Single minute exchange of die in coil manufacturing unit.

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Abstract— It is said that perfection is always not attainable. But in the race of attaining perfection in manufacturing techniques, one achieves excellence. To stand apart in today's globalized world and to survive cutthroat competitions, manufacturers are in dire need to find ways to reduce production times and cost without compromising on product quality. In view of reducing production times, a biggest opportunity lies in reducing set-up time for machines. It is usually possible to reduce the set-up times to a large extent with fantastic results through better team work, better planning, simple modification, continuous improvements. The main objective of this project is to reduce set-up time of expander machine in condenser coil manufacturing unit by using Single Minute Exchange of Dies (SMED). This Study is carried out in one of the condenser coil manufacturing unit. The SMED system proved a track record in many types of industries. The results Shows that reduction i9n set up time is possible by certain work method changes. Single Minute Exchange of Dies (SMED) is the approach to increase output

***Index Terms*— SMED, Cycle Time, Internal and External Activity, bottleneck**

I INTRODUCTION

due to the intricacy of market order and Competitiveness, many Manufacturing Organizations are under Pressure to produce and dispatch products in shorter delivery times. In the past a lot of effort has been put to reducing the cycle time and speeding up the output rate whilst totally ignoring the change overtime from one product to another. This has lead to the Economic batch quantity Concept and has resulted in small batches appearing to be Uneconomical to run. Reducing Setup times (Which we rarely Concentrate on) can give the Equivalent of huge increase in process speed (Which we almost and always concentrate on).This is all achieved without detriment to the quality of the Product. The idea of a setup time reduction Plan is move towards SMED (Single Minute Exchange Die) or OTED (one touch Exchange of dies). Three main reasons for setup reduction are:

a) Flexibility:- To be able to respond very quickly to changing market demands,you need to be able to produce small lot sizes in an a economical way.

b) Bottleneck Capacities:- Reducing setup times increases the available capacity, Which can be interesting as an alternatives to buying new equipment or installing an extra shift in situations where the market demand increases

c) Cost Reduction: - Since, especially on bottlenecks, the direct production cost is related to machine performance

II PROCESS

The plant is equipped with the most advanced technology to produce condenser coils. The important machines in the coil shop are fin press machine, tube bending machine, expander machine, auto-brazing machine, coil bending machine, water deep testing setup, and drying oven. The flow diagram of coil shop is shown. At the fin press, the aluminum sheet is cut according to the width of the coil. This piece of punched coil is called "fin." The fins are stacked according to the height of the coil. At the hair pin bender machine, the copper tubes are bent and cut into size according to the height of the coil. At the lacing table, the punched fins and copper tubes are assembled by inserting tubes into fins. Then, the assembly is taken to expander machine. At the expander machine, the coil assembly is mounted vertically on the machine, and the expansion bullet is passed through inner grooved copper tubes. After expansion, the fins get firmly locked with copper tubes. The coils then pass through the auto-brazing machine to close the open ends of the coils. The coils are then taken to coil bending machine, when bending is needed in the coil. The header and capillaries are then brazed with the coil at the manual brazing station. Finally, the coil is tested for brazing joint at water deep testing stage and subsequently dried in the oven.

III Problem definition

The expander machine has a very high setup time of 57 minutes. The objective of the project is to reduce the set up time of the expander machine.

IV Data collection and analysis.

It is vital to understand the machine configuration and setup procedure. The following figure shows the machine with operators and key components of the machine. The current setup time of expander is about 60min. The target is to reduce the setup time to minimum possible level using SMED techniques.

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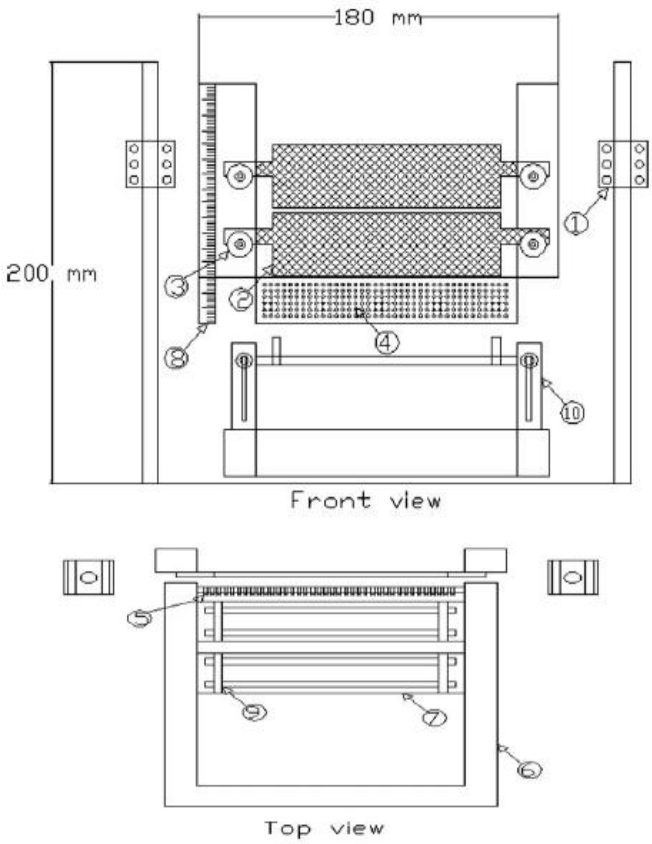

Fig: expander machine front and top view. Expander machine front and top view

1 Holding block, 2 Back plates, 3 Back plate washer, 4 receiver plate, 5 Receivers, 6 Aluminium frame, 7 Door plate,8 Scale,9 Side stopper,10 Door plate support.

The whole process of setup is then divided into small elements so as to assess whether the element is external or internal. External elements are those that can be performed while the machine is working, whereas for carrying out internal elements, machine needs to be stopped. In case the element is internal, the possibility of converting that element into external element is investigated. Each element is examined to identify the scope of improving the element time by improving design and work method that involve human, machine, and material. Key steps in setup of expander are holding block setup, back plate setup, row change setup, receiver circuit setup, door plate setup, and side stopper setup. The steps are stated below:

Step 1 Holding block setup:
For adjusting the height, the holding block is loosened up and hooked up with the ram of the expander. The ram of expander is then adjusted by using control panel. The rough reference is taken by the scale attached at the one side of the machine. One operator controls the panel and makes the necessary adjustment according to the direction given by the other operator. Once the height of expander is setup, the holding blocks are tightened firmly by using pneumatic torque wrench.

Step 2 Back plate setup:
The back plate is a part of the expander that supports the coils from behind during the expansion process. The plates are made up of aluminium with steel structure supporting it. The weight of each plate is around 50 lbs. The plates are lifted manually by two operators and mounted on vertical frame of the expander. The plates are then adjusted for its horizontal inclination. The process involves trial and error. A wrong alignment can cause quality problems. There is also a significant risk of safety hazard due to heavy weight of plates.

Step 3 Row setup:
Row setup is needed whenever setup is done for a coil which has different coil thickness (number of layers) with respect to the previous coil. The aluminium frame is positioned vertically to set the row and disconnected and pushed forward or backward depending on the row of the coil for which the changeover (setup) is done. There is a safety hazard or risk due to the possibility of the heavy aluminium frame getting toppled and causing an injury.

Step 4 Receiver circuit setup:
In this step, the receivers are fit in the receiver plate by hammering the receivers in receiver plate holes. There is a push fit joint between the receiver and the receiver plate.

Step 5 Door plate setup:
Door plates are mounted on the door frame. The number of door plates to be mounted depends on the height of a coil. Door plates are made up of aluminium with mild steel structure providing the necessary rigidity to the entire structure. Each plate weighs around 50 lbs. The plates are preassembled with L-shape door plate supports. The whole assembly is lifted manually and mounted on the door frame. The surfaces of all door plates are then aligned by making fine adjustment in joints between the door plate and the door plate support.

Step 6 Side stopper setup:
In this step, the side stoppers are mounted in the groove of the door plate. The height of the side stoppers depend on the

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width of the coil. For multiple rows of the coil, additional height attachment is mounted on the side stopper.

Before trying to improve the process it is of utmost importance to understand the procedure of set up in detail. The following table shows the detailed element-wise analysis of the setup of expander. The whole setup is divided into 18 different elements (10–180). Each element is defined as external or internal element (in this case all the elements are internal).

Table: current set up of expander machine.

Sl no	operation	Total time (mins)
1	Loose the stopper	0.52
2	Take the ram down and touch to the holding block	0.18
3	Lock the holding hook with ram	0.30
4	Loosen the holding block	0.57
5	Take the ram up with the holding block	0.12
6	Adjust the height	0.37
7	Fasten the holding block	1.20
8	Verify holding block fitment by taking blank stroke	1.32
9	Change the row as per coil rows	9.81
10	Adjust and fit the back plates	11.23
11	Adjust the door plates	10.50
12	Receiver fitment in plate	9.46
13	Make coarse setiing of side stopper	3.65
14	Load the coil and fine adjustment of side stopper	1.90
15	Lift the coil and check alignment, adjust height	2.50
16	Tighten the height stopper	1.40
17	Bring tube sheet from rack	0.50
18	Take the coil down and fit the tube sheet	2
19	Tighten the side stopper	0.45

To generate ideas for improvement, the Gemba (hands-on-Kaizen) is conducted. The participants were shop floor engineers and experienced operators. Following suggestions are made after brain storming sessions at the workplace. It is expected that the design change will eliminate all the non value added contents, and thus, element time will be reduced accordingly. The suggestions are made to simplify the design of the key component like receiver plate, aluminium frame holding mechanism, holding block, back plate, door plate support, door plates, etc. three design Kaizens were proposed to change the design of key setup elements or components.

(Kaizen 1) shows the design change (before and after) of the row change mechanism. Earlier the aluminium frame of the machine had to be adjusted manually for different number of coil row. The operation was very risky due to safety hazard and took a long time to perform, as the aluminium frame had to be dismantled and moved manually, depending on the number of rows of the coil. In the proposed Kaizen 1, the aluminium frame is fixed with an upper plate, which works as a gear rack and is connected with a pinion gear. Furthermore, the upper plate is locked with lower plate with grooved joint, enabling plates to slide over each other by gear rack and gear pinion and also keeping them in contact thus avoiding the risk of toppling of aluminium frame

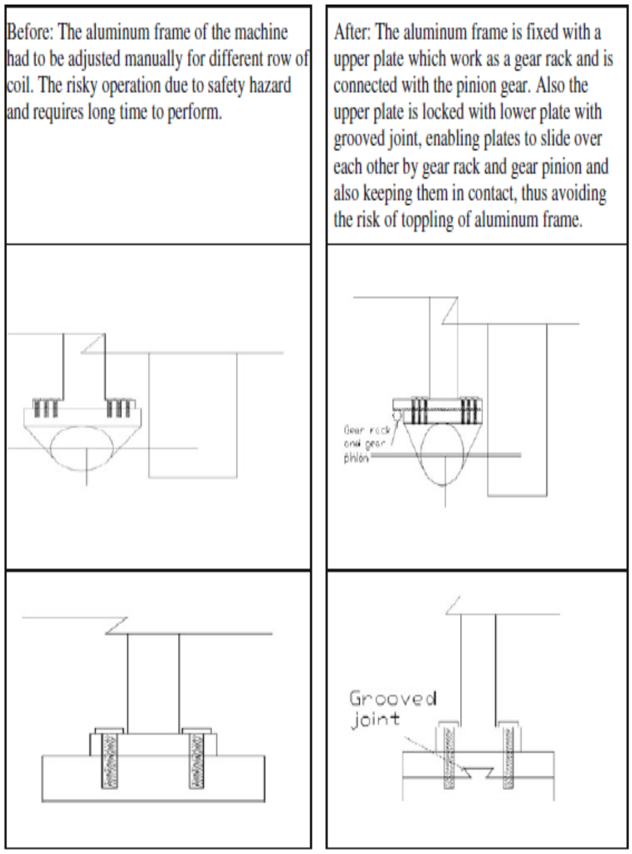

Fig: design change of row change mechanism.

(Kaizen 2) shows the design change of the back plate mounting mechanism. Earlier, the back plates were adjusted vertically by lifting the heavy back plate (50 lbs) manually and aligning the plate surface visually, which consumed considerable amount of time and was prone to visual error. In the proposed Kaizen 2, the round spacer of the back plate holder is changed to a rectangular spacer for easy and accurate vertical referencing from the scale. In addition, the

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scales are mounted on both side of machine. In the proposed method, the back plate bolts are tightened at the same level first, and then back plates are mounted directly over them. This new operation eliminates the need of visual adjustment.

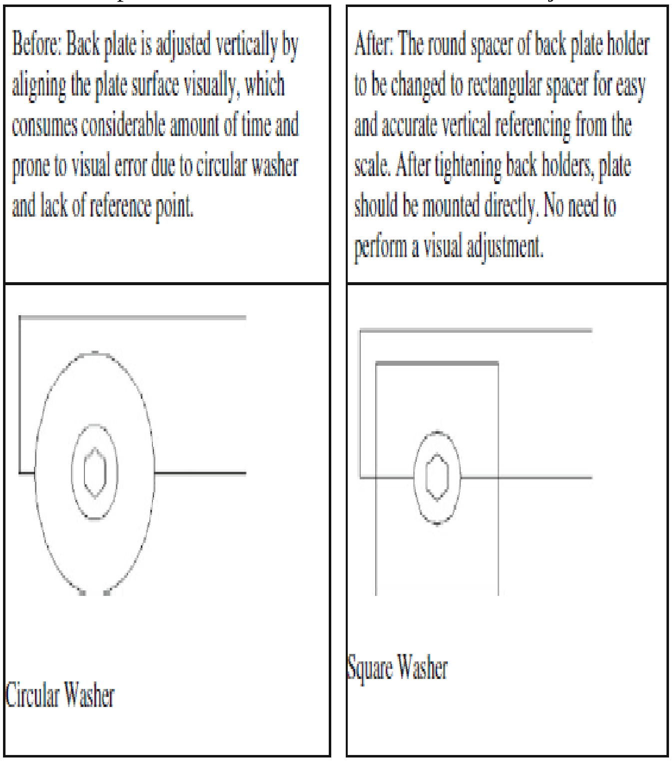

Fig: design change of back plate.

(Kaizen 3) shows the design change of door plate mounting mechanism. Earlier, door plates were fixed in the groove of door plate support frame. Due to the open groove, the plated setting was disturbed during production requiring it to be readjusted during setup. In the proposed Kaizen 3, the continuous groove is replaced by a fixed hole joint and thus fixing the door plates firmly in the position.

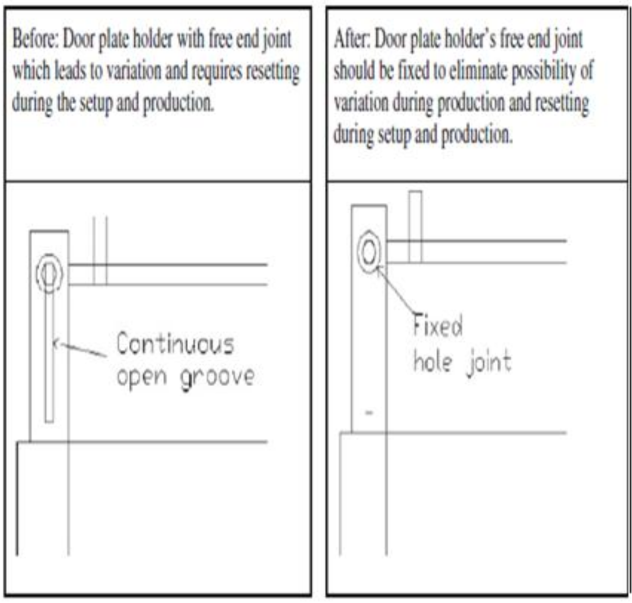

Fig: design change of door plate.

The improvements in other Kaizen targeting changes in work method are as follows:

- Provide scale at both side of the expander to avoid visual adjustment error.
- Keep the expander accessories on a movable trolley, which can be easily brought near when the setup is going on to save travelling time.
- Provide separate tool sets for operators involved in setup to avoid waiting and delay.
- Use pneumatic tools in place of manual tools.
- Provide individual sets of side stopper for one to four rows of coils to avoid side stopper height setup (one touch).

Table: future setup of expander machine.

Sl no	Operation	Earlier time (mins)	Expected time(mins)
1	Loose the stopper	0.52	0.27
2	Take the ram down and touch to the holding block	0.18	0.18
3	Lock the holding hook with ram	0.30	0.17
4	Loosen the holding block	0.57	0.28
5	Take the ram up with the holding block	0.12	0.12
6	Adjust the height	0.37	0.37
7	Fasten the holding block	1.20	0.60
8	Verify holding block fitment by taking blank stroke	1.32	1.32
9	Change the row as per coil rows	9.81	2.15
10	Adjust and fit the back plates	11.23	2.18
11	Adjust the door plates	10.50	2.0
12	Receiver fitment in plate	9.46	9.46
13	Make coarse setting of side stopper	3.65	3.65
14	Load the coil and fine adjustment of side stop	1.90	1.20
15	Lift the coil and check alignment, adjust	2.50	2.50

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	height		
16	Tighten the height stopper	1.40	1.20
17	Bring tube sheet from rack	0.50	0
18	Take the coil down and fit the tube sheet	2	2
19	Tighten the side stopper	0.45	0.45

Current change over time for the expander machine has been reduced from 00:57:98 to 00:30:1.

Measured time before project: 00:57:98

Estimated project time: 00:30:1

Time saved after implementation: 00:27:88

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Estimated project time: 00:30:1

Time saved after implementation: 00:27:88

V Conclusion

- SMED and Kaizen (continuous improvement) were employed to reduce setup time of the expander machine from 57.98 to 30.1mins
- . Several innovative Kaizens (continuous improvement) design change or improvements were proposed to reduce the setup time of the expander. The Kaizen design included rack (gear) and pinion (gear) mechanism for row change, using rectangular spacer and scale on both sides of the machine for the easy alignment of back plates, fixing the location of the door plate in door frame to eliminate the possibility of variation and need for readjustment
- . Several Kaizen target changes in work methods were proposed that included providing scale at both sides of expander, keeping expander accessories on a movable trolley, providing separate tool sets for operators and using pneumatic tools instead of manual tools.

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