Application of Lean Manufacturing for Improving the Process at Blue sky Machining Corp.

Anvesh Rajak, Maganjot Singh Dhami
Department of Mechanical and Industrial Engineering
University of Windsor, Windsor, Canada
rajak@uwindsor.ca

Abstract

Lean manufacturing is a systematic approach towards identifying the values in relation to the customer, exposing the waste with a sole aim to reduce the amount of waste and the non-value added activities. Lean manufacturing is indeed a very powerful approach which seeks continuous improvement in quality and reducing the waste. A process improvement methodology can become much better if both the approaches i.e. lean manufacturing and six sigma take into consideration these approaches streamline operations, increases values and reduce waste. In this paper we have described the case study done at Blue Sky Machining Corp. With the application of various lean tools in order to maximize the production, reducing the throughput loss, and realizing the potential causes that can result in the loss of customers. We have significantly focused on achieving the standard operation time at each level of production.

Keywords: Ishikawa Diagram, 5Why, FMEA, VSM

1. Introduction

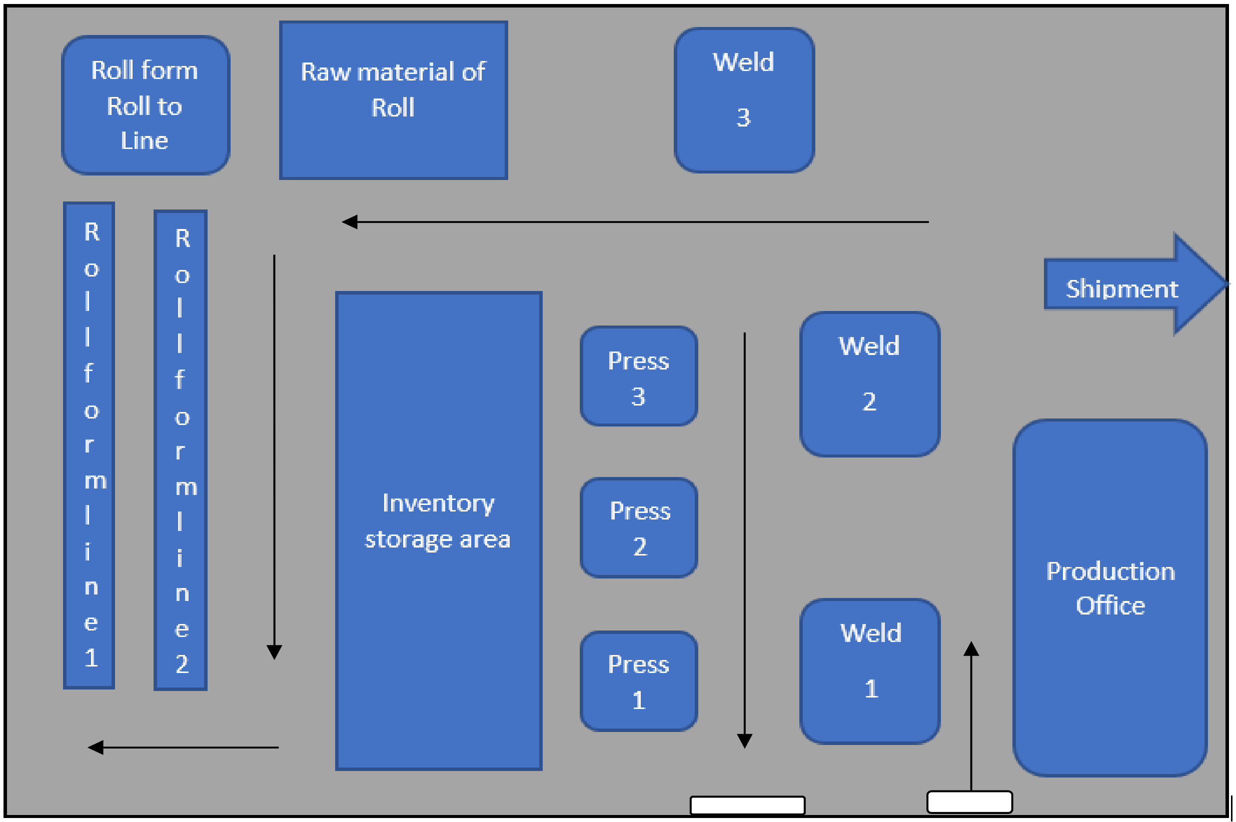
1.1 Introduction about company

Blue sky machining corp. is a production machining specialist of a division of shur lok products. The company is capable in the efficient manufacturing of complex light weighted automotive structure and meeting its customer expectation. The company is focused towards the manufacturing of the light weighted aluminum structures used in the automotive industry. Blue sky machining Corp. is having modern technology form of MIG or resistance welding. Currently the company is having manual, automatic and tandem presses ranging from 80 to 1000 tons with feeder equipment and uncoilers. The roll forming machine is responsible for the formation of the tubular products. So, the there are three processes that are currently responsible for the successful manufacturing of the light weighted structure.

The three major big companies are the customers of blusky including GM and Chevrolet Silverado Truck. The parts which the company manufactures are F4026AE, F4027AD, F4028AF, F4029AF, and F4045AG.. The manufactured products are dispatched to the customer for seven days in a month with a pack out quantity ranging from 216 to 250.

1.2Plant Layout

The following figure shows the plant layout of Blue-Sky industry. The plan has several workstations include two roll form line, three press stations, and three welding stations. Raw material in forms of long wound roll next to the mounting platform so that minimum travel is required while loading on it. And inventory placed between roll form station and press station, it is convenient to place in from the roll form and takeout for press operation as well when need arise. Testing and measuring instruments for the first few parts for quality and specification after changeover or any minor stop in production line are placed far side on right from production office. Final inspection performed along after welding operation and part goes to the packaging.



Process Flow Chart

A process flowchart is a graphical portrayal of a manufacturing process through a flowchart. It's utilized as a method for getting a top-down comprehension of how a process functions, what steps it comprises of, what occasions change results, etc. Process flowcharts are a fundamental piece of process mapping. They help visualize the processes, making them essentially simpler to completely comprehend.[2]

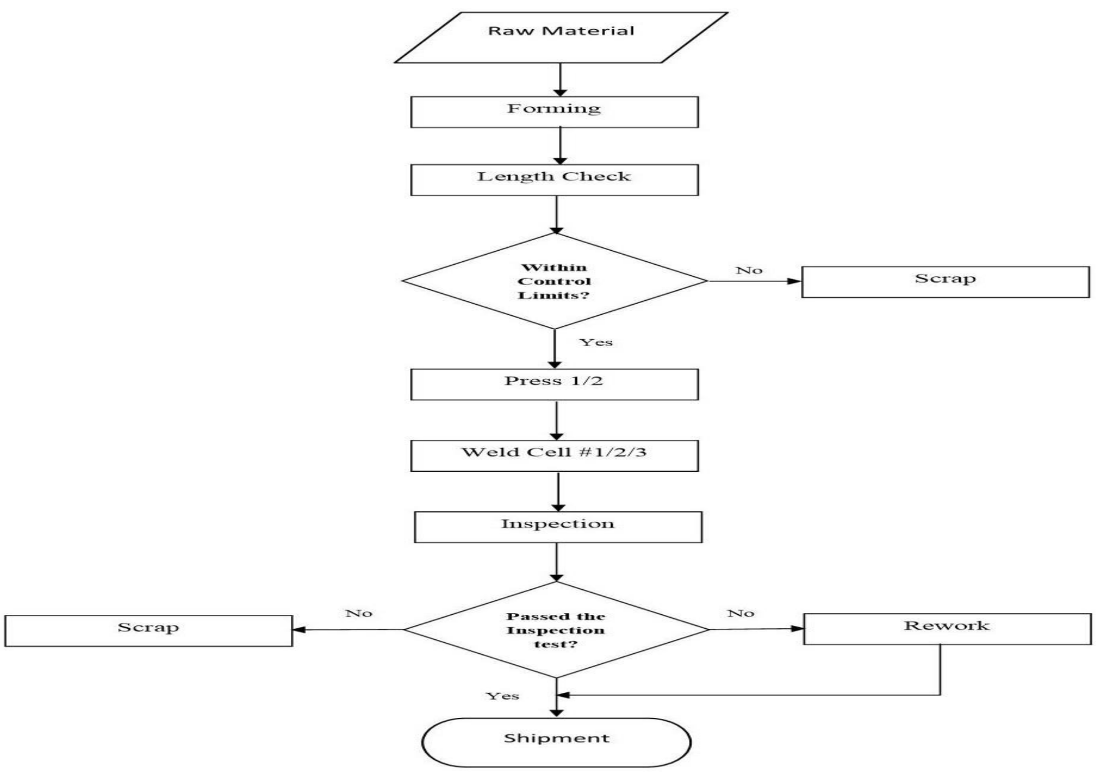


Figure. 2 Process flow Chart

1.3Problem description

The purpose of this project is to find the open and hidden problems in the company. The company is going through a high demand of the products and to match that demand the production facility must run on its full capacity.

- The Company is facing problem of accumulation of the inventory at every level of production.
- The welding unit has higher cycle time than takt value.
- There is also a need of rework at the roll form section which hampers the through put rate.
- The production lead time is very high.
- There is through put rate loss at the pressing machine section. The amount of scrape which the company is producing is much higher.

The company is not having a standardized way of movement during the operations resulting in the excess time consumption

2. Method

For overcoming the problems in this project, we have thoroughly used and implemented the lean manufacturing and six sigma tools such as value stream mapping, Kaizen, Ishikawa diagram, 5- Why analysis, FMEA and MODAPTS

2.1Value Stream Mapping

Value stream mapping (VSM) is a lean assembling system to investigate, plan, and deal with the progression of materials and data required to carry an item to a customer. It utilizes an arrangement of standard symbols to delineate different work streams and data streams. Things are mapped as value-adding or non-value adding from the customer's point of view, to find things that don't include value. [6]

Value stream mapping can be utilized to improve any procedure where there are repeatable advances – and particularly when there are numerous hands off. In assembling, hands off are easier to envision since they typically include the handoff of an unmistakable deliverable through stations. On the off chance that, for instance, an issue emerges when amassing a vehicle, line laborers can see the physical parts collecting and sticking up a specific piece of the sequential construction system. They would then be able to stop the line to take care of that issue and get the procedure streaming once more. [3]

2.2 Pareto

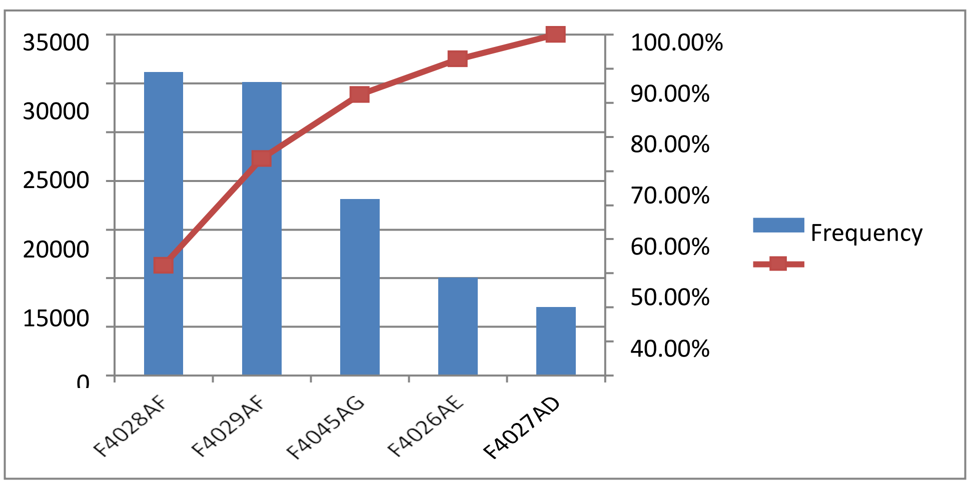


Figure 3 Pareto chart

Blue Sky Company does production of multiple products and they are running five different products. They are known by the F4028AF. F4029AF, F4045AG, F4026AE and F4027AD Among those five products, each product has different units of demand, the highest one is F4028AF with more than thirty thousand units a month. During a month, around eighty percent of the production quantity shared by the 28, 29 and 45 product number and only 28 parts has thirty percent of all production units. The pareto chart as shown represent the number of units demanded in a month and the cumulative percentage share of the product in total production units and it also shows that 80% of the problems are due to 20% of the causes.[5]

2.3 Current State VSM

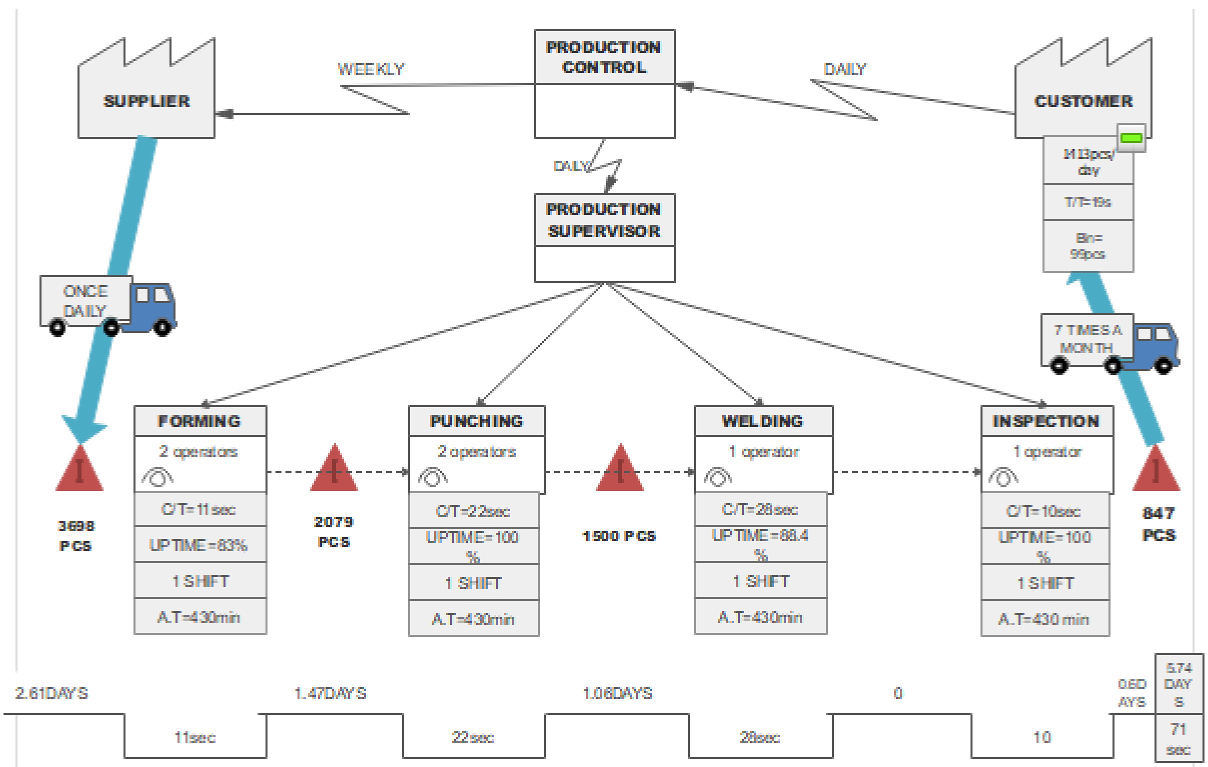


Figure 4 Current State VSM

The data for the cycle time, inventory and the other useful data of different processes was calculated and with the help of that the Current state Value stream Map (V.S.M) was drawn. At first, it was found that the 1413pcs of F4028 were needed per day by the customer and with the help of this takt time was calculated and it came out to be 58 seconds. Further, it was found that the current state value stream mapping consists of 4 main processes: Forming, Punching, Welding and Inspection. The cycle time for Forming process is 11seconds and 2 operators are operating the process. Further, the cycle time for Punching is 22seconds and 2 operators are operating the process. For Welding, only 1 operator is needed, and cycle time is 28 seconds. This is followed by inspection process which has the cycle time of 10seconds. So, total cycle time for all the processes is 71seconds and with the data of inventory, total lead time is calculated as 5.74 days.

Calculation for Takt Time:

Takt time is defined as the rate at which a product needs to be produced to meet customer demand. Takt Time (sec) = Time available/customer demand

Customer demand = 1413 parts of F4028 per shift Total Breaks = 50 minutes

Total available time = 480-50 = 430 minutes Takt time = 430*60/1413= 18.25 seconds

Calculation for Pitch:

Pitch= Takt time* pack-out quantity Pack-out quantity= 99

Takt time = 18.25 seconds

Pitch= 18.25*99 = 1806 seconds= 30.1 minutes

2.4 Overall Equipment Effectiveness current

Press Machine

Manufacturing an item is a complex process. Without measurements and rules, it is anything but difficult to lose control and have your business overseen by the production. Overall Equipment Effectiveness (OEE) is an apparatus that joins different manufacturing issues and information focuses to give data about the procedure. By dissecting and computing information, it likewise works as a structure for main driver examination. Through a reported procedure of consolidating the fundamental information OEE gives explicit procedure data. [4]

OEE= Availability * Performance * Quality

Calculation for Availability:

Shift Length= 480 minutes

Breaks= 50 minutes

Downtime= 0 minutes

Planned Production Time= Shift Length – Breaks= 480-50= 430 minutes

Operating Time= Planned Production Time – Down Time= 430-0= 430 minutes Availability= Operating Time/ Planned Production Time

= 100%

Calculation for Performance:

Ideal Cycle Time= 18 seconds

Actual Cycle Time= 22 seconds

Performance= Ideal Cycle Time/ Actual Cycle Time= 18/22 = 81.81%

Calculation for Quality Rate:

Quality = Good parts produced/Total parts produced Total parts produced= 1063

Rejected Pieces= 60 Good parts/shift = 1003

Quality = 1003/1063 = 94.35%

Overall Equipment Effectiveness= Availability * Performance * Quality

= 1 * 0.8181 * 0.9435

= 0.769 or 76.9%

Roll form

Calculation for Availability:

Shift Length= 480 minutes

Breaks= 50 minutes

Downtime= 70 minutes

Planned Production Time= Shift Length – Breaks= 480-50= 430 minutes Operating Time= Planned Production Time – Down Time= 430-70= 360 minutes Availability= Operating Time/ Planned Production Time

= 83%

Calculation for Performance:

Ideal Cycle Time= 9 seconds

Actual Cycle Time= 11 seconds

Performance= Ideal Cycle Time/ Actual Cycle Time= 9/11 = 81.81%

Calculation for Quality Rate:

Quality = Good parts produced/Total parts produced Total parts produced= 2079

Rejected Pieces= 114 Good parts/shift = 1965

Quality = 1965/2079 = 94.51%

Overall Equipment Effectiveness= Availability * Performance * Quality

= 0.83 * 0.8181 * 0.9451

= 0.6416 or 64.16%

Welding operation

Calculation for Availability:

Shift Length= 480 minutes

Breaks= 50 minutes

Downtime= 0 minutes

Planned Production Time= Shift Length – Breaks= 480-50= 430 minutes Operating Time= Planned Production Time – Down Time= 430-50= 380 minutes Availability= Operating Time/ Planned Production Time

= 88.37%

Calculation for Performance:

Ideal Cycle Time= 28 seconds

Actual Cycle Time= 28 seconds

Performance= Ideal Cycle Time/ Actual Cycle Time= 28/28 = 100%

Calculation for Quality Rate:

Quality = Good parts produced/Total parts produced Total parts produced= 99

Rejected Pieces= 5 Good parts/shift = 94

Quality = 94/99 = 94.94%

Overall Equipment Effectiveness= Availability * Performance * Quality

= 0.8837 * 1 * 0.9494

= 0.839 or 83.9%

2.5 Why Analysis (roll form)

The 5 why analysis has been done for the roll form section. In this analysis we addressed the issues like roller speed variation, decreased feed rate and poor sensor performance at the cutting machine. The reason the speed variation of the roller was roller chain stiffness and turned pin of the chain on further addressing this we can to know that main reason for this was the lack of lubrication and overload for a long period of time. This problem could be resolved by adopting the preventive maintenance during the changeover. Another problem that has been addressed here is decreased feed rate is due to the roller slipping over the raw material surface which is due to the decreased frictional force acting between the surface of the roller and the raw material which on further investigation made the point clear that this was due to the misaligned roller which generally happens due to the improper maintenance. Another prominent hindrance which addressed here is poor sensor performance at the cutting machine which has led to the variation in the length of the cutting machine.

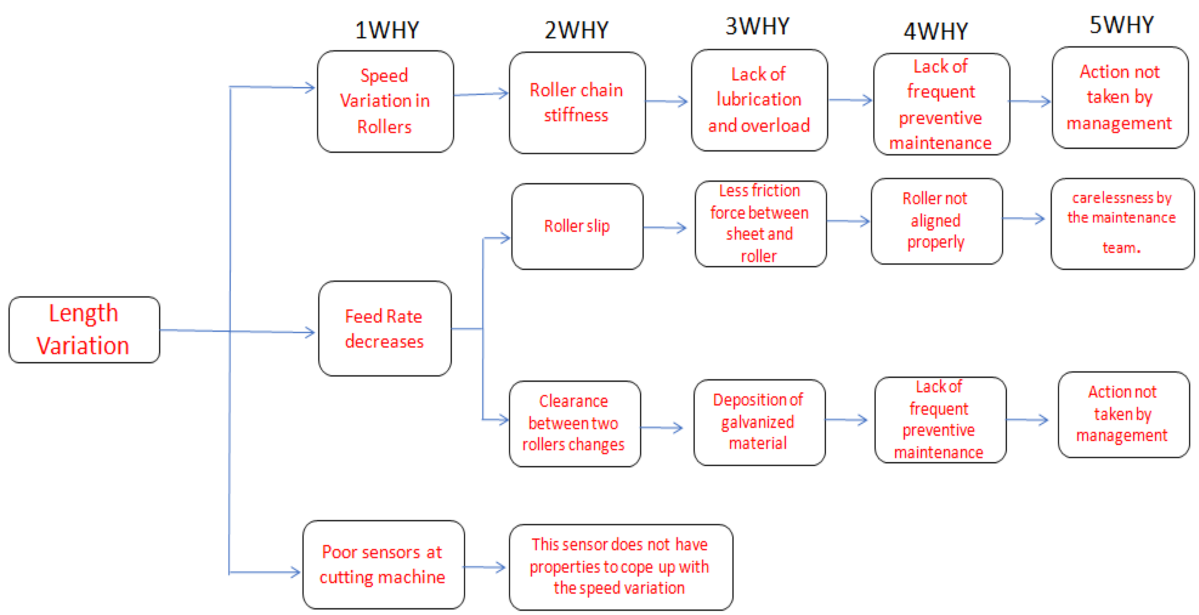


Figure 5 '5Why Analysis'

2.6 Cause and Effect Diagram

It is very important aspect to know a relationship of problem and root causes which can be classified into categories like man, machine, method and material. The above fig. is a cause and effect diagram know by the name fishbone diagram or the ishikawa diagram. From the FMEA it was very evident that the variation of length was a prominent failure mode. So, in this figure we have classified the section as man, machine, method and material. So, the section of men has two prominent causes, machine has three causes, material has two causes and method has one cause that is contributing to the effect.

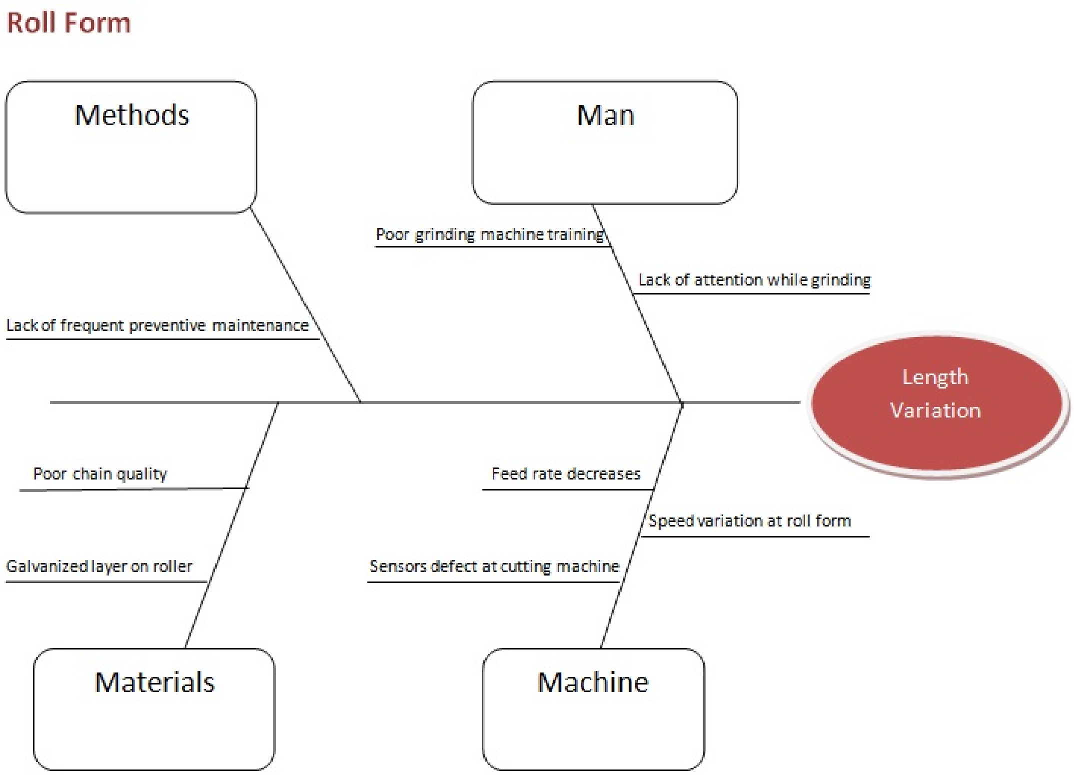


Figure 6 Fish-bone Diagram at roll form

5 Why Analysis (Press machine)

The 5Why approach was created by Sakichi Toyota the founder of Toyota. It is a critical component of problem solving and it is also known by the cause mapping. For the cause mapping purpose, we have used this 5why analysis at pressing machine. The major problem found out was the through put loss on further investigation we found out that excessive operator movement and delayed detection of plate by the sensors were the reasons for the through put loss. The reason for the excessive movement was lack of standardized motion adopted by the company and this could be understood with the point that the company does not perform motion study activity. The delayed detection of plate was due to the low sensitivity of the sensor or the quality has been belittled with the time. There are defective parts produced in this operation this was due to the fact the datum hole doesn't fit on the machine completely and this problem arises when datum hole is not punched precisely at the roll form operation. The variation in the speed of the roller with the punching operation gives rise to the variation in the distance of datum hole. The turned key of the chain is the culprit to for the variation in speed this could be prevented by adopting frequent preventive maintenance.

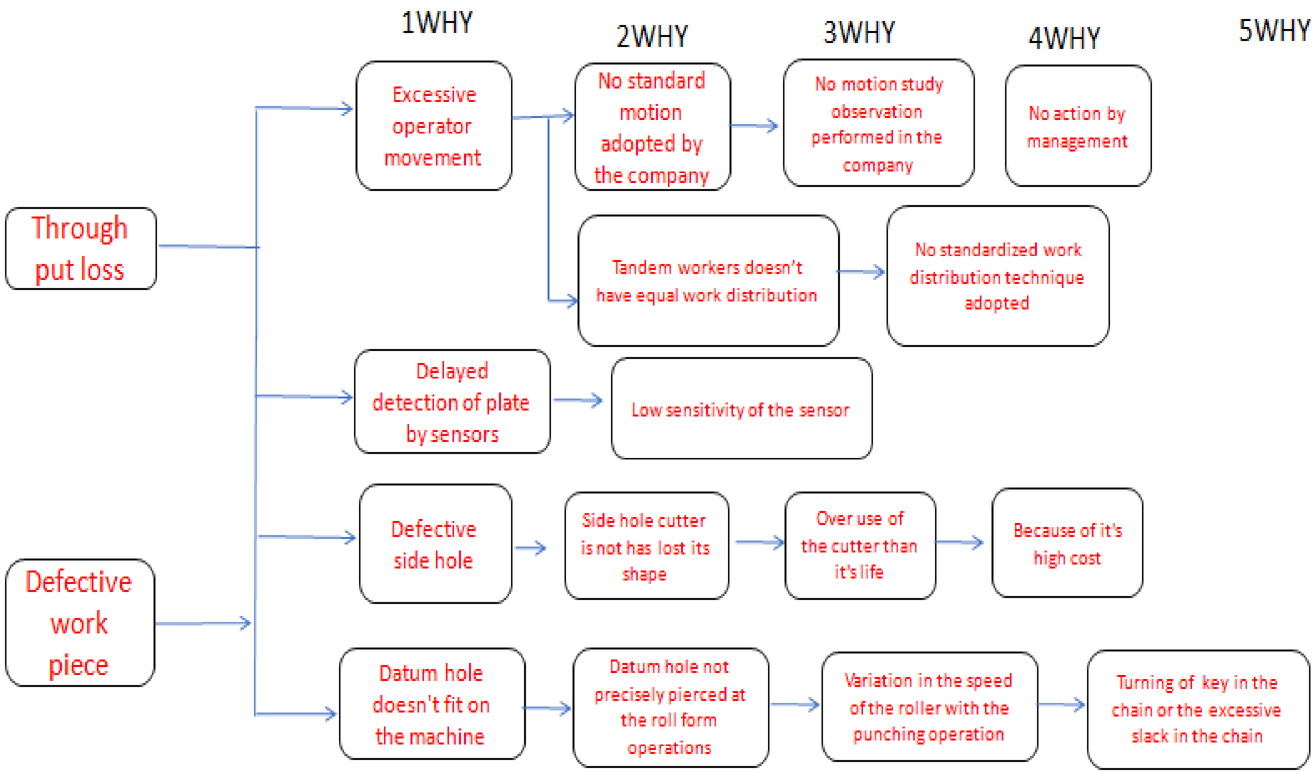
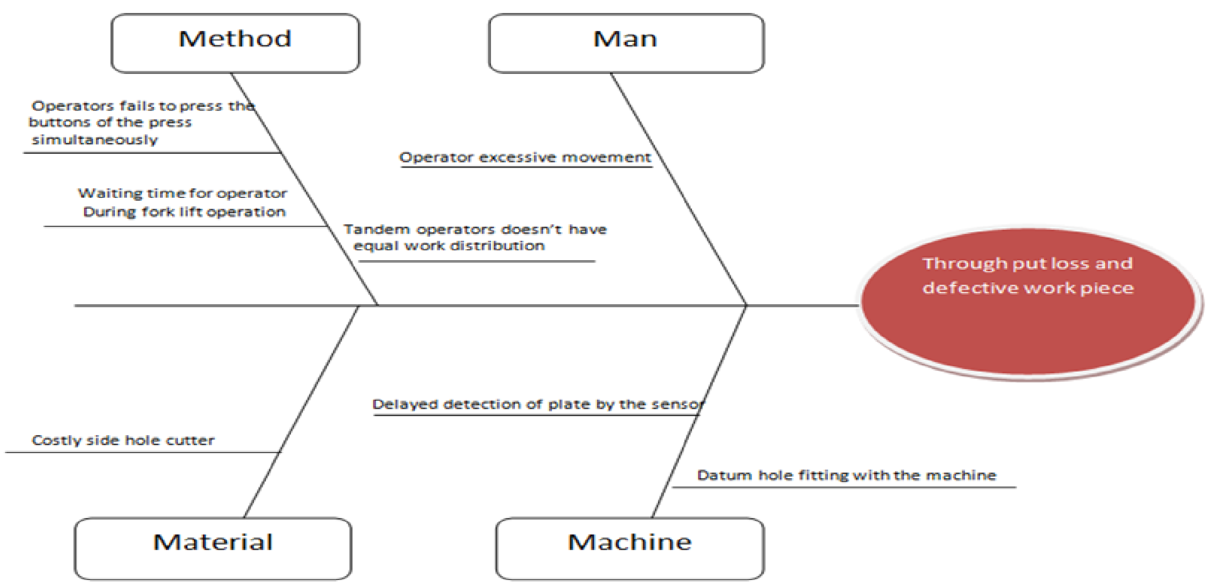


Figure 7 5Why analysis Press machine

Cause and effect diagram (Press Machine)



In this section of ishikawa diagram representation the man section has two causes, machine section has one cause, method section has two causes and the material section has no prominent cause for the effect.

Figure 8 FIsh-bone diagram (Press machine)

FMEA

Process step	Potential failure mode	Potential Effect	Severity Rating 1 To 10	Potential Effect	Occurrence Rating 1 To 10	Current Control	Detection Rating 10 To 1	RPN
Roll forming	Variation in the length	Longer length	2	Rework on grinding machine	4	Master measuring specimen	1	6
		Shorter length	10	Rejection	2	Master measuring specimen	1	20
Press operation	Misaligned hole axis	Misaligned hole axis	10	Rejection	2	Master measuring specimen	1	20
	Side hole partial opening	Side hole partial opening	5	Partial rejection	4	Master measuring specimen	1	20

Figure 9 FMEA

In the above table we have done the failure mode effect analysis for the process steps of roll forming and press operation. FMEA is a step by step approach which tries to cover all the possible ways of failures in designing, manufacturing and assembly processes. FMEA describes the how the failure can occur and which of the failure can be as severe as to lose a potential customer. FMEA consists of three rating section they are severity, occurrence and detection. Severity is rated on the scale of 1 to 10 in which rating 1 defines as the failure is not very severe and there is no customer loss where as a rating 10 defines as the failure is severe and the is a chance of losing a potential customer. Occurrence is rated on the scale of 1 to 10 where a rating 1 is given to least occurring failure mode and 10 is given to a high frequency occurring failure mode. Detection is rated based on how easy it is to detect a defect rating 1 is given for the failure mode that is easy to detect and a rating 10 is given to the failure mode which we cannot detect at all. The RPN (risk priority number) value which is accepted is less than 30.[7]

In the above table after FMEA analysis we got the results and concluded that variation in length with potential effect as shorter length has a lot of scope of improvement as it is having a higher risk priority no. i.e.20. Another failure mode that must take into the consideration too is press operation; the potential effect that must be taken care of is misaligned hole axis and side hole partial opening because they have very high RPN value i.e. 20.

MODAPTS

Modapts is the predetermined time standard of modular arrangement used for estimating the completion time based on task, breakdown and to deter value added non value added and necessary non value added activities. In addition, it helps to standardize the working procedure and steps to be followed by operator. This analysis is carried out on the press operation which contains required body movement to perform work and complete one cycle to make a part. Based on the study of operator's working movement from getting auxiliaries to all the way down passing completed part and return to original position. From real time study the following table shows the activities and their mods.

So, the total mods are 162 and the time is 20.89 seconds according to the observations. Here, the few corrections are: placing the tots at right angle instead of parallel to machine which will allow operator to turn only quarter circle instead of a half circle and place it quite close to operator so that excessive movement can be reduced; and the palm button to start the cycle can be brought as close as possible.

According to the actual time and motion study, we have monitored several cycles and the time for each cycle noted it varies from minimum 16.76 to the maximum 25.89. Were in some cycle the time was little bit more because of one of the operator's error or machine error. So, on an average the cycle time is 22 seconds.

Sr No	Element Description	Code or Reference	Frequency	MODs
1	Get auxiliaries	M4G1	2	10
2	Put on Die Left, Right	M4P2 M2P2	1	10
3	Look for Signal and decide	E2 D3	1	5
4	Turn 180 degree	M8	1	8
5	Walk 4 pace	W5	4	20
6	Get part (level varies)	M7G3 M7P0	1	17
7	Turn 180 Degree	M8	1	8
8	Walk 4 pace with part	W5	4	20
9	Put part on Die with matching hole	M2P5	1	7
10	Check signal and Decide	E3 D3	1	6
11	Walk 3 pace to press button	W5	3	15
12	Press button with both palm	M3P0	2	6
13	Walk 3 pace to press	W5	3	15
14	Get the part and pass on another side (use both hand for both operation)	M3G3 M5P2	1	13
15	Return to original position	M2P0	1	2
		Total		**162**

Table 1 Modapts

Therefore, after replacing the Table 2 MODAPTS for current state tasks with possible improvements the updated modapts study is as per the table shown above. So, the total mods here are 131 and the time is 16.89 seconds.[8]

Sr No	Element Description	Code or Reference	Frequency	MODs
1	Get auxiliaries	M4G0 M2G0	1	6
2	Put on Die Left, Right	M4P2 M2P2	1	10
3	Turn 90 degree	M7	1	7
4	Walk 3 pace	W5	3	15
5	Get part (level varies)	M7G3 M7P0	1	17
6	Turn 90 Degree	M7	1	7
7	Walk 3 pace with part	W5	3	15
8	Put part on Die with matching hole	M2P5	1	7
9	Check signal and Decide	E3 D3	1	6
10	Walk 1 pace to press button	W5	2	10
11	Press button with both palm	M3P0	2	6
12	Walk 1 pace to press	W5	2	10
13	Get the part and pass on another side (use both hand for both operation)	M3G3 M5P2	1	13
14	Return to original position	M2P0	1	2
		Total		**131**

Table 2 Modapts

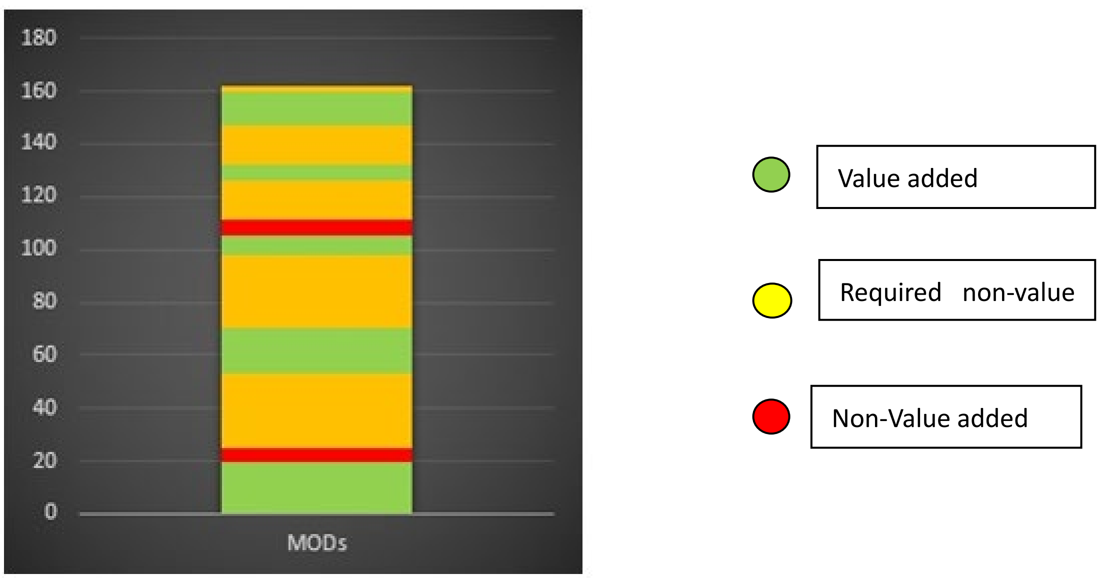
Yamazumi Chart

This is the Japanese word means to arrange one top of another. It can be presents using the bar graph and all the activities include in the process are stack up. It consists of value-adding activities, non-value adding activities and necessary non-value adding activities.

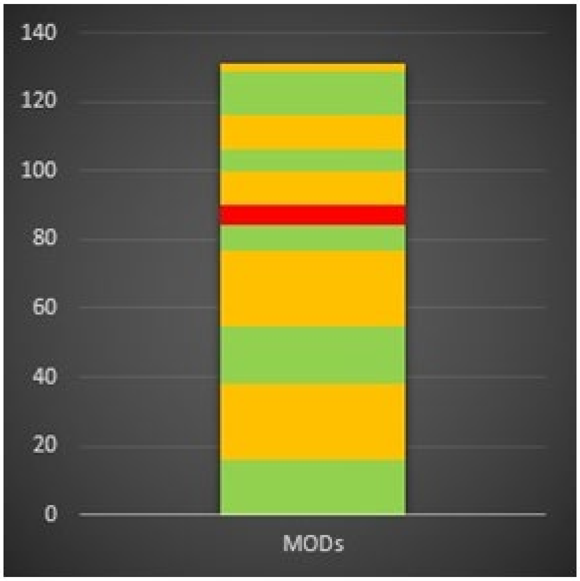
The first chart is the current state yamazumi chart shows the pile of activities in an operation. The green region shows the value-adding tasks, the yellow region represents necessary non-value adding activities, and the red region shows the non-value adding activities. For the making of yamazumi chart we did video recording at the press section, roll form section and the welding section. Then we tried to play all those videos pausing at various intervals and then playing again. So, on the close observation we got the idea that the major throughput loss is at the press section. The workers working on the tandem press were performing excess unwanted movements working at the press machine this resulted in the throughput loss. So in this yamazumi chart we have recorded the movements of operator, mods and the seconds they are taking to perform an activity. So the chart consists of three regions the green region shows the valued added activities means the activities which are adding value to the product. The next region is the yellow region which is the region of required non-value added activities these regions cannot be eliminated or ignored as this region is important like quality check. The last region is red colored region and this region is of non-value activities and our sole effort was to eliminate this region in the chart by eliminating all the excessive movement performed by the operator.

Using this chart, it is easy to interpret and identify the redundancy and make the better process flow.[9]

In the first yamazumi chart one can see there are two red zones in the chart this zone is of non-value added activities like getting auxiliaries and spending excess seconds than normal or looking for the signal and standing ideal for longer duration than normally expected.



From the second yamazumi chart, the view of future state process is clear and the impact of reducing non value added and necessary non value added activities can be seen. The sum of 31 mods from current state has reduced and a red colored section of non-value added activities has been eliminated.



Future State VSM

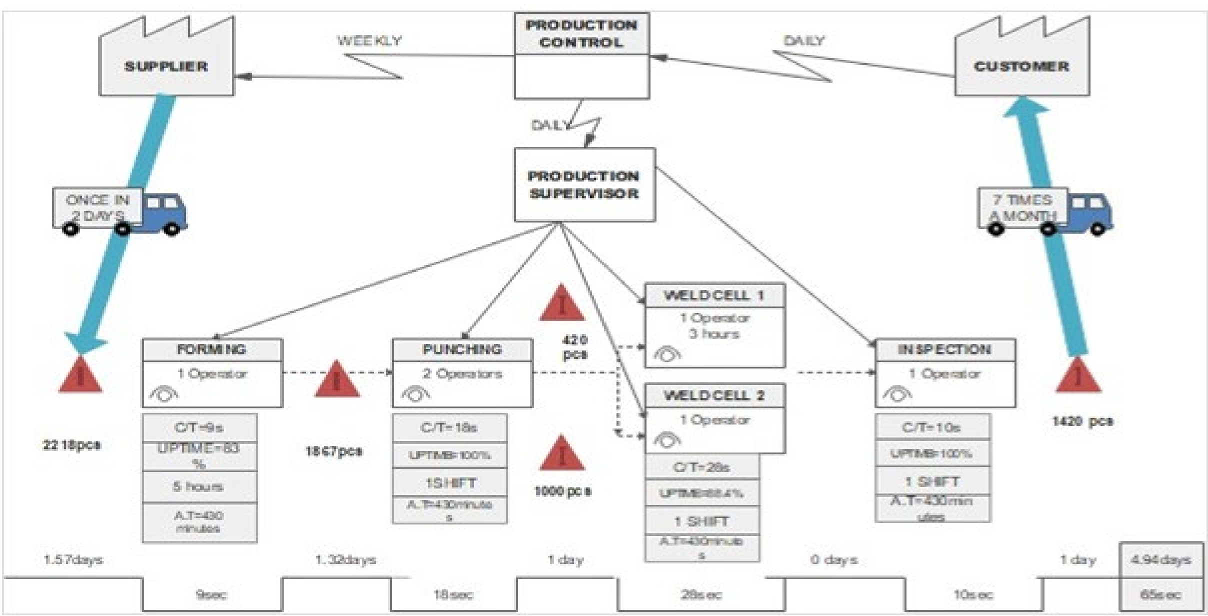


Figure 10

Strategy to achieve future state VSM

For the future state we propose that the supply of raw materials (sheet metal coil) is reduced to once in 2 days instead of daily as it will reduce the inventory at the starting which will eventually increase the manufacturing cycle efficiency. Further, we propose that the operator at forming process should work there for first 5 hours and the remaining time will work at weld cell 1. This way it will reduce the overburden on weld cell 2 operator and will help in attaining desired target. The operator at forming process will work for three-fourth of his shift time and in this case less inventory will accumulate after forming process. By doing MODAPTS on the operators at punching process and applying necessary improvements, the cycle time is reduced to 18 seconds which will ultimately results in increase in the number of parts made in one shift. The operator from forming process will then operate weld cell 1 and decrease the burden on weld cell 2 operators. Some part of the total inventory will be used by this operator for 3 days and remaining inventory will be used by the other operator at cell 2. This way he will help in achieving the production target of the company for one day.

Improved OEE

Roll Form

Calculation for Availability: Shift Length= 300 minutes

Breaks= 50 minutes

Downtime= 20 minutes

Planned Production Time= Shift Length – Breaks= 300-50= 250 minutes Operating Time= Planned Production Time – Down Time= 250-20= 230 minutes Availability= Operating Time/ Planned Production Time

= 92%

Calculation for Performance: Ideal Cycle Time= 9 seconds

Actual Cycle Time= 9 seconds

Performance= Ideal Cycle Time/ Actual Cycle Time= 9/9 = 100%

Calculation for Quality Rate:

Quality = Good parts produced/Total parts produced Total parts produced= 1867

Rejected Pieces= 10 Good parts/shift = 1857

Quality = 1857/1867 = 99.46%

Overall Equipment Effectiveness= Availability * Performance * Quality

= 0.92 * 1 * 0.9946

= 0.915 or 91.5%

Pressing Operation

Calculation for Availability: Shift Length= 480 minutes

Breaks= 50 minutes

Downtime= 40 minutes

Planned Production Time= Shift Length – Breaks= 480-50= 430 minutes Operating Time= Planned Production Time – Down Time= 430-40= 390 minutes Availability= Operating Time/ Planned Production Time

= 90.69%

Calculation for Performance: Ideal Cycle Time= 18 seconds

Actual Cycle Time= 18 seconds

Performance= Ideal Cycle Time/ Actual Cycle Time= 18/18 = 100%

Calculation for Quality Rate:

Quality = Good parts produced/Total parts produced Total parts produced= 1420

Rejected Pieces= 15 Good parts/shift = 1405

Quality = 1405/1420 = 98.94%

Overall Equipment Effectiveness= Availability * Performance * Quality

= 0.9069 *1* 0.9894 = 0.8972 or 89.72%

Conclusion and Result

With the application of various lean tools we analyzed the whole process and steps involved in the manufacturing and here we are proposing the final solution to the problems:

1. The inventory accumulation can be eliminated by improving the cycle time of roll form and press machine operation from 11sec to 9sec, 22sec to 18sec respectively.
2. The ideal cycle time at roll form is achieved by introducing an Omron ZW-8000 / 7000 / 5000 Series sensors. [10]These sensors are high precision sensor and can easily work on a reflecting surface. And hence we can get rid of the variation in length of the product which would eventually save our time on rework.
3. The application of MODAPTS helped us in mapping the excessive movement that was been performed by the operator. On restricting the motion of operator on pressing machine has helped us to achieve the ideal cycle time i.e. 18sec.
4. Finally we started a new weld cell (already present in the plant) for 3 hours in a 8 hours shift and restricting the roll form operation for 5 hours and enabling that one operator to work in the new weld cell for 3 hours creating a multi skill environment hence can increase the overall efficiency of the cycle
5. The current state VSM cycle efficiency comes out to be 0.047% and the future state VSM cycle efficiency comes out to be 0.0509%.

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