The Application of Lean Production on Punching Line of F Company
Yu-bin ZHENG*, Gui-xiang SHEN, Bin YANG and Bin LIU
School of Mechanical Science and Engineering, Jilin University Changchun, 130000, China
*Corresponding author

Keywords: Punching line, Lean production, Single minute exchange of die, ECRS principles.

Abstract. This paper systematically analysis the production situation of the punching line of F Company, and uses Single Minute Exchange of Die, Process Flow Diagram and ECRS principles to improve the punching line. After the improvement, the time that needed to exchange the die is shortened to half of the original.

Introduction
F Company aims at the development and production of parts of saloon cars, and it mainly produce punching part and weld assembly. The company implements a production mode that is called Multi-specification & Small-batch, and each workshop should produce hundreds of products, so that workers have to exchange the mold frequently. If the company can not systematically standardize their ways of die exchange, their productivity would be limited. This paper takes the punching line of F Company as an example, and illuminates the application of Single Minute Exchange of Die to reduce the time it takes.

Single Minute Exchange of Die
Die exchange, also known as Settings or Preparation, is the practice that change a line or machine from running one product to the next. The process of die exchange is mainly composed by 4 parts: Preparation, die exchange, adjustment, readjustment[1,2].

The SMED is a Process improvement method that base on industrial engineering to reduce the time it takes to exchange die, and setup or adjust the equipment. The name Single-Minute Exchange of Dies comes from the goal of reducing changeover times to the “single” digits, in other words, it means to reduce changeover times to less than 10 minutes[3].

In SMED, the changeover time includes the following parts[4]:

1. Internal changeover time (must be completed while the equipment is stopped);
2. External changeover time (can be completed while the equipment is running);
3. Adjustment time (guarantee the quality and deal with failure while the equipment is stopped).

The Original Changeover Process
The punching line of F Company is located in the press shop, and mainly consists of 4 machine tools, which are called C1, C2, D1, D2, respectively. Those equipment are responsible for processing cutting angle, drawing, shaping and marking, and trimming. The overall layout of the punching line is shown in Figure 1. And Table 1 illustrates the original changeover process, which is based on On-site Data and facts.

Table 1 illustrates the original changeover process, which is based on On-site Data and facts. As table 1 indicates, the process takes 51.6 minutes in total, and workers need to move 69 meters. In addition to that, there are 29 activities, including 18 operations, 9 moves, 1 storage, and 1 hold. All of this make the line become so inefficiency, so that, the workers failed to completed production plans on time.

After a series of study and analysis, we can find out the primary causes of this line:
(1) The management of F Company did not pay enough attention to SMED, and workers don't know how to achieve this techniques without several full strategy guides, such as standard operation instruction.
(2) The workers did not realize the benefits of SMED, and they just exchange die by rule of thumb.
(3) Forklifts and cranes can’t meet the request of SMED.
(4) There is only one set of tools to exchange die, and they were kept in random order, which wasted a lot of time.

Table 1. The original changeover process.

| Title                          | Activity Name                        | Equipment | Distance [m] | Time [min] | Number of workers |
|-------------------------------|--------------------------------------|-----------|--------------|------------|------------------|
| Downtime                      | 1                                    | 0.3       | 1            |            |                  |
| Take the crane to the storage area of die | 2                                    | crane     | 12           | 1.2        | 1                |
| Put die on the crane          | 3                                    |          | 0.1          | 1          |                  |
| Unload die                    | 4                                    |          | 0.5          | 1          |                  |
| Keep die in place             | 5                                    |          | 0.3          | 1          |                  |
| Move die to the machine tool  | 6                                    | 5         | 4.2          | 1          |                  |

Table 1. The original changeover process (continued)

| Title                          | Activity Name                        | Equipment | Distance [m] | Time [min] | Number of workers |
|-------------------------------|--------------------------------------|-----------|--------------|------------|------------------|
| Get the dismantling tools     | 7                                    | 3         | 0.1          | 1          |                  |
| Bring the tools back          | 8                                    | 3         | 0.1          | 1          |                  |
| Dismantle the old die         | 9                                    | 3.1       | 1            |            |                  |
| Inform the forklift           | 10                                   | 32        | 0.1          | 1          |                  |
| Wait                          | 11                                   | 6.7       | 1            |            |                  |
| Take the old die down         | 12                                   | forklift  | 4.3          | 1          |                  |
| Clean up                      | 13                                   | 0.5       | 1            |            |                  |
| Put the new die on the right place | 14                                   | forklift  | 5.2          | 1          |                  |
| Adjust and locate the die     | 15                                   | 5.7       | 1            |            |                  |
| Get the dismantling tools     | 16                                   | 3         | 0.1          | 1          |                  |
| Install the die               | 17                                   | 8.9       | 1            |            |                  |
| Get raw material              | 18                                   | 5         | 0.2          | 1          |                  |
| Load                          | 19                                   | 0.1       | 1            |            |                  |
| Trial production              | 20                                   | 0.3       | 1            |            |                  |
| Take the production down      | 21                                   | 0.1       | 1            |            |                  |
| Inspection                    | 22                                   | 0.8       | 1            |            |                  |
| Put waste into the waste containers | 23                                   | 0.1       | 1            |            |                  |
| Adjust the die                | 24                                   | 3.2       | 1            |            |                  |
| Trial production, until products up to standard | 25                                   | 5.0       | 1            |            |                  |
| Pick up tools                 | 26                                   | 0.3       | 1            |            |                  |
| Put the tools back to the toolbox | 27                                   | 3         | 0.1          | 1          |                  |
| Back to the machine tool      | 28                                   | 3         | 1            |            |                  |
| Normal production             | 29                                   | 3         | 1            |            |                  |

| Total | 29 | 2 | 69 | 51.6 | 1 | 18 | 9 | 1 | 1 |
Improvement Method

The SMED aims at decreasing internal changeover time, and converting as many changeover steps as possible to external steps[5].

The key point of the SMED is shown in Table 2:

Table 2. The key point of the SMED.

| External changeover                  | Internal changeover                  |
|--------------------------------------|--------------------------------------|
| • prepare for the presentation       | • tools (type\amount)                |
| • do not have to search              | • site                                |
| • do not move                        | • placement                           |
| • do not messed with tools           | • put in order, rectify               |
| • prepare for the accessory equipment| • sequence of activities              |
| • inspect fixtures                   | • prevent redoing the same activity   |
| • do not have to search              | • unified method                      |
| • do not move                        | • job sharing                         |
| • do not messed with tools           | • effectiveness                       |
| • prepare for the accessory equipment| • parallel job                        |
| • inspect fixtures                   | • work simplification                 |
| • do not have to search              | • manner of fastening                 |
| • do not move                        | • reduce fastening device             |
| • do not messed with tools           | • the Shape and Structure of die and fixtures|
| • prepare for the accessory equipment| • special tooling                     |
| • inspect fixtures                   | • unification of die and fixtures     |
| • do not have to search              |                                       |
| • do not move                        |                                       |
| • do not messed with tools           |                                       |

Then, applying ECRS principles and Process Flow Diagram to improve the line[6], as shown in table 3. And table 4 illuminates the improved process of die exchange.

Table 3. ECRS analysis table.

| Improvement principles | prompt                        | Judgement | Survey                                                         |
|------------------------|-------------------------------|-----------|                                                               |
| cancel                 | Whether the workers can take the die without crane? | Yes       | Increase several smaller storage area of die.                 |
|                        | Whether the workers have to wait the forklift? | No        | Notify the forklift in advance.                                |
|                        | Whether the workers have to clean up the workbench? | Yes       | The workers have to clean up the workbench.                   |
|                        | Whether the workers can get the tools while the equipment is running? | Yes       | Get the tools before downtime.                                |
| merge                  | Whether the adjustment and trial | No        | Workers should adjust the die in place.                       |
Whether the internal changover time can be converted to external changover time?

Yes

Finish the activities that do no need to stop the equipment before downtime.

Whether the changeover process can be simplified?

Yes

Simplify the activities, such as get the tools.

Table 4. The improved process of die exchange.

| Title                                      | Data                  |
|--------------------------------------------|-----------------------|
| **Activity Name**                         | **Equipment**         | **Distance** | **Time** | **Number of workers** |
| 1 Downtime                                 |                       | 0.3          | 1        | 1                   |
| 2 Dismantle the old die                    |                       | 1.5          | 2        | 2                   |
| 3 Take the old die down                    | forklift              | 3.5          | 2        | 2                   |
| 4 Clean up                                 |                       | 0.3          | 2        | 2                   |
| 5 Put the new die on the right place       | forklift              | 4.5          | 2        | 2                   |
| 6 Adjust and locate the die                |                       | 3.5          | 2        | 2                   |
| 7 Install the die                          |                       | 4.5          | 2        | 2                   |
| 8 Load raw material                        |                       | 0.1          | 1        | 1                   |
| 9 Trial production                         |                       | 0.3          | 2        | 2                   |
| 10 Take the production down                |                       | 0.1          | 2        | 2                   |
| 11 Inspection                              |                       | 0.5          | 2        | 2                   |
| 12 Put waster into the waste containers    |                       | 0.1          | 1        | 1                   |
| 13 Adjust the die                          |                       | 2.1          | 2        | 2                   |
| 14 Trial production, until products up to standard |               | 2.5          | 2        | 2                   |
| 15 Pick up tools                           |                       | 0.3          | 2        | 2                   |
| 16 Put the tools back to the toolbox       |                       | 3            | 0.1      | 2                   |
| 17 Back to the machine tool                |                       | 3            | 2        | 2                   |
| 18 Normal production                       |                       |              |          |                     |
| **Total**                                  | 18                    | 1            | 6        | 24.2                |
|                                            | 2                    | 15           | 2        | 1                   |
|                                            | 0                    |              |          |                     |

**Conclusions**

By analyzing the field data, the paper aims to apply Single Minute Exchange of Die, ECRS principles, and Process Flow Diagram to improvement the punching line of F Company, and describes in detail the improvement process. After the improvement,

1. The changeover time of punching line of F Company has decreased from 51.6 minutes to 24.2 minutes;
2. The number of activities has decreased from 29 to 18;
3. The walking distance of workers has decreased from 69m to 6m.

All of those make workers much more productive, and reduce their labour intensity. By the way, the changeover time still can’t meet the requirement of SMED, so that, it is necessary for the F Company to import new technologies and systems.

**Acknowledgement**

This research was financially supported by the “High-end CNC Machine Tools & Basic Manufacturing Equipment” National Science and Technology Major Project of China (No. 2015ZX04003002).
References

[1] Hong-guang Wang, Li-li Zhang, Sheng-li WANG. The Application of Quick Die Change Technology in Big and Medium Bus of Pressing Machining[J]. Equipment Manufacturing Technology, 2009, 04:139-141.

[2] Shi-li LU, Jian-sha Lu, Min-fang Jiang. The Study of SMED in Lean Production[J]. Light Industry Machinery, 2006, 04:91-93.

[3] Yun-fei Du, Zong-fu Zhang. Apply Quick Die Change (SMED) to the Construction Machinery Manufacturer[J]. Construction Machinery Technology & Management, 2013, 11:104-106.

[4] Shu-cang Liao. Based on the Quick Die Change and Its Clinical Significance[J]. Equipment Manufacturing Technology, 2012, 11:199-200+212.

[5] Zhuan-yun Yan. Research on the method of SMED in the study of application of NC machining[J]. Printed Circuit Information, 2013, 04:164-169.

[6] Jing Zha, Dong-ting Li, Lian-sen Zhuang, Hua Jin. Research of Improving Changeover Time on Hot Press[J]. Value Engineering, 2016, 01:102-104.