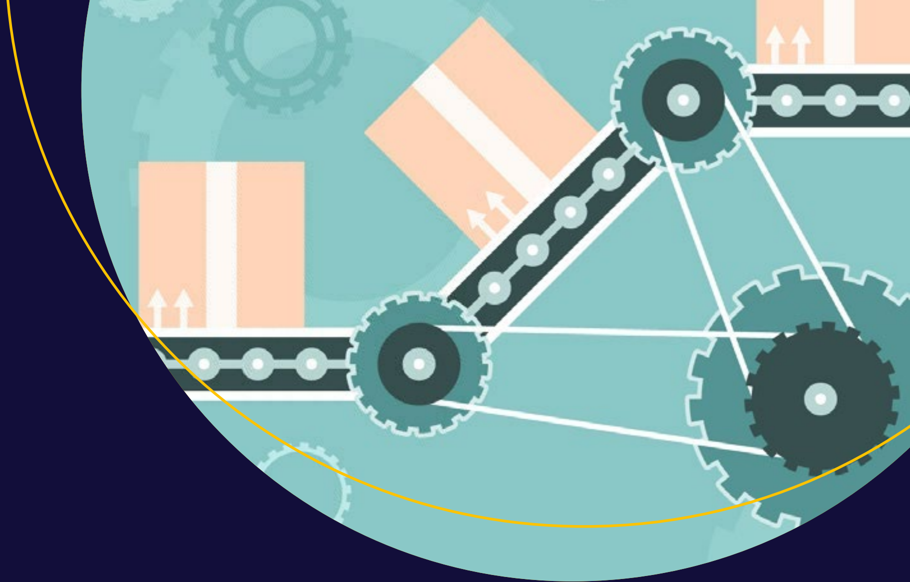

Manufacturing Performance Management using SAP OEE

Implementing and Configuring Overall Equipment Effectiveness

Dipankar Saha
Mahalakshmi Syamsunder
Sumanta Chakraborty

Apress®

Manufacturing Performance Management using SAP OEE

Implementing and Configuring Overall Equipment Effectiveness

Dipankar Saha
Mahalakshmi Syamsunder
Sumanta Chakraborty

Apress®

Manufacturing Performance Management using SAP OEE: Implementing and Configuring Overall Equipment Effectiveness

Dipankar Saha
Kolkota, West Bengal
India

Mahalakshmi Syamsunder
Bangalore, Karnataka
India

Sumanta Chakraborty
Bangalore, Karnataka
India

ISBN-13 (pbk): 978-1-4842-1151-9
ISBN-13 (electronic): 978-1-4842-1150-2
DOI 10.1007/978-1-4842-1150-2

Library of Congress Control Number: 2016940067

Managing Director: Welmoed Spahr
Acquisitions Editor: Celestin Suresh John
Development Editor: Matthew Moodie
Technical Reviewers: Suman Mukherjee, Sumanta Chakraborty

Coordinating Editor: Rita Fernando
Copy Editor: April Rondeau
Compositor: SPi Global
Indexer: SPi Global

Distributed to the book trade worldwide by Springer Science+Business Media New York, 233 Spring Street, 6th Floor, New York, NY 10013. Phone 1-800-SPRINGER, fax (201) 348-4505, e-mail orders-ny@springer-sbm.com, or visit www.springer.com. Apress Media, LLC is a California LLC and the sole member (owner) is Springer Science + Business Media Finance Inc (SSBM Finance Inc). SSBM Finance Inc is a Delaware corporation.

For information on translations, please e-mail rights@apress.com, or visit www.apress.com.

Apress and friends of ED books may be purchased in bulk for academic, corporate, or promotional use. eBook versions and licenses are also available for most titles. For more information, reference our Special Bulk Sales–eBook Licensing web page at www.apress.com/bulk-sales.

Any source code or other supplementary materials referenced by the author in this text is available to readers at www.apress.com. For detailed information about how to locate your book's source code, go to www.apress.com/source-code/.

Printed on acid-free paper

Contents at a Glance

Contents

Foreword

As Robin S. Sharma once said, "What gets measured gets improved." In the industrial space, the process of continuous improvement is founded on this concept. There are always new and challenging ways to drive improvements in processes and workflows, but understanding their priority, cost, and impact on the rest of the system isn't always easy. It comes down to tracking the resources–people and machines–that are performing the work and then managing any variations that arise from the standard process. People are needed at the operations level to deal with variations, and there's no shortage of machine tools to provide technical feedback on how well a process is running. In fact, these tools have been refined so much that one can easily apply the concepts of manufacturing-process improvement to improving things in one's own daily life.

Take the example of commuting to work in the morning rush and trying to avoid traffic. I might start the process by planning out a route via a GPS or an online maps website and noting the expected duration of the trip. Then after taking the route, I can compare the actual time to the planned time, and also the quality of my experience during the commute. From there, I may try alternate routes depending on the given time of day or things like weather, construction, annoying intersections, and so forth. This is essentially what the Overall Equipment Effectiveness (OEE) metric is measuring, but it is applied specifically to manufacturing processes. While OEE isn't a singularly perfect metric and can't be looked at in a vacuum, it does cover many scenarios, and it can be a tool that provides guidance to an overarching continuous-improvement strategy like Short Interval Control. It can be a tool with which your organization can determine where the industrial engineering budget is spent.

For those of you who have been part of the SAP MII community from the start, you know that we are continually innovating as a collective group, building off of the success of one, or many, customers and using these stories as a mechanism by which to grow new and innovative solutions. Without this kind of ecosystem and sharing of stories we would be much further behind than we are today. We owe a great deal of our success in this space to key experts in the MII field, a few of whom have authored this book–Dipankar Saha, Mahalakshmi Syamsunder, and Sumanta Chakraborty. Dipankar has a long and rich history with the MII product, having co-authored a previous book on MII, and is very active in the SAP Community Network (SCN) for MII, writing many notable and forward-looking blogs and documents on MII. Mahalakshmi is a leading expert on the SAP Manufacturing Suite and has many online documented resources and successes in the automation and performance-management arena. Last, but certainly not least, is Sumanta, whom I have had the pleasure of working with at SAP for many years now, where he is the lead Product Owner for the development of the SAP OEE solution. His cool and personable manner of working through problems behind the scenes and in front of customers has proven how valuable a resource he is to our organization, as people have been asking for an OEE solution for many years and his work has made that a reality for them.

The efforts of those mentioned, along with the efforts of the countless others who have contributed to knowledge sharing and innovation, are the lifeblood of what enables this community to thrive. I am very blessed to be part of it and am truly in awe of the work done all around the globe to further promote effective and organized manufacturing operations. I am looking forward to the next step in innovation. We have many ideas and many contributors, and this is a true testament to the power of our community and the creative thinkers who make it up.

—Salvatore (Sam) Castro
Director, LoB Manufacturing, SAP Labs, LLC
Dresher, PA, USA
February 2016

About the Authors

Dipankar Saha works for IBM India as IT Architect & Service Delivery Lead for SAP Manufacturing. He has co-authored several books on SAP MII & ME and regularly participates in different public forums, events, and seminars presenting papers on topics related to SAP manufacturing. He has worked on several SAP MII, OEE, and ME implementation projects, globally defining solution architecture and managing solution deliveries. Previously he worked for SAP Labs India and was involved in the design and development of SAP MII. Dipankar is a SAP Certified Associate Enterprise Architect. He has over fourteen years of experience in the IT industry and has a bachelor's of technology degree in chemical engineering.

Mahalakshmi Syamsunder is a manufacturing solution consultant currently working for IBM India. She has contributed to solution consulting for various manufacturing and utility clients. She also carries a deep expertise in shop-floor automation and was involved in design, development, training, and implementation of projects on SAP MII, ME, OEE, and plant automation. Mahalakshmi has a bachelor's degree in electronics and communication engineering, and a master's degree in technology management. She has five years of experience in the automation space and over seven years of experience in SAP manufacturing.

Sumanta Chakraborty is an experienced professional with over eighteen years of cross-industry experience in various roles. As a mechanical engineering graduate from NIT, Durgapur, India, he started his career in automobile manufacturing and gradually moved into the development of enterprise software products centered on manufacturing, ERP, and supply-chain management. For the past twelve-plus years Sumanta has been with SAP Labs India Bangalore, and is currently in the role of SAP OEE Product Owner, with end-to-end product-management responsibility at the global level. He works with SAP customers and partners across the globe with a team that is spread across continents. Sumanta is very well known in the SAP manufacturing ecosystem.

Acknowledgments

While I have been engrossed with the workings of manufacturing performance management using SAP OEE, I did not think it possible I would one day pen a book on the subject. The idea of writing this book for the gainful academic and pragmatic benefit of IT professionals and aspiring students of this amazing and expanding body of knowledge germinated around February 2015.

Even as the premonition of penning this book struck and convinced my imaginations, I could not have possibly conceived the book as you read it without support and inspiration from many quarters. Firstly, to my parents who from earthly origins and indefatigable zeal raised me and bestowed upon me enviable qualities of scientific inquiry and humane values. My father, P. Subramanian, and mother, S. Rajakumari, have been invaluably supportive and encouraging in their love and affection for me. I offer my infinite salutations at their lotus feet with a prayer of continuance of their infinite blessings and inexhaustible love and affection for me.

Secondly, my husband, Syamsunder, whom I exclusively adore as his abiding wife. I cannot imagine the toil of my effort bearing fruition without his unstinting support, feedback, and help on several drafts of this volume. Late nights, mornings with me not having the rise of the splendid sun for the better part of the year, and totalitarian reclusiveness from societal obligations are some among many occasions when he assumed the additional charge of our family and household. Many thanks for your understanding and encouragement through this exciting journey from the germination of an idea to a paginated book hopefully worthy of readership. Vedesh Sheetal, the apple of my eye, my son, only six years of age, broke all known conventions of hyperactivity associated with him to knowingly or otherwise offer his approval of support for this endeavor. I shall more than make up lost time and motherly affection on him after sharing this body of knowledge with you.

Lastly, I dedicate this book, my humble offering of gratitude, to my gurus in education and the industry, and to my current manager, Dipankar Saha, who had the trust in making me an author. I do wish you will benefit from the book, and I look forward to your patronage in future editions and books I plan to pen on information technology.

—Mahalakshmi Syamsunder

Product development around manufacturing and the supply chain has always been my area of expertise. But writing a book to articulate my knowledge and expertise was always a challenge and additional hard work. While taking up such a challenge, I cannot forget the two most affectionate people of my life, my parents, who have brought me up and taught me that there is no substitute for hard work. My dad, Bimal Chakraborty, and my mom, Anurupa Chakraborty, along with my brother, Subhro Chakraborty, have been the people who have made me the person who I am today. There are also three beautiful lives at home, my loving wife, Sampa, and two little daughters, Soumi and Ishani, who are always waiting for me to be with them when I'm at home. Needless to say, writing a book is always an additional effort and it takes up personal time that is usually reserved for them. I'm really grateful for their tremendous support and encouragement to finish my work on time. Last but not least, building a successful SAP OEE product that helps our customers manage manufacturing performance would have never been possible without an excellent SAP OEE development team that SAP Labs India has provided me. Finally, I'd like to thank the SAP manufacturing community of customers, consultants, and practitioners who have continuously collaborated with us to build the product and will ideally take this product forward.

—Sumanta Chakraborty

For my family and friends who have inspired me to write this book

And for the SAP community who may find this book useful

—Dipankar Saha

Writing a book is not an easy task, and behind the scenes there are always many who contribute selflessly to make the book a success. We'd like to take this opportunity to thank all those without whose help this book would not have seen the light of the day.

First of all we would like to thank Rita Fernando, Celestin Suresh, John and Matthew Moodie, our editors for this book. Rather than being just editors, they acted as our guide and mentors and immensely helped to make the content perfect, so that you, our readers, get a product of high quality.

We'd like to thank our families, without whose help and constant support this endeavor would have been just a dream. They tolerated us and provided constant support when we burned much midnight oil writing the book.

We are grateful to the SAP OEE product development team at SAP Labs India, namely Anil Kumar Tota, M Saurabh Sharma, Prayas Das, Pruthvi Kumar. L, Sandip Jha, Sulaksh Gupta, and Tarun Rawal, who helped us all through reviewing the book content despite their busy schedules and providing help and support whenever required. We'd also like to thank Nalini B A, Rajesh Kamath, Sailaja Vadlamudi, Sandhya Srinivas, Shalini Kohli, Shilpa Maniyar, Sriram Kannan, and Yamini Priya Bhavirishetty from SAP Labs and Suman Mukherjee, who have provided their support in reviewing the content at different points in time.

We'd like to thank Kalpati Srinivas, Sudipta Mukherjee, Chandan Jash, Swapna Mukherjee, Moumita De, Pallavi Shah, Sudipta Chakraborty, and Laboni Bhowmik of IBM, who have enriched the content at every step. Despite being our friends and colleagues, they did not for a moment hesitate to constructively criticize the content when required and also helped us with facts, figures, and other technical suggestions that ensure a much more fulfilling experience for you, the reader.

We'd also like to thank G Venkatraghavan, Somnath Dey, Subhabrata Ganguly, Anup K Ghosh, Sauti Sen, and Asidhara Lahiri of the IBM leadership team and Juergen Weiner, Veronika Schmid-Lutz, Dharmendra Kumar, Rajeev Kansal and Chethak T K from SAP leadership team, without whose encouragement and support the process of writing this book would not have been as smooth as it was.

Last but not least, we'd like to thank the SAP Community Network, without which we would not been able to collaborate and learn so much, and where we always find help whenever required from the community of developers, users, and experts. We owe you.

Dipankar Saha
Mahalakshmi Syamsunder
Sumanta Chakraborty
Kolkata & Bangalore, India
February 2016

Introduction

SAP Overall Equipment Effectiveness (OEE) is a manufacturing performance-management solution from SAP used for managing and measuring execution and performance in manufacturing industries. This book is intended to provide a thorough guide for using and customizing SAP OEE. It is the product of many months of effort, and we bring together our knowledge and expertise in this topic with the lessons we have learned through several SAP OEE implementations. We sincerely hope that, as the first book on the topic, this will be a useful resource for all those who intend to use and implement SAP OEE.

Target Audience

This book is intended for consultants, developers, and users implementing and using SAP OEE.

Structure of this Book

This book is organized into nine chapters as follows:

Chapter 1 explains manufacturing performance management and how different KPIs are used to measure it. It also explains the OEE standard and its calculation, as well as the importance of enterprise to manufacturing execution systems' integration for data collection and analysis.

Chapter 2 explains the OEE solution as delivered on the SAP MII platform along with its architecture and different components of the solution. In addition it covers the overall usage and benefits of the solution.

Chapter 3 explains the add-on component for SAP OEE available in SAP ERP and how to configure the master data, configuration data, and transactional data required for SAP OEE. It also reviews the configurations required in SAP ERP to transfer the data to SAP MII for setting up OEE.

Chapter 4 explains the OEEINT component available in SAP MII to transfer OEE messages bi-directionally, how to do the basic configurations in MII for OEE, and how to transfer the different messages from SAP ERP to MII for OEE and then how to monitor them in MII.

Chapter 5 explains the configurations required in SAP MII for OEE along with the user roles, configuration wizards for OEE, and different worker UI configurations in MII for setting up OEE dashboard and OEE configurations transport.

Chapter 6 explains how to configure, set up, and use OEE dashboards or worker UI. It explains the different types of standard dashboards available in SAP OEE and how to report downtimes and various other operational data required for OEE calculations. It also explains the standard data flows in SAP OEE, with the database tables involved in the transactions. It also covers the OEE KPI calculation logic and the mechanism by which to trigger the order confirmations and goods movement from SAP OEE to ERP and replicate the data to SAP HANA for analytics.

Chapter 7 explains the different customization and enhancement options available in SAP OEE along with the OEE data model, customizing OEEINT workflows, and OEE analytics on SAP MII. It also explains different scenarios for enhancements on SAP OEE and different industry-specific use case scenarios.

Chapter 8 explains the new features available in SAP MII 15.1, such as the Goods Movement application, Plant Maintenance notification creation, alerts in OEE dashboard, data collection at machine level, upload reason code, and downtime data; it also explains the goods-movement reporting process in SAP OEE.

Chapter 9 explains the different analytics options available in SAP OEE and how to use them. It explains the local plant-level analytics development, consuming local SAP MII data through SAP Lumira, as well as global consolidated reporting at the corporate level using SAP HANA by replicating the data from SAP MII. It explains the different standard reports available in SAP HANA for OEE.

The appendix explains in detail the different configurations and their purpose specific to each worker UI in OEE.

The glossary details the different technical terms and their description as used in all the chapters.

CHAPTER 1

Manufacturing Performance Management: An Overview

This chapter will explain manufacturing performance management and how it is used to measure and monitor the performance of assets and processes involved in manufacturing execution. It will also look at how industry would be affected without the measuring process in place. In addition, it will explain how to optimize manufacturing performance by defining and measuring the metrics.

Manufacturing companies, like any other business in today's world, face tremendous pressure to optimize operational costs, increase resource utilization, and improve product quality. With competitive markets and globalization, common factors for almost every industry, optimizing and improving processes and costs is the only way to survive. To enable optimization and improvement of quality, the first step is to measure the operational parameters so that suitable actions can be taken to quickly improve them.

Manufacturing performance management is the method by which the operational performance of manufacturing execution–such as resource utilization and availability, rate of production, and first-pass quality of the produced product–can be measured and analyzed to understand the gaps and scope of improvements. Without having a manufacturing performance-management practice in place it is almost impossible for a manufacturing business to survive, as the planners and decision makers cannot understand the scope of needed improvements and opportunities for optimization.

Measuring performance needs to ensure the collection of operational and planning data from different heterogeneous sources and then must analyze them to understand the impact. First of all, it requires a solution via which the data from various sources can be accumulated in a single place by integrating with different types of systems and applications that generate the data at various granularity levels. The planning data are typically available in the ERP system at the corporate domain, whereas most of the operational data are available at the plant sites in manufacturing execution systems, with the plant historian, in legacy databases and applications, or manually collected on paper. Once the data are accumulated from different data sources, it needs to be aggregated and analyzed to generate meaningful metrics from it.

Therefore, to implement manufacturing performance management, a solution is required that can enable the collection, aggregation, and analysis of manufacturing planning and operational data as well as provide meaningful insight so as to optimize manufacturing operations.

Need for KPIs to Optimize Manufacturing Performance

This section will explain the need for key performance indicators (KPIs) to measure, monitor, and analyze manufacturing and production performance, along with how to benchmark the process performance using KPIs. We will also look at how OEE and other KPIs help in capturing production losses and achieving optimal production performance.

D. Saha et al., *Manufacturing Performance Management using SAP OEE*,
DOI 10.1007/978-1-4842-1150-2_1

Any growing or established business needs to be closely and carefully managed to ensure the success of new investment decisions and expansion plans, and to sustain their success and their competitive advantage. KPIs are at the heart of any system of performance measurement and target setting. When properly used, they are one of the most powerful management tools available to a business. KPIs provide a definitive measure for production and resources performance.

Let's take an example of a consumer products manufacturing company where food products are manufactured and packaged in semi-automated production lines. There are machines in the production line, such as a filler or a palletizer, that are bottleneck machines–i.e., they are critical and mandatory work centers in the processing flow path. They have a limited capacity, which affects the capacity of the overall production line. The downtimes for the bottleneck machines cause production delays. The planners and other stakeholders want to know the availability of the machines compared to their planned availability. The availability of the machines varies over time due to different factors, such as mechanical faults, unavailability of raw materials, human errors, and breaks, which need to be captured with corresponding reason codes.

Also, there are other metrics that the plant management and planner need to monitor–such as the material yield for orders, shifts and production lines, quality (acceptable/good quality yield versus planned yield), and rate of production–that help in understanding the bottlenecks and scope of optimization and improvements. KPIs are measurable quantities on the time scale, as well as on other dimensions. For example, the machine availability KPI can be based on the time when the machine is available, calculated for each hour, each eight hours (a shift), or each day, factoring in its downtime and planned availability. The KPI can also be measured for each product being produced on it or each operator who operates it. In this example, apart from the time dimensions, other dimensions for the availability KPI are product and operator, as KPI may vary for different products and operators for various reasons. In addition, each KPI has a target value, which is the threshold limit for the measure of the specific KPI. The KPIs can be positive, negative, or bi-directional depending on whether the KPI measure value tends to exceed the target (positive) or to come in below the target (negative). When it is bi-directional it can exceed or be below the target value depending on certain conditions. For example, power consumption can be bi-directional KPI, whereas the availability and efficiency of a machine are positive KPI; machine downtime and safety incidents are examples of negative KPI.

To measure the performance of manufacturing process and resources it is necessary to define the KPIs and measure them continuously to ensure the process is stable and optimized. KPIs are defined as quantifiable factors that are clearly linked to the drivers of business success. For any manufacturing company, certain KPIs are defined with specific targets that need to be achieved or exceeded (or to not be exceeded) based on their type. The KPIs used in manufacturing industries vary depending on the industry type and manufacturing process.

Some of the common KPIs used by manufacturers, broken down by business goals, are as follows:

- Improve Quality

  Yield Count (Good or Bad) relates to the measure of the total number of units of product produced in a production line for a production run, shift, or day. It provides a basic indicator of the production personnel and/or the machine efficiency, as well as whether the organization targets for production efficiency are being met.

  Rejection Ratio measures the scrap quantity versus the total quantity of units produced in a production line for a certain timeframe. It indicates the quality of the production process; a lower value is better for maximizing profit.

  Production Rate provides the speed at which the product is produced, i.e., total quantity produced in a given timeframe. The speed of machines varies, and it is important to maintain the optimized rate, as a too-high rate may affect quality and a too-slow rate may affect profitability.

- Reduce Inventory

  WIP Inventory/Turns is a commonly used ratio calculation to measure the efficient use of inventory materials. It is calculated by dividing the cost of goods sold by the average inventory used to produce those goods.

- Reduce Machine Downtime

  Machine Downtime refers to the time during which a machine or production line is not available for operation. It can be either the result of a breakdown or simply a machine changeover, and is considered one of the most important KPI metrics to track in manufacturing industries. Machine unavailability or non-operation time affects the productivity and profitability of the organization. Tracking downtime typically requires assigning a "reason code" to the event, so that the most pertinent ones can be tracked.

- Improve Efficiency

  Overall Equipment Effectiveness (OEE) is a multi-dimensional metric that provides an overall measure of the effectiveness and utilization of a machine or production line; this is determined by multiplying availability by performance and quality. This is one of the most important KPIs for any manufacturing company. Production managers always want OEE values to increase, because this indicates more efficient utilization of available personnel and machinery.

  Takt Time measures the amount of time, or cycle time, for the completion of a specific task. This could be the time it takes to produce a product, but it more likely relates to the cycle time of specific operations. This helps to determine where the constraints or bottlenecks are within a process.

  Time to Make Changeovers measures the speed or time it takes to switch a manufacturing line from making one product over to making a different product.

There are many other KPIs being used by different industries based on their manufacturing processes. Also, most KPI targets or desired ranges are benchmarked for specific industries and processes, which the manufacturers tend to follow. As there are multiple factors to be managed in the manufacturing process, it is essential to measure them as KPIs to ensure the performance is always on track.

Benchmarking and Target Setting

Benchmarking is a valuable way of improving and understanding business performance and potential. Benchmarking can be done by making comparisons with other businesses or internally within the business. A key driver of any business is the focus area of benchmarking.

For example, a manufacturing company can set its KPI targets (Quality, Customer Satisfaction, and so on) as a benchmark based on its counterpart running a similar successful business.

Comparing absenteeism rates or operator efficiency between similar departments may enable the business to spread good working practices from the best performing areas of your business to lower performing areas.

Target setting involves setting performance targets in the key areas that drive the business performance. Performance targets are a powerful management tool that can help deliver the kind of strategic changes that many growing businesses need to make. The top-level objectives of a strategic plan can be implemented through departmental goals, and setting targets based on KPIs is an ideal way of doing this.

KPI Targets should be specific, measurable, achievable, realistic, and time-bound.

KPIs provide a measure of productivity as well as of the losses, depending on their definition. It is critical for manufacturing businesses to keep track of losses such as time loss, material loss, productivity loss, and so forth, which provides important information on how to optimize the production process.

To summarize, it is important to define KPIs, set targets based on the manufacturing process, and continuously measure and track them so as to understand bottlenecks and how to increase efficiency, which in turn helps in increasing the profitability of the business.

OEE Standard and Its Calculations

This section will explain the definition of OEE, different types of losses, methods of loss capture, calculation of factors associated with OEE calculation that are followed as a standard approach, and benefits of OEE.

Any manufacturing process involves throughput from machines, and different types of losses are encountered in the production process. The losses are due to the unreliability of the machines and the operators as well as to other external factors, such as material or operational issues. To determine the production process' efficiency, it is important to understand and track the losses occurring. The losses in can be of broadly three types:

- Availability loss
    - Time loss for availability of resources or machines due to breakdowns or scheduled and unscheduled breaks
    - Loss due to setup, changeover process, material and labor shortages, etc.
- Speed loss
    - Loss in production due to reduced speed or increased cycle time due to machine, material, or human issues
    - Loss due to idling and minor stops that are not part of regular maintenance
- Quality loss
    - Material loss due to quality issues like rejects during startup, improper setup, etc.

To measure and track these, a KPI is required through which all the possible losses can be measured. Overall Equipment Effectiveness (OEE) is one such KPI that can be used to measure and track performance efficiency by capturing the losses. OEE is an essential metric and basic methodology for manufacturers pursuing a "lean" manufacturing strategy–that is "zero waste" in their "value streams."

For many manufacturing companies OEE is becoming a very important and mandatory KPI with which to measure and track. OEE is defined as the effectiveness of a machine or production line that is used for the manufacturing process; it uses the following formula: `Availability x Performance x Quality`

Where:

- Availability (of machine) = net operating time/total planned operating time
    - Net operating time = total operating time - downtimes
    - Total operating time is the shift duration based on the factory calendar
- Performance = actual rate of production/planned rate of production
    - Actual rate of production = cycle time = total quantity produced/total time taken
    - Planned rate of production = Nominal or Rated speed of production.
      E.g., 100kg/min or 1000 pieces/hr.

- Quality = units of good quality produced/total units produced
    - Units of good quality = total units of produced – total units of rejected

As is evident from the above formulas, OEE targets three distinct points of loss that can be potential areas of improvement for the manufacturing process. To measure and calculate OEE KPI, you must capture certain information from the production process. This information can be collected directly from the manufacturing automation system, if available, or can be manually collected as well. The typical data that needs to be collected are as follows:

- Downtimes for the resource/production line, with reason code; i.e., start and end time of the machine downtimes, from which the downtime duration can be calculated
- Total yield of the machine/production line in a specific time window; e.g., shift or hour
- Total yield quantity not conforming to first-pass quality. This includes scrap and waste as well as reworked material quantity that does not pass the quality tests the first time

The preceding parameters need to be captured continuously, and with that information the OEE KPI can be calculated periodically for specific time periods, which provides an indication of the losses and the effectiveness of the manufacturing process. Typically, for most of the manufacturing industries, 85 percent OEE is considered a benchmark for a minimum target.

Once the OEE KPIs are calculated and analyzed, they can be drilled down to find out the root cause of a low OEE value and to understand the actual points where the losses are occurring, which can then possibly be optimized. OEE is measured for resource or machines used in the manufacturing execution process, usually the bottleneck ones that control the throughput of the process. Typically in a filling and packing line, the filler machine is considered the bottleneck in some cases, and so it may be the most critical resource for that production line.

To measure and calculate the OEE, it is necessary to continuously collect the downtimes, material loss, and rate of production for that resource. The data can be collected automatically, if it is an automated production line with a Plant Historian system or Manufacturing Execution system capturing the pertinent information. This is done via sensors connected to the machines. Otherwise, the production operator must capture the operational data manually for each production run or shift–for example, how long the machine was idle or down, quantity of material produced, and scrapped or reworked material, as well as the rate of production–based on which the OEE KPI can be calculated.

The machine downtimes measured in OEE are of various types, as shown in Figure 1-1. The plant operating time is based on the factory calendar, which is the total time the factory operations are running. This calendar accounts for planned downtime for scheduled maintenance, scheduled breaks, and idle time due to lack of production plan. The rest of the time is considered as the planned production time based on the production plan. The planned production time versus the planned downtime and idle time measures the utilization of the machine, i.e., how much the resource is used for production.

Regarding the planned production time, the major loss happens due to unplanned breakdowns and downtimes of the machines, which when deducted from the planned production time provides the machine's productive time, or total operating time. This measures the availability of the resource.

There may be some delays or an inconsistent speed of production due to machine or human factors, which result in speed loss and a reduction in the machine's productive time; this gives a measure of the performance of the resource.

Finally, out of the net operating time, some of the yield may be scrap, waste, or rework, and the time used for producing good quality product is considered to be the fully productive time. This provides the measure of the quality KPI of the resource.

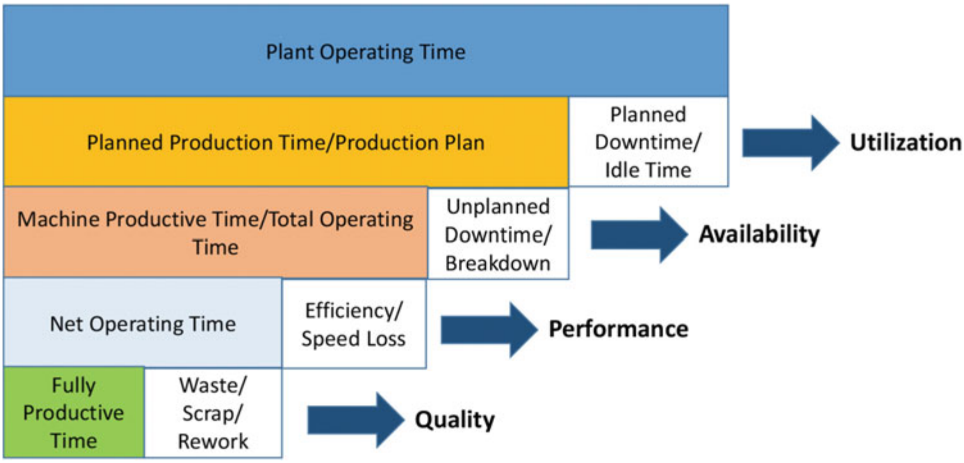

Figure 1-1. *Production losses and KPIs for OEE*

Losses that are otherwise not easily visible and accountable can be highlighted by measuring OEE. Figure 1-2 explains a sample OEE calculation for a resource based on the production data in a shift.

Production Data						
Shift Length	8	Hours =	480	Minutes		
Short Breaks	2	Breaks @	15	Minutes Each =	30	Minutes Total
Meal Break	1	Breaks @	30	Minutes Each =	30	Minutes Total
Down Time	47	Minutes				
Ideal Run Rate	60	PPM (Pieces Per Minute)				
Total Pieces	19,271	Pieces				
Reject Pieces	423	Pieces				
Support Variable	**Calculation**				**Result**	
Planned Production Time	Shift Length - Breaks				420	Minutes
Operating Time	Planned Production Time - Down Time				373	Minutes
Good Pieces	Total Pieces - Reject Pieces				18,848	Pieces
OEE Factor	**Calculation**				**My OEE%**	
Availability	Operating Time / Planned Production Time				**88.81%**	
Performance	(Total Pieces / Operation Time) / Ideal Run Rate				**86.11%**	
Quality	Good Pieces / Total Pieces				**97.80%**	
Overall OEE	Availability x Performance x Quality				**74.79%**	
OEE Factor	**World Class**	**My OEE%**				
Availability	90.00%	**88.81%**				
Performance	95.00%	**86.11%**				
Quality	99.90%	**97.80%**				
Overall OEE	85.00%	**74.79%**				

Figure 1-2. *Sample OEE calculation based on production data*

By analyzing the OEE KPI, the following benefits can be achieved in the production process:

Efficient and effective usage of existing equipment and facilities by

- reducing planned downtimes due to scheduled maintenance, breaks, material shortages, and so on, thus increasing the machine utilization; and by
- minimizing machine breakdowns and unplanned downtimes to increase availability.

Real-time visibility on the shop floor production, which aids in

- eliminating the factors for speed or production-rate loss– i.e., minor stops and misfeeds–that do not require maintenance, thus increasing performance;
- understanding the factors for quality loss so as to minimize the scrap, waste, and rework quantities;
- quantifying plant/line/machine performance; and
- analyzing recurring production losses and their sources, and coming up with ways to improve.

OEE acts as a stepping stone for the manufacturer to achieve world class production. It enables the manufacturer to realize financial benefits in terms of reduced downtime costs, repair costs, and quality costs and increased labor efficiency and productivity, which ultimately leads to increased production capability.

To summarize, OEE KPI provides a clear and useful measure of the performance and effectiveness of the manufacturing process and resources and provides a mechanism by which the process can be optimized. It does this by helping the manufacturer understand the main points of loss so they can take action to reduce them.

The Need for an Effective Operator Interface for Data Collection

This section will explain how important it is to have an effective operator interface in place before introducing a performance-management system on the manufacturing shop floor. It will explain the different aspects of an effective shop floor operator interface.

Any shop floor performance-improvement program needs some amount of data to be collected via manual interaction. Hence it is important to involve the shop floor operators and provide them with a user interface that they can use effectively. The basic purpose of an operator on the shop floor is to produce, to make. His primary duty is to operate the machines and to take care of them so that they do not break down. If a breakdown happens, his job is to get it running again or to initiate maintenance to repair it. Any other documentation task or data entry on a computer is seen as a secondary activity for him. Hence, an operator interface that needs to be used by the shop floor as part of the manufacturing performance-management solution needs to have features such as the following:

- The operator interface should add value, not another burden, to the operator in his daily work schedule. This should be the highest priority of the new user interface. His job should become easier than what it was in the absence of the new operator interface. Otherwise, it will be looked upon as another burden he needs to fulfil before the end of every shift. The user interface should reduce his workload, reduce complexities, and improve his efficiencies.

- The user interface should be designed for the operator. In the IT industry, while developing a user interface, we often miss the exact personas (the person who will be the actual user) and deliver something that is for a mix of personas. Drawing clear boundaries between what is an operator's interface and what is a supervisor's or manager's interface will greatly improve the acceptance of the user interface. Too much or too little information on the screen or too many clicks to navigate will be viewed as negative factors.
- A smart design of the operator interface will give him a seamless experience, much like his smart devices at home. In today's world, the probability is very high that the operator uses a smart device at home. Nowadays, like most of us, a significant part of an operator's daily life is centered around personal smart devices. This is changing our expectation and interaction pattern with any user interface today. Hence, a user interface should have an interaction pattern that is simple and intuitive, and should provide an experience as smooth and obvious as the operator is used to with his smart devices. This will increase the acceptance of the system to a great extent.

Shop-Floor to Top-Floor Integration

This section will explain the need for shop-floor to top-floor integration for manufacturing performance management. It will also provide an introduction to SAP MII and how MII as a framework ensures the shop-floor to top-floor integration.

To calculate and measure the OEE KPI, data must be collected about the various losses, such as machine downtimes, material wastage and scrap, production speed loss, and so on; this must be done continuously during the production runs. The data required for OEE calculations are available from different sources and measuring points, which can be either automatically available in some systems, or collected manually. The systems from which the manufacturing operational data can be collected are Plant Historian, SCADA or DCS, MES, or legacy database; these systems capture the process parameter data from various equipments and data-collection points in the production lines. Most of operational systems mentioned store the process data as time-series data–i.e., data-point value with the corresponding timestamp–and may provide OPC (OLE for Process Control) or other proprietary connectors through which the process parameter data need to be queried and aggregated in order to calculate the KPIs. The operational systems at the shop floor provide the real-time process data, but the planning data against which the actuals need to be compared reside in the enterprise planning and logistics systems, such as ERP.

It is also required to provide the transactional user interfaces through which the shop-floor users can manually capture data such as machine downtime, yield, scrap, and so on, as well as assign reason codes when the data are collected automatically.

Once the data are collected and the KPIs are calculated, one needs a dashboard with reports and analytics through which the OEE and other KPIs can be monitored and analyzed.

It is a common problem for the manufacturers who have multiple real-time and planning systems to aggregate and analyze the data centrally in near real-time mode. Without a system that can do that, the manufacturing shop-floor users lack the visibility and understanding of the actual situation on the shop floor and don't know how to optimize the process by minimizing the losses.

To address these challenges, a platform is required that can easily integrate with different types of operational systems on the manufacturing shop floor, as well as with the planning system at the enterprise level, and that can aggregate the data by user-defined logic to derive meaningful KPIs and then provide a visualization platform through which the KPIs and the information can be monitored and analyzed.

SAP Manufacturing Integration & Intelligence (SAP MII) is such a platform and is provided by SAP as part of its SAP Manufacturing portfolio of products, which aim to address the previously mentioned challenges. It is a stand-alone, web-based solution that runs on SAP NetWeaver Java WebAS. As its name makes clear, SAP MII provides two basic functionalities:

- Integration with different applications in enterprise and manufacturing plants
- Intelligence on process information via reports, analytics, KPIs, alerts, and so on

For the integration functionality, SAP MII provides different types of connectors and interfacing mechanisms to exchange messages bi-directionally from SAP ERP, MES, Plant Historian, SCADA, and other legacy applications using different technical protocols as required. It provides Message Services to receive messages from any external system–such as ERP and MES–and SAP JCo and JRA interfaces to execute RFC (Remote Functional Call) and BAPI (Business API) in the SAP ERP system. Using SAP Plant Connectivity (PCo), which is an add-on component with SAP MII, SAP MII provides near real-time connectivity to almost all types of shop-floor automation control systems via various protocols, such as OPC (OLE for Process Control), ODBC (Open Database Connectivity), and OLEDB (OLE Database Connectivity), as well as proprietary protocols for specific SCADA and Plant Historian systems, such as Citect, OSISoft PI, iHistorian, and so on. It also provides Web Service–, JDBC-, FTP-, and HTTP-based integration capabilities with external systems through its business-logic services.

The intelligence is provided via custom reports, analytics, and dashboards, which are developed using the visualization service and the business-logic engine, where custom business logic for data processing can be developed as required based on the data collected from different systems.

Additionally, SAP MII provides a framework to map process data points as tags, which are available in the Plant Historian and SCADA systems using the Plant Catalog Services (PIC), to persist data as required using manufacturing data objects (MDO), and to define KPIs and alerts using KPI and Alert frameworks. It provides Business Logic Services (BLS), using which any type of custom business logic can be developed by graphical modelling. SAP MII also provides a component as an adaptor framework called SAP Plant Connectivity (PCo), which is used to connect to SCADA, Plant Data Historian, and other real-time systems via OPC and various other protocols, both by ad-hoc query and real-time notifications of a change of values in the source system.

Being a custom development and composition platform, any type of integration, analytics or monitoring, and transactional application can be developed on SAP MII. It can be used to collect the data from the manufacturing operations systems in near real-time, as well as provide transaction user interfaces with which to collect the data manually and develop business logic to aggregate and process the data so as to derive certain KPIs.

A SAP MII solution overview is shown in Figure 1-3.

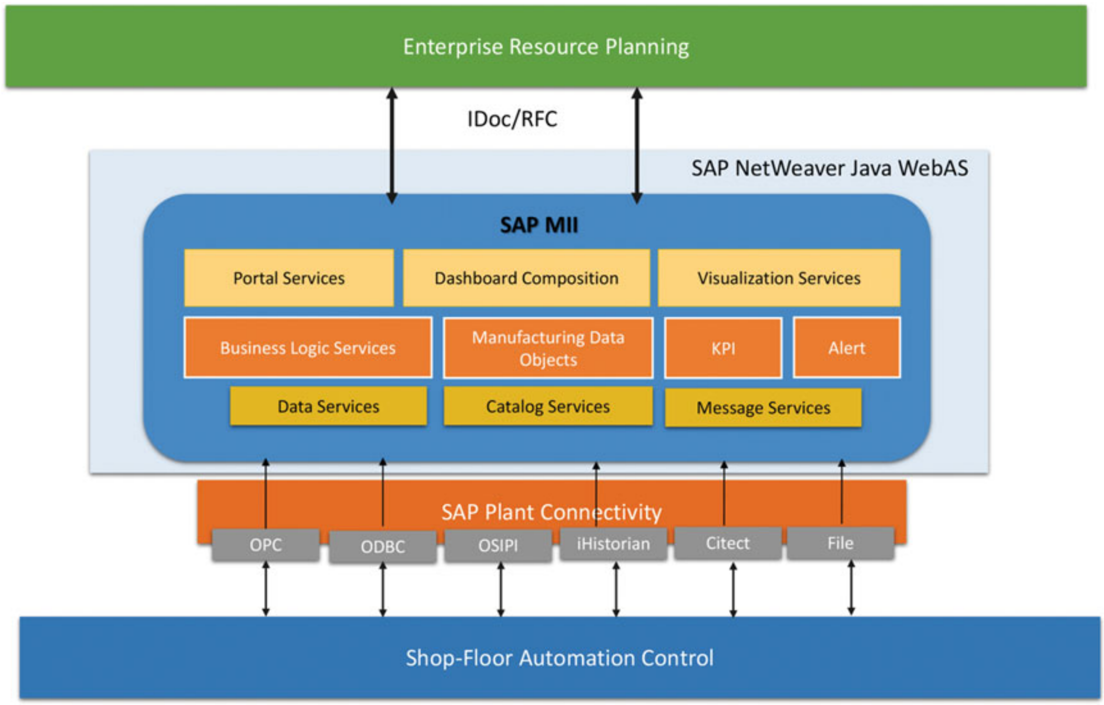

Figure 1-3. *SAP MII overview*

Thus, SAP MII provides a powerful platform on which to develop manufacturing KPI management solutions by collecting data from various sources, persisting and aggregating them by specific business logic, and providing analytics with which to monitor and analyze the KPIs and data in real-time.

Summary

In this chapter, you have learned why measuring and monitoring KPIs is critical to the success of any manufacturing company, and how SAP MII can be used as a platform to develop KPI management solutions for manufacturing operations.

In the next chapter, you will learn about the SAP OEE solution on MII and how it can help in manufacturing performance management.

CHAPTER 2

SAP OEE: A New Product for Manufacturing Performance Management

This chapter will explain how SAP OEE is developed on the MII platform and how MII is used as an integration component (OEEINT) between ECC and OEE. It will also describes various features and components of SAP OEE.

As we learned in the previous chapter, Overall Equipment Effectiveness (OEE) is an important KPI that is critical for any manufacturing business to measure so as to understand the losses and points of optimization. With this information, they can make their products more cost effective and increase profitability. Three types of KPIs need to be measured in order to measure OEE:

- performance or speed of the process
- availability of the machines
- quality of the product

To measure these elements, the data for operational parameters such as yield quantity, scrap quantity, cycle time, machine downtimes, and so on need to be collected in real-time. Once collected, it needs to be stored and aggregated, at which point the OEE KPI can be calculated and analyzed.

SAP OEE on MII platform

SAP OEE is a solution developed by SAP to address these requirements and is to be used on the manufacturing shop floor to view and collect data during manufacturing execution, and ultimately it will analyze the OEE and different production KPIs related to OEE. The solution is based on three different platforms or products–SAP ERP, SAP MII, and SAP HANA.

- SAP ERP is used to define the master and planning data, such as the material master, work center master, plant hierarchy, reason codes for deviations, data-collection elements, and production or process orders.
- SAP MII is used to provide the plant-operator dashboards through which the production operators can view and record operational details.
- Finally, SAP HANA, which is SAP's in-memory database and platform for high-volume data analysis, is used to calculate and analyze the OEE and related KPIs.

D. Saha et al., *Manufacturing Performance Management using SAP OEE*,
DOI 10.1007/978-1-4842-1150-2_2