USING IT DESIGN AND DATA ANALYSIS TO DRIVE OPERATIONAL EXCELLENCE IN CONVERTING (SLITTING)

Roopram Ramharack, President, Adhesiology Inc, New York, NY
Rollo Sicoco, Data & Cybersecurity Architect, Estenda Solutions Inc, Conshocken, PA
Chandresh Thakur, Sr. Process Engineer, Amazon Inc, Seattle, WA

1. Introduction

Data Analysis is proving to be very valuable to drive efficiency and productivity in many fields, for example, financial, medical, public policy, etc. In the manufacture of adhesive tapes, we found that data collection is often very inadequate and even when data are collected, the analyses and use to drive improvements have a lot of room for improvements.

Even more challenging – often the IT system does not exist for the adequate data collection. Commercial enterprise systems and shop floor systems need a lot of customization to make "floor ready", especially for the Converting Operation.

This is a case study in solving these challenges and showing how valuable it can be. In this presentation we show the design of the IT system, a framework for data collection and the results of the analyzed data. We show how the results can then be used to reduce the number of converting machines, to reduce set up times, to speed up run times. These data can be used to set targets for scrap reduction in converting and in coating.

This was essentially an IT project to conceptualize the system, to design it, to beta test it and to implement it.

Then, there are the data collection and data analytics parts to isolate what the data are telling us and what we need to do.

First, we will review the IT system that was designed and implemented. Then we review the data analytics and how we used it to improve efficiency and reduce scrap in the manufacturing of tapes.

We will show the details of the data set collected over three years; and we will show the cost savings (in percent time saved).

We limit the presentation to Converting.

2. Solution Design

The ERP system of the company had the basic modules for order entry, inventory management, receiving, purchasing, manufacturing (or job management), scheduling, packing and shipping. But it lacked the functionalities needed to serve the finer data and system requirements for a tape/adhesive manufacturing business. The base system lacked the ability to specify orders, process jobs and capture data related to the tape business, such as cut/roll sizes, liner width, substrate type and coat weights in the order, jobs, reports

and labels. Users ended up managing their data and working outside the system to support their processing, analyses, and reporting needs. In most cases, tasks were handled manually and outside of the base system requiring double or late entries, additional workflow steps and process delays. The lack of finer data in the base system limited the ability of the company to automate its processes, increase productivity, and build data insights to support the business objectives.

The solution integrated the required finer data and implemented custom modules to automate the shop floor operations down at the machine area or workstation level. This enabled the automation of the various coating and converting operator functions, eliminated manual data entry, simplified data capture, and enabled visibility of data across the shop floor. This also allowed the optimization required in scheduling and in job processing. Further, it allowed the integration of barcode scanning for easy data capture and label printing at the machine workstations. The solution enabled users to view data in a timely fashion, run processes more effectively, eliminated manual work and delays, and increased output and productivity.

The expanded data provided by the solution promotes better data analysis and increased ability to build data insights. The shop floor automation enables personnel to innovate their work processes better and faster.

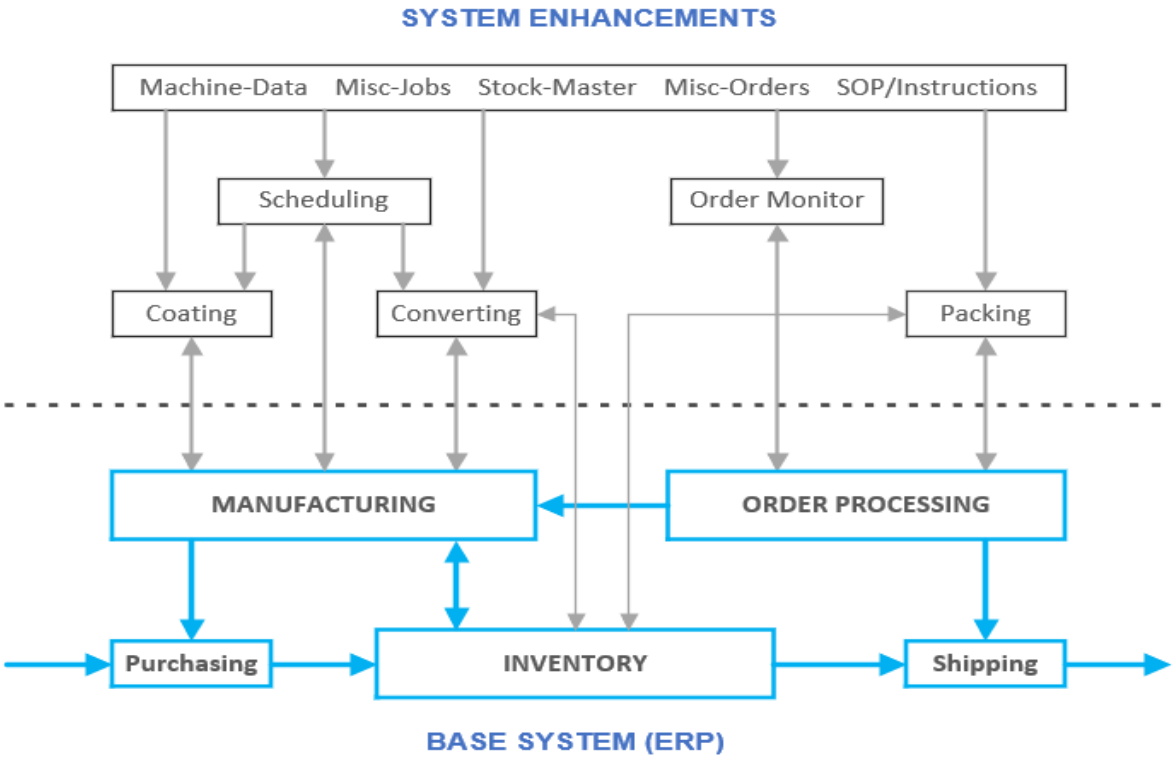

Figure 1. System Design

Master Data Management

Key to making the automation work is with the integration of critical master data. Most base system (ERP) provides the standard fields on stock, customer, product structure and basic routing data to support the general requirements for managing inventory, orders and the manufacturing processes. But for a tape manufacturing company, the system does not provide enough data to fully support and automate the shop floor operations and data processing requirements unique for the business.

The solution incorporated additional data sets, such as roll cut-sizes (width and length), % solids of fluids, coat weights, machine run widths, etc across the whole system. These data sets are required for the solution to fully integrate and automate the order processing, scheduling, inventory management, coating, mixing, converting, packing and shipping operations. The solution provides the custom interfaces or modules to manage the additional data.

The solution provides the following enhancements to master data management:

a. Expanded stock master data – stock/product categories, class, adhesive family, coat-weight, substrates, roll thickness, cut-size, etc.
b. Expanded processing instructions – standard SOP and customer requirements at the cut-size, product, product family, order and customer levels; view by instruction type (coating, converting, packing, shipping and invoicing)
c. Expanded machine data – configuration by product type, run speed, run/setup/load time
d. Expanded WIP master data required for scheduling, planning and shop floor automation.
e. Expanded structures/routings for multi-pass products into separate stock codes and BOMs.
f. Expanded customer master data – market type, product groups, category by product.

3. IT Custom Modules

The solution provided expands the capability of the base system by integrating the required finer data sets and providing custom interfaces or modules to enable the seamless flow of data electronically. The solution utilizes the SDK (Software Development Kit) provided by the base system to enable the modules to query data and post transactions with the base system. With the finer data integrated, the solution, through the custom modules and reports, provides a complete view of the data required by the users and various processes. The solution allows users to view, process and manage all the data required, such as order roll breakdown, coating widths and converting roll cut-sizes. The modules automatically sync with the base system (ERP) to query order data, transact job/WIP transactions, and post inventory updates.

3.1 Order Monitor Module

The Order Monitor interfaces with the base system and added needed functionalities. It enables users and departments to have an expanded view of the order details, work status and shop floor commentaries. It allows users to view and specify instructions, requests, monitor the fulfillment status, reschedule, and view job notes/comments. And to drive the full automation in the shop floor, the module provides the ability to enter other types of orders related to the adhesive tape business, such as sample orders, rewinds, customer special orders, stocking orders, etc.

The Order Monitor module provides the following:

a. Monitoring of the order schedule, status, run dates, late shipments and late reasons/comments.
b. View orders electronically at the shop floor to eliminate paper trails and access data timely.
c. Provide view of standard and custom product/order processing instructions for each order.
d. Ability to reschedule orders, manage expedites, and post job requests/comments.
e. Entry of non-standard orders – samples, trials, rewinds, lot charge orders, etc.
f. View/track status of shop floor, packing and shipment status
g. Track delivery and view/analyze data on turnaround/late and reasons/remarks.

h. Reports on order frequency, volume, turn-around times and late deliveries by order type, customer class and product categories.
i. Generation (email/notification) of customer acknowledgements and delivery alerts.

3.2 Scheduling Manager

The solution provides custom programs/modules for the scheduling and planning of the mixing, coating and converting jobs. The modules utilize the custom master data to provide the ability for the scheduler to view, manage and schedule jobs in relation to the order details, machine run parameters and product specs. The scheduler can change the job schedule, run size and batch similar jobs to optimize machine setup. The scheduler can view the status of the jobs and job notes/comments entered by the operators.

The Scheduling Manager modules provide the following:
a. Manage and schedule jobs electronically, including status updates and job notes by the operators.
b. Ability to prioritize the daily jobs at the machine level.
c. Job schedule updates are automatically reflected in daily schedule visible to the machine operators. This eliminates the tedious reprinting of job sheets and/or job instructions.
d. View job detail run data, including materials produced, usage, leftover material ("offcuts"), scrap, scrap codes, machine, runtime, start/stop times, job notes and events by operator.
e. View job reports per machine, day/week, customer, product.
f. View or report material demand - daily, weekly, calendar.
g. View the job/machine SOPs and related order instructions.
h. Incorporate detailed and daily calendar view of scheduled workload and machine capacity.
i. Provide ability to calculate estimated job time, view workload and analyze machine capacity.
j. Reporting and analysis of machine workload (schedule vs capacity).
k. Reporting and analysis of productivity (actual runtime vs estimated time, daily/weekly production).

3.3 Converting Operator (IT Design)

The solution provides a custom module that enables the converting machine operator to view schedule and related job/order details and instructions, run the process and transact job data electronically and easily. The module handles the most common types of converting operation noted above. This eliminates the work required to handle the jobs via paper trail. Job run status and operator notes are posted back so order monitoring, job scheduling, production control and inventory management will have real-time job updates. The solution integrates barcode scanning for material picking and returns and also integrates label printing.

The Converting Operator module provides the following:
a. View the daily/weekly schedules, job details, and related order/material info electronically.
b. View the job/machine SOPs and related order instructions.
c. Job schedule updates are automatically reflected in the machine workstations eliminating the need for reprinting of job sheets and/or job instructions.
d. Integrated inventory view and material lot lookup.
e. Manage and process non-standard mixing/coating jobs – remix, trials, etc.
f. Process/run coating and mixing jobs electronically. Eliminate the manual filling-up of job sheets.
g. Automatically print job tickets and run sheets at the end of the run or shift.
h. Post run data/actuals and shift data - run/setup/down time per shift/job.
i. Integrated barcode scanning for material picking and return

j. Integrate printing of labels – stock, box, core, address with auto formats based on product
k. Job actuals, run data and notes posted by the coating/mixing operators are visible in the order processing, scheduling and inventory management modules for real-time job feedback.
l. View job detailed run data, including materials produced, usage, leftover or returned material, scrap, scrap codes, machine, start/stop and run times, job notes and operator.
m. View job reports by machine, day/week, adhesive type, substrate, route, product class and category.
n. View or report material demand daily/weekly/period by machine, component and product group.
o. Calculate estimated run time based on machine, run-size, adhesive family, product specs and type.
p. View/report on daily/weekly total scheduled workload and machine capacity.
q. View/report on productivity (actual runtime vs estimated time, daily/weekly production).

3.4 Packing Operator (IT Design)

Finished rolls are assembled, labelled and packed at the packing area. Some rolls come directly from the machine work area – ie log rolls from coating and small rolls from converting – and some rolls are picked from inventory (stocks). Some rolls are even pre-labelled at the machine work area. The rolls are packed with the required printed labels.

The solution provides a custom module that simplifies the process of picking and assembling of the required roll cut-sizes for an order. It automates the printing of the required core, roll, box, address and pallet labels required for the order. It allows the operator to send extra material back to stocks with the appropriate stock labels. The solution also integrates barcode scanning and label printing.

The Packing Operator module provides the following:
a. View and manage open orders electronically to eliminate paper trails and access data timely.
b. View of standard and custom product/order processing instructions for each order.
c. View shipping schedule and track/account rolls for each order (packed, in converting, from stocks).
d. View/track status of jobs related to the orders
e. Integrate the roll picking and packing of orders lines. Eliminate separate paper trail and data entry.
f. Integrate label printing. Auto print format based on transaction (stock, box, core, address, master and proforma labels).
g. Post order lines and shipment date during actual delivery/pickup.
h. View delivered orders and analyzed data on turnaround/late and reasons/remarks.
i. Reports on order frequency, volume, turn-around times and late deliveries by order type, customer class and product categories.

4. Order Processing

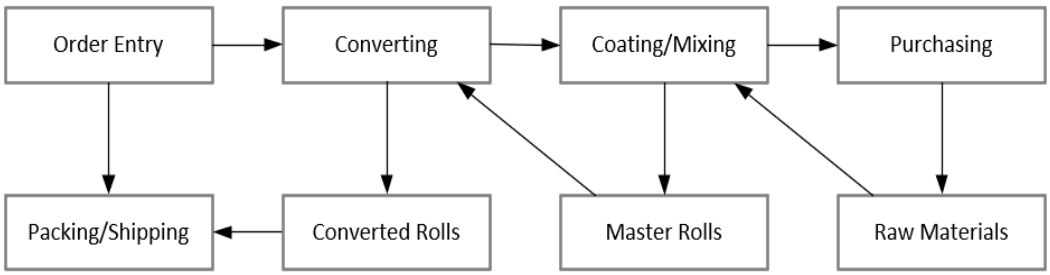

Figure 2. Demand and Material Flow

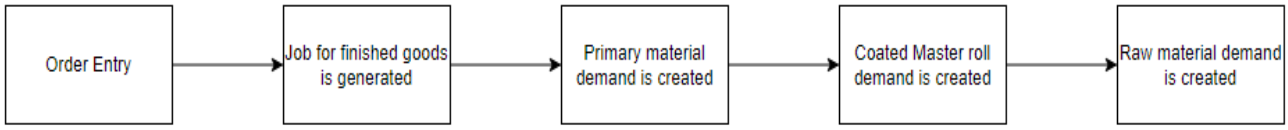

Figure 3: Job Creation and Material Demand based on Customer Orders.

Based on figure 3, once the customer order is entered it leads to the demand for coated master rolls. The demand for raw material is generated once the demand for coating material is generated. The flow of the order/job entry is considered in this business case since it allows a higher control over the inventory level from the start to the end of the process.

Past Process:

The manufacturing plant was able to handle around 40 customer orders per day. These orders were processed through different manufacturing processes within the coating and converting departments. For example, manufacturing a 0.5-inch double sided foam tape takes around three different manufacturing processes to develop finished product (Coating, Converting and Slitting). The customer orders can only be efficiently met by having clear traceability throughout the manufacturing process. Clear communication (preferably electronic!) between manufacturing and customer service is the key to customer obsession. The orders were printed and traced manually by shuffling papers and tracking them down at the machine level. This led to 73% inefficiency for an employee (6.6 labor hours - 80 jobs in converting - 5 min/order) on the manufacturing floor where resources were spent to provide the info back to the customer service team.

Current Process:

The Order Monitor module serves as a communication platform that helps to track the different job activities - related to any particular order - between customer service and manufacturing. It consists of features such as order entry, update/expedite or specific instructions to that particular order. It also acts as a data monitoring system that tracks orders that are shipped late or early to improve customer experience.

5. Converting Operation (Implementation)

Converting is the other key operation in the shop floor for a tape manufacturing company. Tape rolls are processed in one or more steps to convert the tape product to the desired cut-sizes as required by the order. And different types of converting operation (logging, die-cutting, spooling, slicing, etc) require different machine setup data, run parameters and data processing logic.

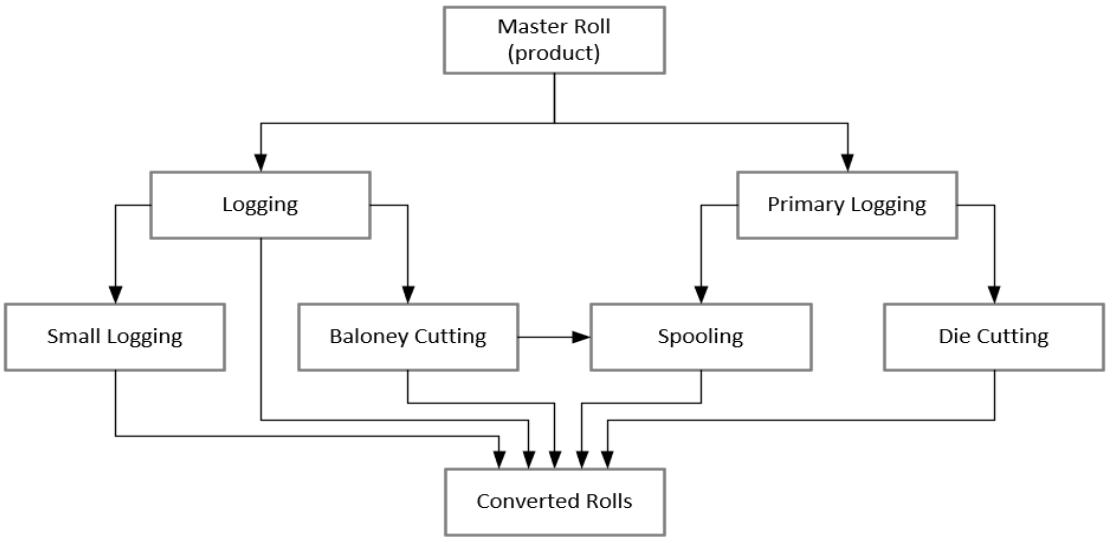

Figure 4. Converting Operations

Past Process:

Planning and scheduling in the manufacturing process were based on the customer needs. The shipping dates were generated by the scheduling team, and this depended on the capacity of the machines. As mentioned above the jobs were created according to the customer demands. Jobs were entered manually for every single process. The average number of jobs entered per day throughout the manufacturing process in converting department is 80. The total man hours required to enter all the jobs in the system was 2.66 hours/day (2 mins per job). Additional time is allotted to expedite/change orders based on customer service request.

The process flow below describes in detail the steps that were required from start to the job completion. The manufacturing floor consisted of 9 different type of job sheets depending on the process type in the converting department. These different sheets required that manufacturing associates be trained to fill several different job sheets correctly based on machines that were assigned. In other words, there was no standardized job sheet for the manufacturing plant. The total time spent to schedule, plan and process the data of a single job in converting department was 27.6 mins. This total time included the time it took to print 10 labels per job (16 secs per label) as well as assigning the finished goods to the designated customer. This led to inefficiencies and higher labor hours spent on the floor. In addition, while processing these data manually, there was no visibility of jobs to enable manufacturing to bundle the same SKUs.

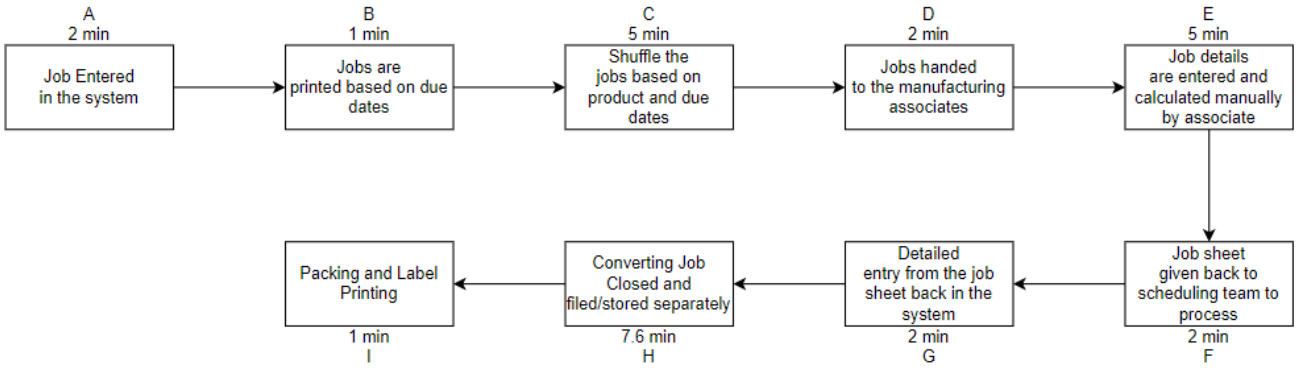

Figure 5: Flow diagram representing the shop floor process for job processing

The output of the machines was mainly measured using total square yards (sq yds) produced divided by the labor hours allotted to that machine. Due to lack of visibility of the future orders for a particular week, the jobs based on the same SKU were setup multiple times on the same machine. This created inefficiencies in the scheduling that increased the overall scrap and downtime on the machine leading to overall lower productivity in overall sq yds. Due to the manual process limitations, capturing the inefficiencies in the process such as downtime and breakdown of the equipment were not possible. The average sq yds per hr generated in 2018 is 136. The total headcount for the department was 26.

Current Process:

The first goal was to identify the current issues/limitations of the existing process and identify the future state that will be required to optimize the overall manufacturing process. Standardizing and eliminating the manufacturing job sheets for the whole manufacturing plant and identifying the key attributes that will be required for the process, the manufacturing associate and the scheduling associate need to be included in the future state.

The Scheduling Manager was used by the department supervisors/scheduling team to enter, schedule and prioritize the jobs based on the customer request. The operators used the Converting Operator module to enter the operational process data. Using these modules helped to eliminate/simplify a majority of the manual steps (A, B, C, D, E and F) as described in Figure 6. In addition, the calculations that were performed manually by manufacturing associates were automatically performed by the programs/modules and reduced the overall time spent on the job sheets by 50%. The total time to process the job sheet in the manufacturing floor is reduced from 27.6 mins to 5.83 mins improving the overall efficiency by 79%.

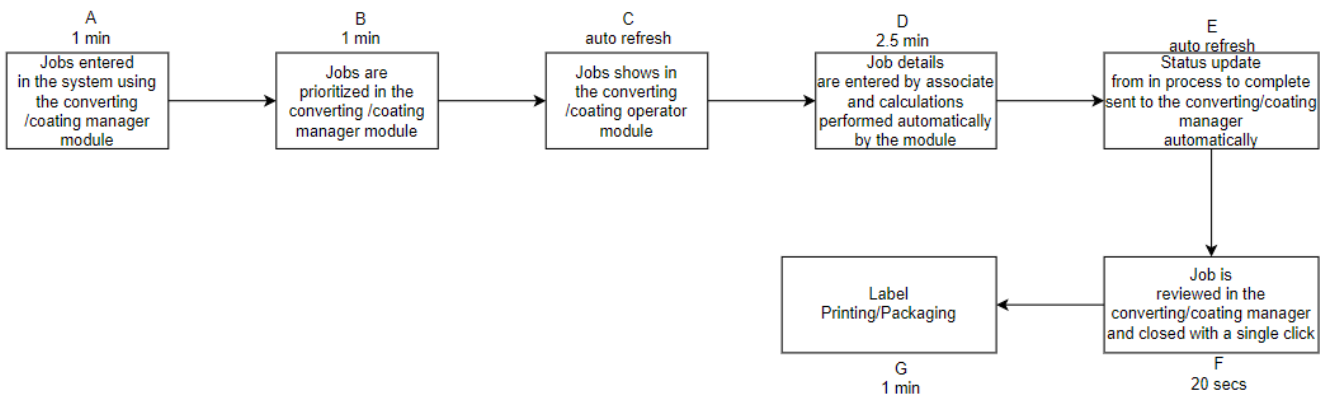

Figure 6: Flow diagram future state process flow shop floor automation

The key results of the changes are as follows

CONVERTING OPERATION					
Parameters	**2018**	**2019**	**2020**	**2021**	**% Improvement**
Machines	24	18	16	17	33%
Number of schedulers	5	3	2	2	60%
Job processing time (mins)	27.6			5.83	79%
No of Operators	26	20	16	16	38%
Sq yds produced	449,353	485,895	491,779	607,293	35%
P-50	461,346	451,171	472,939	614,285	33%
P-75	433,567	435,859	446,787	529,071	22%
Average Sq yds/Hr	136	147	154	161	18%
P-50	141	151	154	160	13%
P-75	122	130	128	154	26%

- Eliminated 9 manual printing of the jobs sheet for the converting floor and everything was now online and can be accessed from anywhere and by anyone that has access rights.
- The Scheduling team can easily update the job sheets daily and prioritize the jobs for every single machine within seconds and helped to reduce time by 60% (40 labor hours to 16 labor hours)
- The total time spent to schedule, plan and process the data of a single job in converting department was reduced by 79 % (27.6 mins to 5.83 minutes)
- Now able to close the jobs within seconds since it would already contain the entry data from the manufacturing associates.
- Able to track the uptime and downtime for every single job
- The number of machines by reduced by 33%
- Able to optimize scheduling since having the visibility for future jobs enabled batch production and reduce lead times by 3-4 days.
- Led to overall improve improvement in sq yds/hr by 18% (Figure 6)
- Able to identify the process bottlenecks by capturing the downtime and scheduling inefficiencies that helped to increase the overall capacity by 35%
- Able to check inventory level within the modules for the particular SKU in seconds rather than navigating through different software

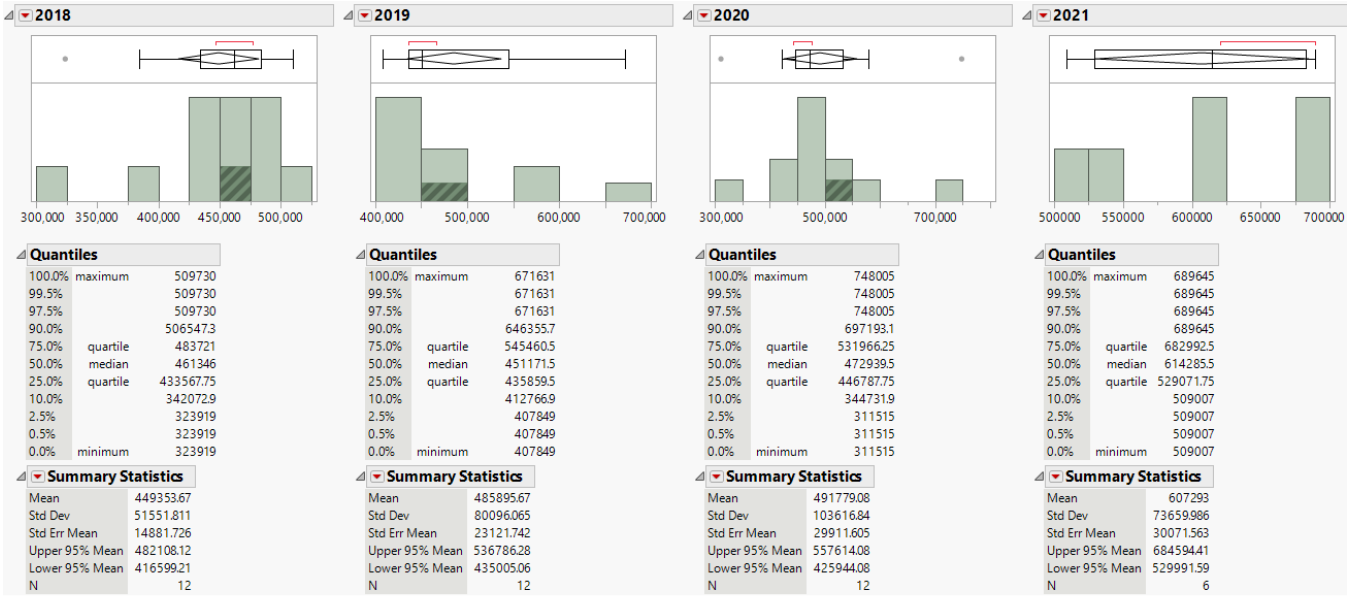

Figure 7: Sq yds distribution from 2018 (manual) to 2021 (comparing with shop floor automation)

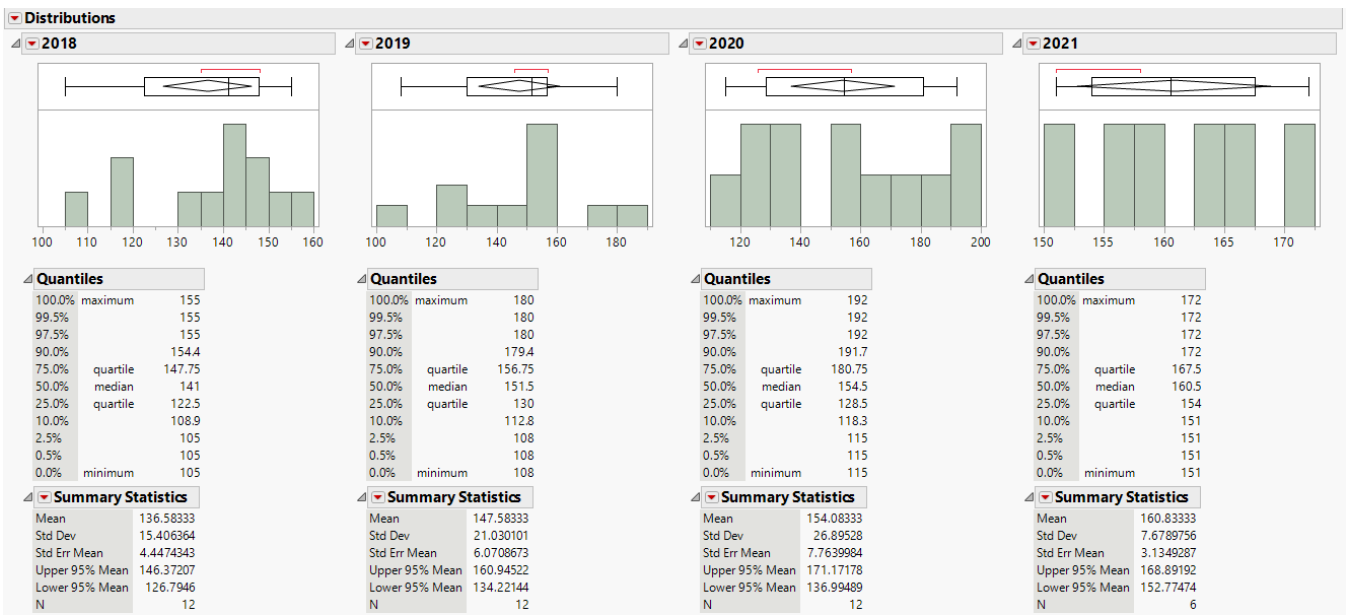

Figure 8: Sq yds per hour comparison from 2018 (manual) to 2021 (with system automation)

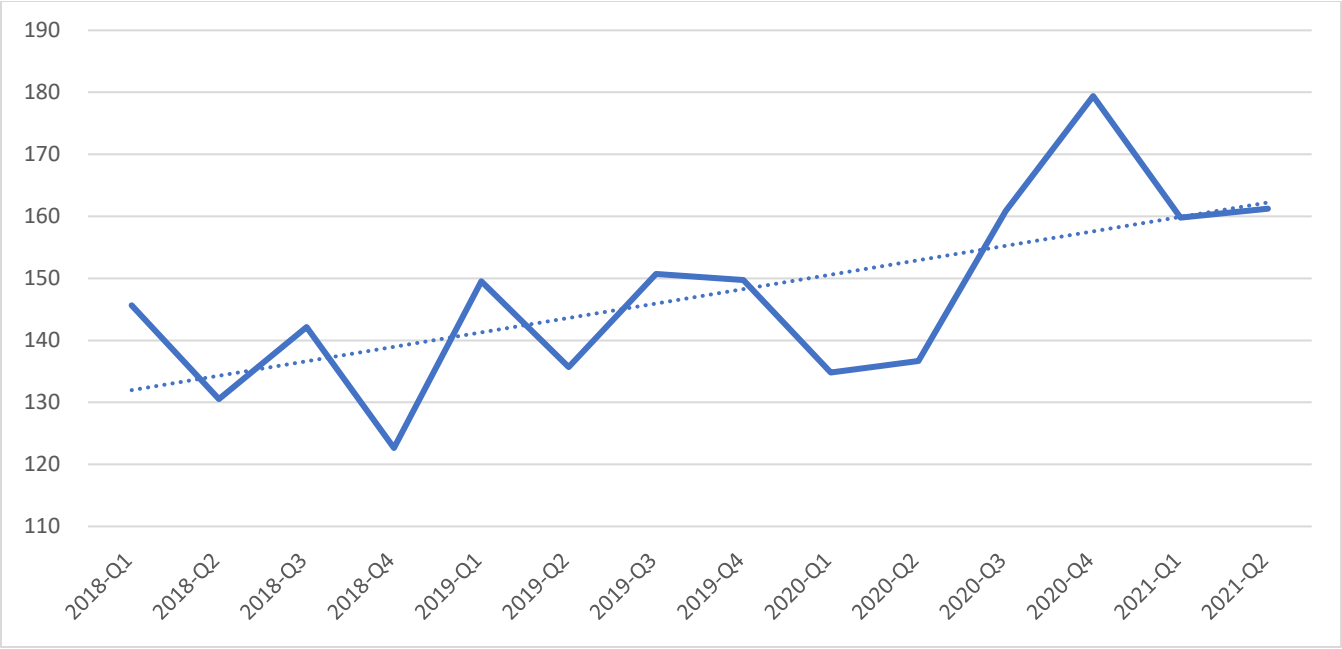

Figure 9: Average Quarterly Output in SY/hr

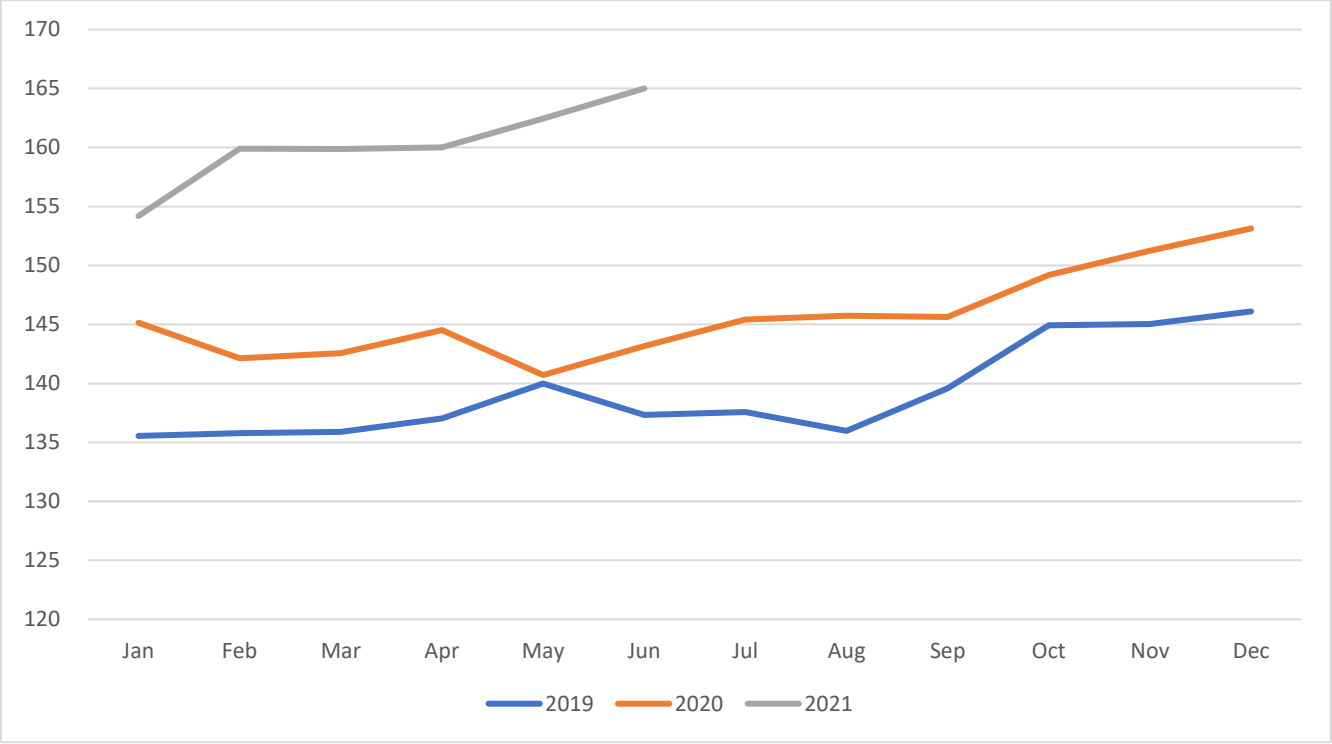

Figure 10: Rolling 12-mo Output in SY/hr

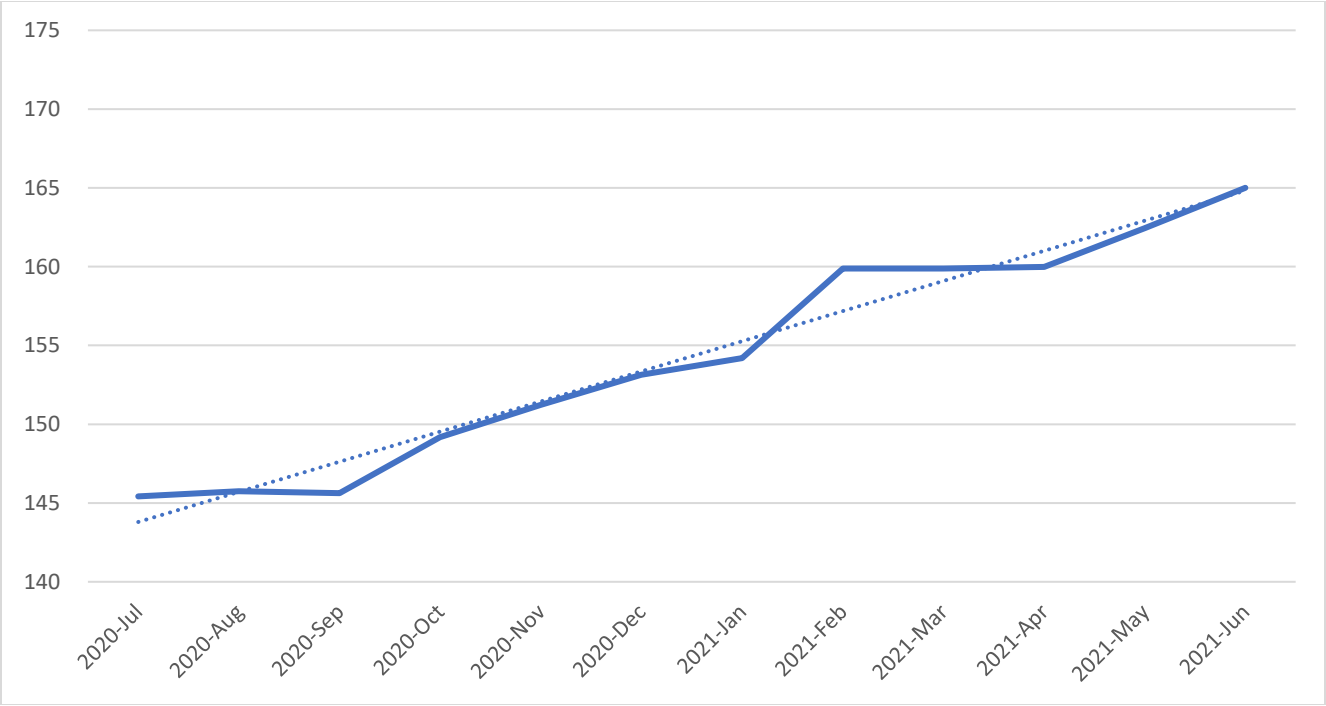

Figure 11: Rolling 12-mo Output in Quarterly SY/hr

6. Summary

The shop floor in the converting Department can be automated to allow for more efficient and relevant data collection and greater efficiency for the operator. This case study showed that when the data are analyzed it gives more insight into reengineering the department to be much more efficient and productive. In this study the efficiency gains were significant – the department output increased by 18% productivity, a 33 % reduction in needed machines and the head count reduced from 26 to 16 – a reduction of almost 38%.

Similar efficiency gains can be gotten in the Coating Department from the time measurements and analyses of the processes. With these more accurate and transparent data, inventory control is much easier. One can more easily manage and optimize (reduce) the inventories in Master roll, slit rolls, logs, etc.

Now costing can be much more accurate as we have accurate data on run speeds, down times, waste, etc. So, customer pricing can be more accurate.

7. Conclusion

One of the more complicated departments in the manufacture of tapes is the Converting department – it usually has the most machines, the most operators, generates the most SKUs and scrap and thus has the most complexity. It is made even harder to manage because of the lack of proper software. In this case with proper software, data collection and analyses along with some process and machine modification

the department can be made much more manageable and efficient. There are fewer needed machines, fewer needed employees, more machine uptime and less waste of time and materials. Data collection and data analytics are indeed very valuable in complex systems.