CHAPTER 5

SAP MII Implementation in Process Manufacturing

This chapter provides an overview of process manufacturing and the industries that fall under this kind of manufacturing. It also explains how SAP MII and its related modules can be used to provide solutions to those industries.

Process Manufacturing

Process manufacturing is slightly more complex than discrete manufacturing. It involves the conversion or transformation of raw materials to produce the final product. It is not possible to separate the materials involved into different processes, in order to arrive at the original raw materials. This process depends on several key factors like the proportion of raw materials (percentage), the base preparation time (blending, mixing, cooking, etc.), mold or container handling, bottling or filling management, packaging or sealing management, quality and waste management, and warehouse management. As the base material preparation is done by blending, mixing, purifying, and cooking, or other relevant methods, the measurements and the percentage of raw materials are maintained in the planning systems and depend on the batch size, which is termed as the control recipe. The control recipe and the corresponding formulas are maintained in the planning process. In this industry, manufacturing is done based on market research, without any "customer demand". After the product is manufactured and released into the market, a market survey is conducted and, based on the survey, the product is again enhanced and released to the market. This is the main difference between the process and discrete industries. Process manufacturing is common in the pharmaceutical, consumer packaged goods, and oil and gas manufacturing industries.

Oil and Gas Manufacturing

From the time when the humans learned to use the machines and motors to ease their daily lives, the concept of fuel was introduced. Fuel was required to run the motors and machines. Initially, machines ran on steam, but to produce that steam, either coal or oil was burned. Oil was used indirectly to produce the steam. After the invention of the

S. Mukherjee and S. Mukherjee (Das), *SAP MII*, DOI 10.1007/978-1-4842-2814-2_5

combustion mechanism, steam engines were replaced and these new machineries could run directly on oils. With the innovations in engines, machines, and automation, oil and its biproducts are one of the mandatory requirements for modern civilization.

Petrol, diesel, and kerosene are the three main products used for modern transportation and utilities. Natural gas is one of the essential products for daily life as well as for industrial use. Other products like lubricants, chemical additives, glycerin, and other cosmetic products are also derived from such oils. All these products are sub-products of crude oil, which is drilled from the earth.

Crude oil cannot be used directly because of its various contaminants. The oil and gas industries follow various processes to clean the crude oil so it's usable.

Generally, the following two processes are used to extract and process crude oil (see Figure 5-1):

- Oil upstream
- Oil downstream

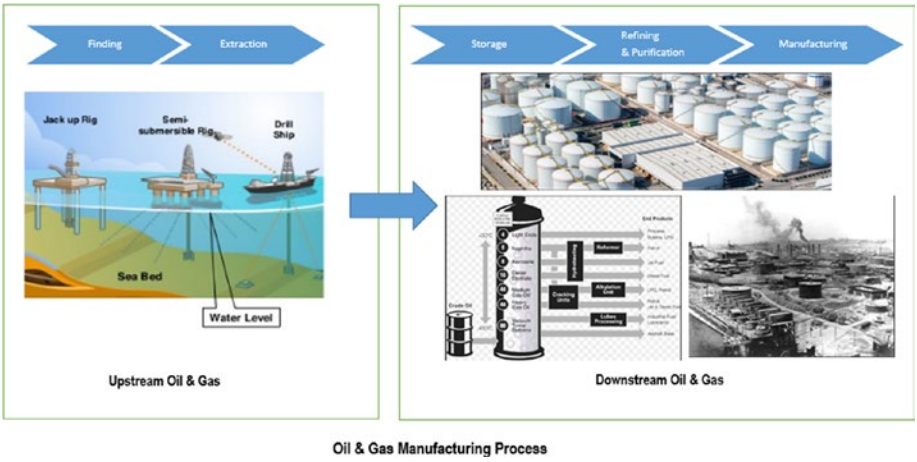

Figure 5-1. *Oil and gas manufacturing process*

Oil Upstream

The term *oil upstream* is mainly related to extracting crude oil from under the earth. In this process, the focus is to find the crude oil and extract it; it does not involve the purification process. The different extraction steps or processes are directly linked to the oil upstream.

In the petrochemical industries, the search of underground oil is done during the upstream process. Locating the crude oil is not enough; after it is found, it's brought up to the surface. The oil rigs and the wells are set up in the oil field to carry out the oil extraction work. Once the extraction is done, it is supplied to the purification plant for refining.

Requirement of SAP MII in Oil Upstream

Oil rigs and wells are not necessarily located in the same region or geographical area. The oil industry personnel must get all the information from the oil rigs collectively at a single place, i.e., in one user interface application. They need all the required information to be in one place for analysis at the same time.

The information they need is of the following kinds:

- Oil rigs are movable and thus the exact coordinates of the oil rig are very important. Operators need to drill exactly at the correct position to extract the crude oil.
- Sea weather is also an important information that should be available. Weather conditions affect the correct course of action to be taken.
- It's also important to know the status of the oil rig, whether it's down, running ,or in an ideal state. Based on this status, it is easy to determine the crude oil production rate, the volume of crude oil extracted, and other critical attributes involved in the process. It's important to know the status of the equipment involved in processes in order to monitor malfunctions or downtimes of the equipment. Higher management expects that if there is an issue, it will be immediately recognized and resolved as soon as possible.
- Business stakeholders and management people want an analytical view of the information from the different oil rigs in drill-down mode. From the same dashboard or report, they should be able to drill down from the highest geographical view (such as the Asian region, European region, etc.) to a more granular geographical view (such as each unit of a rig placed in some location of Asia), depending on their need to analyze and monitor the data.
- As this is a highly hazardous, risky, and accident-prone industry, an advanced alarming mechanism must be in place. It is also expected that the mechanism will predict potential accidents by analyzing historical data. Based on that analysis, it can then trigger some early alarm or alert to avoid the incident.

Solution with SAP MII

As SAP MII is a composite application platform, it can provide custom applications with a user interface that includes all the information in a single interface. SAP MII can integrate with Google Maps API to provide a real-time view of Google Maps with all the coordinates. As SAP MII has built-in connectors to connect to automated Level 0 and Level 1 systems, it can connect to different PLCs, SCADA, and historians, and can fetch real-time time-series data. Further, SAP MII has built-in alarming mechanisms using SAP PCo. SAP MII can also connect to the alarm suite directly, so it is possible to do the predictive analysis in SAP MII using SAP HANA and then trigger the rig's alarm directly.

Oil Downstream

Oil downstream is mainly concerned with purification of the extracted crude oil. The crude oil is processed and refined until the finished product is achieved. During the downstream process, the manufactured crude oil is converted into other products and then sold to the end customers.

This process starts by transferring the crude oil from the rig to the first refinery through the pipelines and then to the surface. In the refineries, the contaminants are separated from the crude oil and the crude oil passes through multiple separation processes to get the first level of purified oil, which is diesel. The diesel is further refined to get the next level of purified oil, which is petrol. Kerosene is the most refined oil, and it's achieved at the final level in the refining process. In the intermediary separation processes, multiple biproducts are also extracted, including like petroleum jelly, lubricating oil, etc. To get the final industrialized biproducts, further processing is required. Sometimes those biproducts are transferred to secondary refineries through pipelines or on vessels.

There are some general steps that are followed during the purification process.

First, the crude material is stored in a tank or vessel. Processing is done through multilevel heat treatment or by blending in chemicals that purify the material or the biproducts. Once the final product is ready, the oil is again stored in a storage tank for further supply. The biproducts are moved to a packaging section into drums with unique identification numbers. Once the drumming process is done, the packaging section packages them together depending on the batch requirements. Finally, the packaged product is moved to the warehouse for final shipment to the market.

During this process, quality assurance is always front of mind. During the blending process, the blending ratio is finalized for further manufacturing based on the quality report of the initial batch. Similarly, during the drumming process, either further purification is required or the product is ready for drumming, depending on what the quality report says. The quality report determines the results based on the samples collected from the production units and the samples collected based on batches. Every organization has certain fixed sample sizes defined for each batch to determine the quality results of the batch.

Generally, natural gas also follows this similar process.

Requirement of SAP MII in Oil Downstream

Most of these steps (materials, warehouse/tank sales, quality assurance, etc.) are managed by the SAP ERP system (SAP ECC). The purification process is managed by Wonderware systems, SCADA, DCS, Historians, or LIMS, depending on the organization's landscape. The disconnection among all these different systems and the lack of automation between the different processes demands a system that can connect everything. Process order and worklist reports, for example, must be presented with real-time data. These reports show if the order status was released in ECC, or if the order was completed in ECC or technically completed. These reports include data such as auto or manual batch creation, batch status tracking, GI (goods issue) or GR (goods receipt) done, activity across all the processes, which helps during an audit, and event logging and monitoring.

Capturing the data from these different systems is a requirement in oil downstream, because it enables the production users to analyze and monitor the performance and status of the site at a more granular level. Tanks and vessels must also be leveled automatically to reduce spilling materials while loading. Plant maintenance and quality management must be integrated in order to decrease the downtime of the site and to improve the quality and reduce rework.

Solutions with SAP MII

SAP MII can integrate with SAP ECC and can support bidirectional flow of information. Thus operators on the shopfloor can immediately connect to real-time production data. As SAP MII can integrate with SAP ECC using SAP MII, it is possible to provide a custom, user-friendly frontend with minimum user interaction to replicate the ECC processes. The alarm system to check and control the tank or vessel levels while loading the material can also be achieved by SAP MII as it is capable of generating alarms and notifications. SAP MII can connect to a weighing system to determine first and second level weights as defined by the process and help with tank-to-tank or tank-to-vessel transfer processes. SAP MII can integrate with MES like Wonderware, Rockwell, etc., and historians through web services and SAP PCo. It can connect to the LIMS database easily to capture the specific gravity of the material. SAP MII has a PIC feature that creates the hierarchy of the ERP workflow. PM and QM level integrations are also easily possible with SAP MII, as explained in the previous chapter.

CPG Manufacturing

CPG stands for *consumer packaged goods*, which means the goods are directly consumable by the end consumers and are delivered in a packaged form. These industries include food and beverages like soft drinks, chocolate, ice cream, as well as daily life products like toothpaste, creams, toiletries, and so on. In general, from a consumer perspective, CPG products are defined as goods that are used often and need to be replaced frequently. From a manufacturing perspective, consumer products are manufactured in bulk and the production happens without any consumer-specific demand. Sometimes people think that CPG is itself retail. The main difference between CPG and retail is that CPG manufactures the consumable products and delivers them to retail companies and retail companies sell those products to the consumers. So to summarize, CPG is involved in the manufacturing of products and moving the products through wholesale businesses to the retailer. Retailers sell the CPG product to the consumers.

In CPG, the manufacturing process depends on the product. To generalize, the process steps can be explained as follows.

Raw Material Loading and Weighing

The first steps in CPG manufacturing is raw material loading, weighing, and assignment to the kitchen. During this process, the raw material requirements to create the base product is collected from the receiving station or warehouse and then, based on the production

batch size, it is weighed, separated, and placed in the respective individual sections. During chocolate manufacturing, for example, the raw materials like cocoa powder, milk, butter, and sugar are weighed. These materials are not necessarily produced by the manufacturing company, and could be imported from other vendor organizations. For example, some chocolate companies purchase cocoa powder from vendors and some prepare the power as a sub-process by roasting and grinding the beans to get the powder.

Preparation of the Base Material

The next step is to prepare the base material. To do so, all the raw material assigned to the batch is collected and placed in a mixing machine to get the final base product. This process can continue for a long time. Materials are sometimes added simultaneously; in other cases, they must be added sequentially based on time. The mixing and timing is determined by the company's secret procedure, from which the exact quantity or timing is already defined. For example, during chocolate preparation, liquid chocolate is the base material. To prepare the liquid, the cocoa powder, sugar, and milk are mixed to produce a smooth paste. Then cocoa butter, which is extracted from the cocoa bean, is mixed with this paste.

Preparation of Molds

Mold preparation is a parallel step to base material preparation. The mold is required to hold the base material. For example, for chocolate, plastic molds are prepared with the shape and size of the chocolate bars. For soft drinks, molds are basically the plastic and metal bottles that vary in size as per the content capacity. For fruit juice, the molds are basically the laminated pet packets. The molds can be prepared by the CPG manufacturing company itself or by other companies and then purchased by the CPG company.

Filling the Material

The base material is moved to the filling line through pipes to complete the filling process. Filling depends on various manufacturing products. At the time of filling, a few important parameters must be maintained properly. For example, during chocolate manufacturing, the chocolate must be maintained at a certain temperature to retain to its liquid form. The molds are filled with liquid chocolate. Similarly for manufacturing of soft drinks, a certain pressure is required to maintain the aeration of the liquid. During the manufacturing of ice cream, a subzero temperature is needed to keep the ice cream intact and avoid melting.

Once the filling is completed, some sub-processes must be completed. For example, for chocolate and ice cream manufacturing, toppings and paper sealing are added. For soft drinks, ketchup, fruit juice, and other products that use bottles and cans, capping and sealing is required. During cooling, all these products are passed through a refrigeration process to normalize the temperature. Sometimes they are cooled at more than the normal room temperature to give them an accurate shape and proper rigidity. For example, chocolates need to be cooled to give them a solid hard shape so that they can be separated at a later stage. Similarly, for other product types, cooling is required to increase the lifespan of the product (for prolonged shelf life of the product).

Delensing/Separation Process

Delensing or separation is the next step in CPG manufacturing. This involves separating the product form the molding case. The *delensing* term is mostly suited to the chocolate manufacturing industries, as once the chocolate is ready, it is removed from the plastic molds, which are used with the next production batch. Separation describes most CPG production models, because at the time of filling, the products are set in a tray with a fixed number and the plate is called a cassette. For example, in ice cream manufacturing, all the cones and cups are set in a cassette and once the filling and cooling are completed, the cones and cups are removed from the cassettes. This is the separation process. Once the separation is completed, you have the final product.

Packaging the Products

Packaging is the next step. In this step, the final manufactured product is packaged. Individual products are packaged first. For example, individual chocolates, ice cream bars, soft drink bottles or cans are packed and then moved to the next line for boxing up. Labeling and printing is one of the important sub-processes in this step. In this sub-process, the manufacturing date, batch number, lot number, expiration date, and sometimes a barcode are printed on each label and then the corresponding label is pasted on the product.

Final Boxing

The final step is boxing or final packaging. During this step, the entire individual product is packaged or boxed as per the lot size. The lot size is defined in the planning system per batch, For example, one box of chocolates can contain 10, 12, or 15 individual chocolates, and that exact number must be determined in the planning system first. Sometimes this final packaging is also associated with another process, such as cartoning. Cartoning refers to packaging multiple boxes into a single carton.

Quality Control

Quality control is one of the major steps in CPG and it's associated with every step or process under it. During the first step, raw material loading, weight measurement, and assignment to the kitchen, every material is tested in the quality lab for expiration, density, color etc. In the base material manufacturing step, while mixing, samples from the mixture are checked to ensure proper mixing of the components—color, fragrance, taste, etc. During the molding step, molds are checked for length, width, logo position, logo impression quality, aging of the mold, and magnetic testing for contaminations that may be in the base material. For ketchups, soft drinks, etc., where bottles and cans are used, these bottles and cans are checked and tested for no leakage, no harmful chemical or bacteria, flotation of those elements and de-shaping. In the filling step, after filling is done, the quality testing happens using ultraviolet, magnetic, and vibration tests for removing air bubbles or any metal contaminations in that liquid.

Another important quality test is done during this step, which is called the goodwill quantity check. For example, suppose it is decided to have 200 grams of a product per bottle of the product. As per company policy, while automatically filling, they can fill more than the decided quantity, but it is not a good practice to fill lesser than the decided quantity.

The additional weight added per can, bottle, or cup is called the goodwill quantity, meaning Goodwill Quantity (per bottle/per cup/per can) = Actual Quantity - Planned Quantity. In capping and sealing sub-process, the capped and sealed bottle samples are collected from the lines to check the cap position and if the container is air tight and sealed.

During the cooling process, the check is required for the temperature decided to be maintained and after cooling process, the sample product is again checked if it is properly chilled or not as required. For example, after cooling process, chocolate samples are collected and cut in the middle to check if they are chilled thoroughly and there is no melted portion within the chocolate. In the delensing step, each individual product is visually checked manually (sometimes with camera), and there should not be any broken item or improperly filled item. Another test is done by physically tasting the product. Random samples are collected in the current production line. For example, are the raisins, nuts, chocochips, or toppings present in the chocolate or not. The testers taste the sample to give it a go-ahead, verifying the taste of the product. In the packaging step, they check if the product is wrapped properly with proper sealing and verify that the critical information, such as batch number, lot number, manufacturing date, expiry date, etc. are printed on each sample as desired. Figure 5-2 shows this overall process.

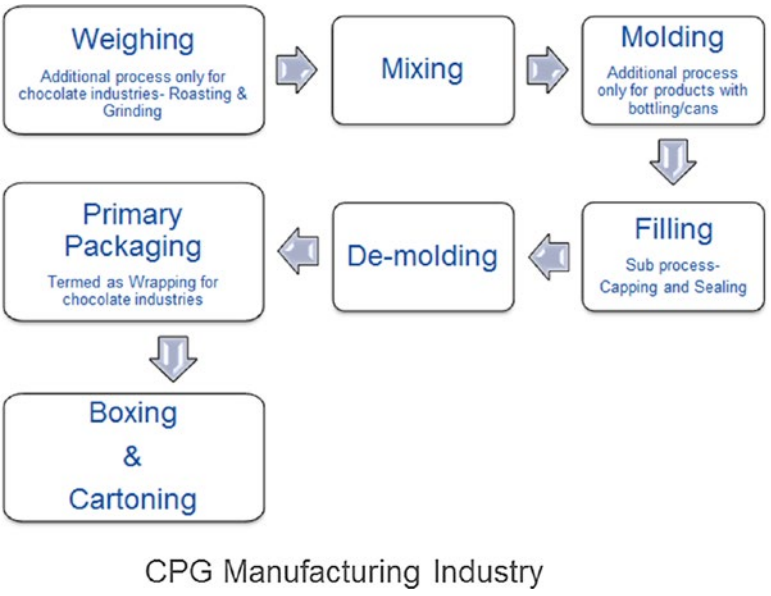

Figure 5-2. *The CPG manufacturing industry process*

Requirement of SAP MII in CPG

CPG sectors require analytical reports and intelligent integration across different systems. As in CPG manufacturing, multiple sensors, sensing machines, and PLCs are involved. The manufacturing time is very fast and all the analytics need to be done on real-time data, so intelligent integration is the major demand in the CPG sector. Multiple SCADA and historians are also involved in the landscape, so the system must integrate with these systems to get historical data. Downtime of the machines involved is another key risk factor for this sector as it may incur a huge loss for the company. Quality procurement is also an important requirement in this sector. As automation is involved in modern CPG sectors, integration with the planning and material management module is also very important in order to reduce the production timeline and to increase the production rate, thus making delivery faster. Analytical reports play a major role in production performance monitoring. OEE (Overall Equipment Effectiveness) reporting is one of the key reports that helps the industry maintain ISO standards. Apart from this, critical quality reports for waste management, re-work management, and quality notification management are also required. Material distribution, order status, and product movement reports help workers understand the movement of material or final product as a part of supply chain monitoring. Other than the analytical reports, status reports are also important. These include machine status reports, line status reports, resource availability reports, production score boards, KIOSK views, etc. These provide a look at the current situation and productivity of the site.

Solution with SAP MII

SAP MII can address all the requirements of CPG manufacturing. The main solution for the CPG is intelligent integration and smart reporting. SAP MII can provide both. From an integration perspective, SAP MII can connect directly to PLCs, sensors, SCADA, and historians through SAP PCo, UDC, and OPC connectors to fetch real-time and historical data. SAP MII can provide all the status reports like machine status, line status, availability reports, etc. SAP MII can integrate with SAP ECC to provide real-time order status reports and material management reports, as those are part of the ERP planning. SAP MII has great flexibility with charting libraries and can easily provide the desired charts required by clients. As OEE reporting is one of the important and critical requirements of CPG industries, it can be handled in two ways—either by using SAP MII and putting all the OEE derived in SAP MII using custom logic or by using the new product of SAP called SAP OEE. PM and QM level integrations are also easily possible with SAP MII, as explained in the last chapter.

Pharmaceutical Manufacturing

The pharmaceutical industry consists of manufacturing products that help in the healing process of living beings. It produces medication for disease. All the drugs being released to the market must comply to rules set by WHO (the World Health Organization), the FDA (Food and Drug Administration in the US), or the MHRA (Medicine and Healthcare Regulatory Agency).

The pharmaceutical industry is categorized into a few divisions, such as lifesaving drugs including tablets, capsules, syrups, and other injections; life support devices like pacemakers, hearing aids, and stent ICU equipment; optical parts, like spectacles, lenses, eye drops, etc., and medical devices like blood sugar measuring kits, RNA, DNA and protein analyses kit, etc. Manufacturing processes are different for each division and are often company secrets and dependent on research and patents.

As an example, we discuss contact lens manufacturing. Lens manufacturing involves two processes—mold creation and polishing and finishing. The mold creation process is an old process where the molds are created from plastic and then filled with liquid gel material to form the lens. The polishing and finishing technique is a more modernized process to create contact lenses. The gel that manufactures the lens is solidified as a cylindrical rod called a plasma stick. Then these rods are cut into small pieces and polished on both the sides. Both process are explained in detail next.

Molding Process

During mold creation, molds are manufactured from plastics; raw plastics are loaded into the machines and then melted. After that, two molds are manufactured for one lens with this liquefied plastic. One is called the front curve mold and the other one is called the base curve mold. Both the molds have to be manufactured as per FDA (Food and Drug Administration) approved power prediction. Both the front and base molds are affixed together and the gaps between both the molds are filled with lens manufacturing gel. These gel-filled molds pass through a few sub-process like vibration and ultraviolet checks to ensure there are no air bubbles. There are several other sub-processes that test the quality and authenticity of the molded lens and these processes come under the organization's quality policy.

Finishing Process

The molds are further de-molded to get the final product, which is the actual lens. The lenses are coated with multiple chemical components like nitrogen, carbon, oxygen, etc. to provide extra protection to the end consumer's eye. After this, the lenses are again passed through many quality checks.

Lens Manufacturing in Modernized Integrated Process

In the polishing and finishing lens manufacturing process, once the plasma sticks are ready and cut into pieces, each small piece is placed into an automated polishing machine. In these machines, the pieces of plasma gel are polished and the final lenses are manufactured. The target powers of the lens are fed into the polishing machine so that it can polish the lens piece to the desired level only.

Quality Control

During the lens manufacturing process, several critical attributes and parameters are involved and need to be checked periodically. Critical parameters are based on the power of the lens. In the mold creation process, critical attributes and parameters are measured in two stages. The first measurement is of critical parameters like predict power, predict center thickness, predict diameter, and predict radius. These are measured in the plastic mold. This stage is called *predict* because from the mold all these results are predicted to get the actual measurement. The second measurement is of critical attributes like actual power, actual cylinder, actual ion permeability, actual center thickness, actual coating thickness, actual diameter, actual axes, vacuum testing, etc. They measured on the actual manufactured lens after the de-lensing process. See Figure 5-3.

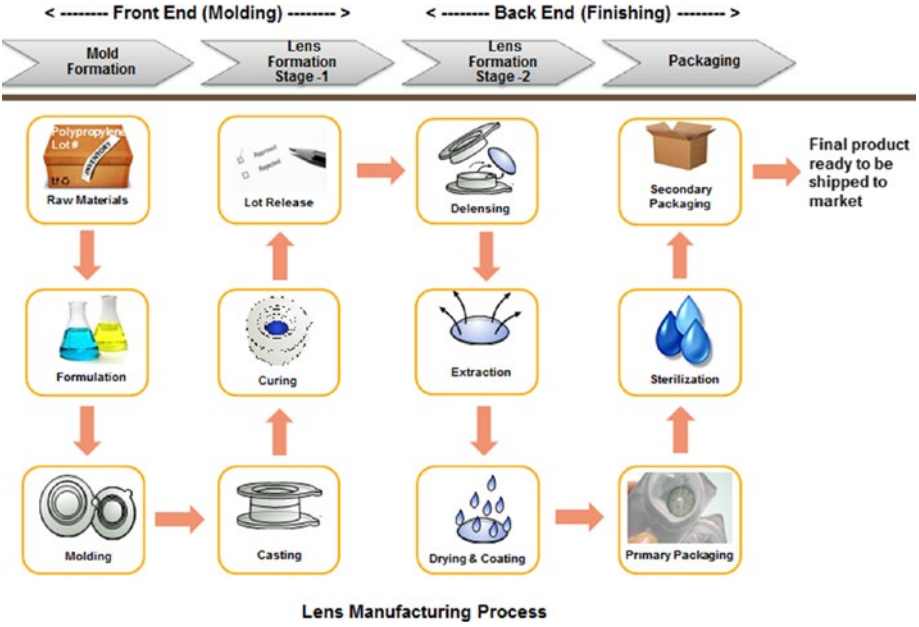

Figure 5-3. *Lens manufacturing process*

Requirement of SAP MII in Pharmaceutical Industries

The pharmaceutical industry's major requirement scenarios involve integration and reporting. For the integration requirements, SAP ECC and machine integration is the most important one. Quality control is done through a series of machine tests and by visual manual inspections. For visual inspection, the manual form is filled and maintained but it is very problematic to keep all the paper records intact. One major critical requirement of the pharmaceutical industry is to track everything, starting from receiving the raw materials until the expiration of the product, because it's directly linked to human life. Most companies keep complete records for a few years even after the expiration of the product for legal reasons, so that any time if anyone wants to check the record of a particular product, everything can be back-tracked.

From a reporting perspective, the product handbook is one of the most critical reporting requirements. It contains the complete record of the product, such as the components used and in what percentage, the expiration date of the raw materials, source of the raw materials, batch number, patient ID, patient approval authority and date, manufacturing time of the drugs, manufacturing conditions and parameters, actual results of the parameters, quality inspection record, storing parameter details, assigned batch details, and more. These details are captured with the exact timestamp and auditing information.

As security and safety is another major concern in this industry, resource availability, process certification of the resource, compliance verification, and machine availability are also important required reports. As explained, the pharmaceutical industry has to deal with a huge volume of data and it needs to keep the data for a long time, so a proper data persistence mechanism with a proper archiving and backup plan is important.

Solution with SAP MII

If we consider the integration requirement of pharmaceutical industries, SAP MII can provide the best solution for it. SAP MII has standard connectors available to connect to SAP ECC and can directly fetch data from ECC using push and pull methods. Master data and planning data can be pushed to MII from ECC and MII can store that data and provide rich analytics it. SAP MII can integrate with the shopfloor machines directly using the standard PCo connector. So using SAP MII, it is possible to get the machine data directly in real-time. As visual inspection is an important requirement, SAP MII can integrate with CSV and Excel files directly to read and store the data. SAP MII can provide custom screens for the inspection form to the end users so that they can log the inspection report directly to the SAP MII screens.

Common custom reports used in the pharmaceutical industry include the yield report, the actual versus planned quantity report, delayed versus on-time schedule report, machine overview report, trending report, production rate report, delta report for quality parameters and attributes for individual processes, historical report, machine status capturing the different status of the equipment throughout a selected period, and audit reports (who, when, what, why, and where). These reports are easily created by using SAP MII to gather all the related data from various integrated systems. Similarly, SAP MII can build the product reports to provide complete visibility of individual manufactured product and can provide digital copies of the report, which are easier to store than paper printouts.

Dealing with the high volume of data is another important requirement of pharmaceutical industries, and there are multiple ways to fulfill this requirement using SAP MII. As SAP MII can be hosted on SAP HANA now, this can be one of the great solutions for this requirement. SAP MII can leverage the in-memory processing capability of SAP HANA and can store the data in HANA DB. It will make the process faster. Apart from this, SAP MII can go with the traditional way to store the data in any relational database and can generate all the required reports.

Another approach is to use BI. In this case, SAP MII can work as an integrator to move the data to the BI data pool. SAP MII is also capable of statistical calculations like mean, average, and standard deviation, which are critical process parameters and critical quality attributes. Due to its flexibility to connect to any legacy system and any SAP system, SAP MII makes it very easy to represent near-to real-time data within a reasonable time period.

Summary

In this chapter, you learned the basic functionalities of different manufacturing sectors involved in process manufacturing, including the pharmaceutical, consumer packaged goods, oil and gas manufacturing industries, and the possible scenarios where automation is preferred. You learned how SAP MII is capable of providing great solutions to all the needs of these industries.

The next chapter explains the various processes and ideas upon integrating SAP MII with ERP, as well as various legacy systems and the shopfloor system with SAP's other products.