The Application of Setup Reduction in Lean Production

Lixia Chen
School of Economics and Management, Changchun University of Science and Technology
Changchun 130022, China
E-mail: clx992326@163.com

Bo Meng
Department of Industry Management, Changchun University of Science and Technology
Changchun 130022, China
E-mail: changchun-cbe@163.com

Abstract

Setup reduction is an important tool in lean production to realize quick setup change and meet the demands of individualized customers. The paper introduces related concepts of setup reduction, analyzes the reason for deploying it in the view of economic theory and lean principles, and proposes six-step approach to setup reduction in detail, which is practicable and feasible for any enterprise to deploy immediately in multi-specification and small-batch production environments.

Keywords: Lean production, Setup reduction, Internal & external activity, Activity optimization

1. Introduction to Setup Reduction

Setup reduction was put forward in 1969 by an engineer of Toyota named Shigeo Shingo, which is the best method of decreasing setup change time and also called Single Minute Exchange of Die (SMED). Chinese enterprises began to learn and adopt setup reduction at the end of 1980s after it was spread and used widely in western countries. It is essential for enterprises to realize lean production in multi-specification and small-batch environment.

1.1 The definitions of setup, setup time and setup reduction

Setup is a set of activities to prepare for the next part to be produced. Setup time is total elapsed time from completion of the last good part from the previous setup to the first good part from the new setup (Figure1).

Insert Figure 1 Here

Setup reduction is a kind of theory and method to shorten the setup time furthest.

1.2 Basic terms of setup

- Machine or equipment means a production machine, assembly machine, assembly bench, etc that produce products customers pay for.
- Dies means dies, molds, fixtures, press tools
- Tools mean hand tools, power tools, etc.
- Accessories cover all the miscellaneous incidental items required for setup, such as
  - Hydraulic & pneumatic fittings, hoses, gages, valves, etc.
  - Electrical & electronic switches, fittings, wires, sensors, gages, etc.
  - Clamping parts such as bolts, nuts, washers, clamps, etc.

1.3 Internal activities and external activities

Internal activities mean all activities performed while the machine is not producing parts are considered internal activities, for example, removing the die, mounting new die, etc. All the setup related activities that are performed while the machine is producing good parts (either the previous order or the new order) are considered external activities. Example: Transporting dies & material to and from store.

2. Why Setup Reduction

2.1 Lean requires setup reduction to eliminate wastes in setup change

Setup reduction can deal with frequent changes in diverse demand environment by improving equipment availability and eliminating various wastes in setup change.

According to the principles of lean production, we should only do value-added activities that customers are willing to pay and others are wastes that consume time and other resources that the customers are not willing to pay for. In traditional setup change process, there are too many wastes such as searching for dies, tools, accessories and documents, adjustments to dies, waiting for parts, dies, cranes, drawings, etc. Setup reduction can eliminate wastes by better utilization of operator's time and capital investment, reducing overall lead time, inventory & storage space needs and reject rates. It is proven that setup reduction can reduce setup change time 50% compared with traditional setup method.

2.2 Setup reduction makes smaller batch sizes possible without the economic penalty

As shown in Figure 2, along with the reduction of setup time, the effective cycle time per part becomes shorter and shorter, which greatly decreases the cost of small-batch products and makes smaller batch sizes possible.

Insert Figure 2 Here

3. Six Step approach to Setup Reduction

We propose a six-step approach to setup reduction: first analyze setup process, separate external and internal activities, convert as many internal activities as possible to external activities, optimize the internal activities and external activities respectively, and evaluate the impact of setup reduction for continuous improvement.

3.1 The first step: analyze current setup process

We should understand the whole process of current setup by following steps:

(1) Video record the selected setup completely that can be repeatedly viewed and accurately time the activities;

(2) All team member review the tape and list all the activities individually in setup analysis form as shown in Table 1;

(3) Develop one common activities list for the team;

(4) Time each activity from the video.

Insert Table 1 Here

3.2 The second step: Separate external and internal activities

Discuss and classify each activity as internal or external consider how it is done today, not how it can be done, mark on the common setup analysis form, calculate activity durations from the already entered start and end times, enter the activity duration in appropriate column (external or internal), add all the ideas for improvement put forward during the discussions to the notes column (keep such list on separate sheet, if necessary).

3.3 Convert as many internal activities as possible to external activities

The team discuss each internal activity to identify those that can be eliminated or those that can be performed while the machine is making good parts (i.e., make it external) by changing the order of the activities, planning in advance, getting additional help, organizing the workplace and dies, etc, and then mark the potential external activities on setup analysis form. During this step, it is especially important for the team to identify opportunities that can be implemented immediately with no-cost or low-cost, without major changes required in physical arrangements and job assignments.

3.4 Optimize internal activities

The objective to optimize internal activities is to identify and eliminate the wastes in setup change by following means.

3.4.1 Identify opportunities for optimization

Study each internal activity to identify opportunities for optimization in advance planning, workplace organization, loading and unloading, location, alignment and mounting, attaching and clamping, fine-tuning and adjustments, first article inspection and ergonomic efficiency.

3.4.2 Standardize dies, tools, accessories, procedures, etc

We should establish a standard that is followed by all and make it available to all concerned for reference. What

should be standardized including production dies (dies, molds, fixtures, Figure 3), documents (drawings, tolerances, setup sheets), fasteners (bolts, nuts, t-nuts, studs), locating devices (mounting plates, dowel pins), setup hand-tools (wrenches, screw-drivers, Figure 4), setup power tools (hydraulic, pneumatic, electrical), accessories (hydraulic, pneumatic, electrical), gages (hydraulic, pneumatic, laser, plug, snap), measuring devices (micrometers, dial indicators), procedures (handling and lifting, clamping, storage) and etc.

3.4.3 Provide employees with training

After the standard is established, we should provide employees with adequate training to let them master it and skills in activities, and improve efficiency.

3.5 Optimize external activities

Study each external activity for opportunities in handling and transportation of dies, storage of dies, tool maintenance and record keeping program, storage & maintenance of hand tools & power tools, storage of accessories and supplies, production planning & sequencing process, raw material / parts storage and handling methods, incoming inspection & supplier quality assurance and device means to reduce the activities of support employees during production time such as putting tools aside machines, setting a handle tool bench beside a machine, providing detailed setup change process record and so on.

Insert Figure 3 Here

Insert Figure 4 Here

3.6 Measure the impact of setup reduction

Usually, in different stages of setup reduction, the time saved is different (Figure 5).

Insert Figure 5 Here

We should evaluate the impact of setup reduction by some indices such as % reduction in setup time, increased equipment availability, labor cost savings from setup reduction, batch size reduction, without economic penalty, and overall equipment effectiveness (OEE).

(1) % reduction in setup time and increased equipment availability

Given: original setup time (OST), reduced (new) setup time (RST), number of setups / month (NSPM),

% Reduction in setup time = ((OST – RST)/OST)×100

Additional equipment time / month = (OST – RST)×NSPM

(2) Labor cost savings from setup reduction

Given: man-hours spent in original setup process (OSM), man-hours spent in the new setup process (RSM), additional man-hours spent in “external” activities (ASM) and number of setups / month (NSPM)

Man-hours Savings / Month =(OSM – RSM + ASM)×NSPM

% Man-hour Savings =(SOM –RSM + ASM) / OSM×100

(3) Batch size reduction, without economic penalty

Given: original setup time (OST), cycle time per part (CT), original average batch size (OBS), reduced (new) setup time (RST) and new average batch size (NBS)

Original Net Processing Time / Part =(OST + CT × OBS) / OBS

New Net Processing Time / Part =(RST + CT × NBS) / NBS

New (Reduced) Batch Size, Without Economic Penalty = ((OST – RST) + CT × OBS) / CT

(4) Overall Equipment Effectiveness (OEE)

OEE is a measurement that represents the percentage of time a machine was actually producing quality parts compared to the time it was planned to be. Three elements of OEE are available time for which the equipment was planned to make good quality parts, production time during which machine made good quality parts at the rate of ideal cycle time and lost time during which the equipment was not producing acceptable quality parts due to various causes such as setup change. So: OEE = production time / available time.

4. Conclusion

Setup reduction is a very useful lean tool for enterprises to eliminate wastes and improve production efficiency. The paper proposes a six-step approach to apply setup reduction especially suggests the measurements for

enterprises to evaluate its effect, but it just give the procedure, setup involves machine operators, setup operators, maintenance technicians, production supervisors, manufacturing engineers, production schedulers, material handlers, forklift operators, product and tool designers and so on, so it can't succeed without good teamwork. In addition, setup reduction requires well-designed and maintained machines and tools, thoughtful planning, efficient and timely material handling, skilled and conscientious operators and unambiguous instructions, which need close cooperation between internal and external customers and we will study further in future.

References

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Table 1. Setup analysis form

Setup Analysis Form

Machine		Mach. No.	
Part		Part No.	
Process		Proc. Seq.	
Operator		Date	

		Time for Activity				
Sr. No.	Activity (Including Transport, Waiting, Walking)	External or Internal	Start Time	End Time	Duration Internal / Duration External	Observations / Notes
1						
2						
3						
4						
5						
6						
7						

Figure 1. The schematic diagram of setup time

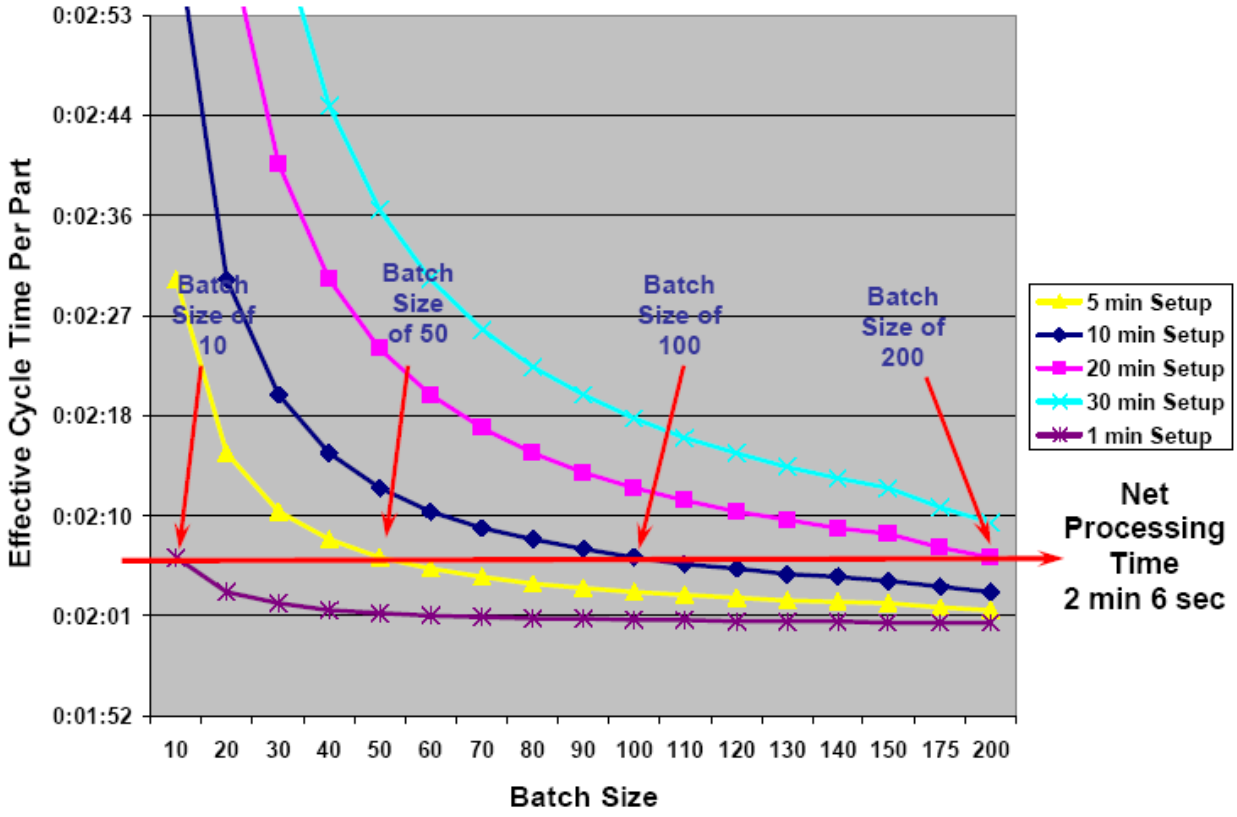

Figure 2. Impact of setup time & batch size on effective cycle time

Figure 3. Standardized, Color Coded Fixtures

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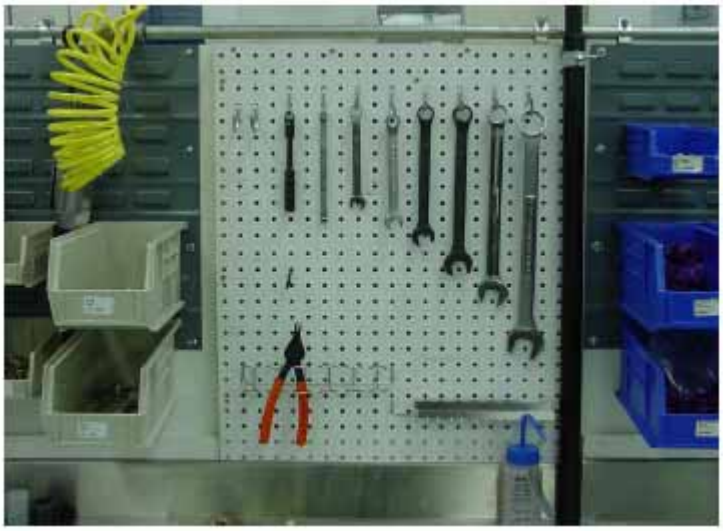

Figure 4. Organized Placement of Necessary Hand Tools

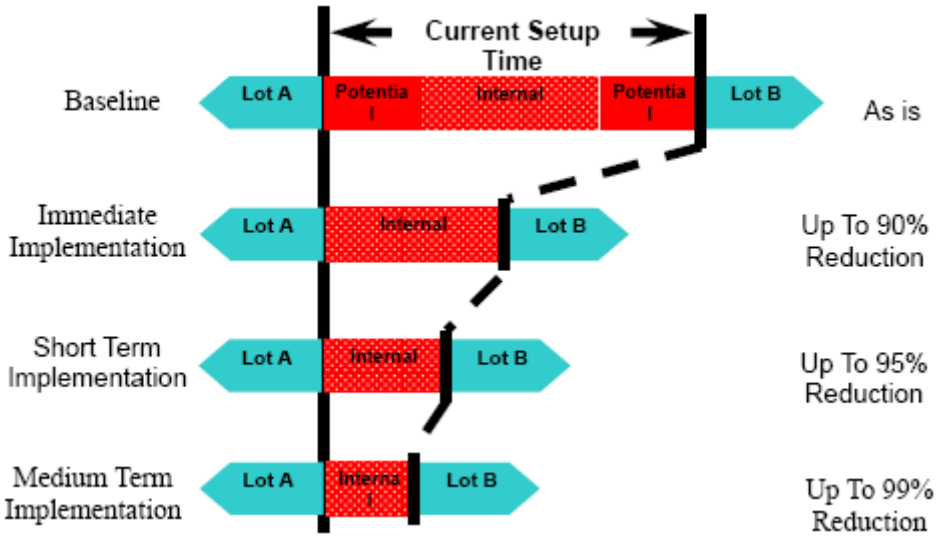

Figure 5. The Improvement in Different Stages of Setup Reduction