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Study and designing of new chute plate for single minute exchange of die (SMED) in sheet metal industry on high speed presses

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ABSTRACT

Today's business growth is totally dependent on the productivity and the customer satisfaction through in-time delivery and services. This Paper addresses the application of lean manufacturing in sheet metal industry. The goal of this research is to investigate how to improve the productivity and in time delivery as expected by customers. In a sheet metal industry, there is always a big challenge for improvement in the productivity of the plant. KANSAL INDUSTRIES sheet metal industry manufacturing for automotive vehicles have faced the productivity problem from the last few years. Machine capacity utilization is a key goal in achieving minimum time consumption for setup change over time. Tool change over process is recognized as possible area for reducing the time consumption. The main objective of the present study is to identify the root causes of bottle necks operation and implement possible solution to the problems. Single minute exchange of die (SMED) method and quick die change (QDC) technology. Size of the Nut/Bolt & Chute plate design was found as the major cause for high setup time. A standard chute plates was designed for rotor and stator chute with software solid work and designed some other relevant assembly component required for easy setting of chute. The SMED Technique has been improved by additional technology QDC and design modification implementation of chute plate was simultaneously applied. A Significant time savings have been achieved with minimum investment.

INTRODUCTION

The survival of any industry in today‘s competitive market place depends on response time, production costs and flexibility in manufacturing. In recent years, companies have become increasingly focused on market demand and customers Satisfaction. This has led to the implementation and adoption of lean manufacturing techniques in the automotive industry. Reducing Tool change over time will boost your company‘s capacity, increase your manufacturing flexibility, and help increase overall output. Setup time can be reduced by using Single Minute Exchange of Die (SMED) concepts, which can be achieved through better planning, process redesign and product. SMED is a scientific approach to reduce setup time that can be applied in any factory to any machine. In which tool can be set in single digit, the ultimate goal of SMED is to perform machine setup and changeover operations in less than ten minutes. Some practitioners have proved that the SMED method really works in practice and in some situations reductions of 80 percent or more are feasible (1, 12).

The two main objectives of this study were: first, to identify the root causes of bottlenecks operations and implement possible solutions to the problems; second, to study the cost saving effect after reducing the setup time. Single Minute Exchange of Die (SMED) methods were applied at two major bottlenecks setup operations; cast on strap and heat seal. The result shows significant reduction of cast on strap setup time to 54% and heat seal setup time to 47%. This study had achieved more than the target 35% of setup time reduction. From setup time reduction, a total cost savings of RM168, 000 was achieved in assembly line A. Mean while the company level a total saving of RM1.11million was achieved for all assembly lines in Company X. The Continuous process improvement and SMED methodology because the automobile industry changes refer to manufacturing different part in increasingly small series which have to produce with minimal time consumption (2,3 & 9). These very strict requirements are creating lot problems in automotive industry worldwide. Generally, additional time is needed for setup caused by poor design of equipment the solution can be achieved both by fast responding on market demands and with early application of new method and technologies. Continuous process improvement and SMED can fix this problem. A key parameter to achieving minimal production time is machine capacity release. A new approach to improving die casting process is to integrating the SMED method and 5S techniques as presented in this article. The proposed method application resulted in the following improvement: average tool change time period decreased, machine flexibility was raised due to reduce tool exchanges in controlled time period increasing in this way different parts production possibilities. Setups determine downtime, capacity, product quality, and to some extent costs. As much as 50% of effective capacity can be lost to setups in some electronics assembly. In this work it was shown that large reductions in setup time possible for electronics assembly and used a two-part approach. The first part consists of classic process re-engineering using ―Single Minute Exchange of Dies (SMED) concepts developed by Shigeo Shingo for metal fabrication. The second part used a sophisticated factory information system, with hand-held wireless computers and barcode scanners, to further reduce setup times and increase setup accuracy (4). This two-part approach gave a reduction of about 86% in key setup times, plus labor savings, quality improvements and other benefits. One narrow measure of performance gave an order of magnitude improvement. The results showed that SMED was applicable well outside its traditional domains such as stamping and metal-working. The author confirmed that the seemingly extreme benefits claimed by SMED advocates are achievable, but only with the assistance of modern information technology. To reach aimed sustainability well arranged standard procedures must be prepared. Optional changeover procedure was constituted with aid of predetermined time system (MTM-UAS) to standardize and preserve the improved changeover operations (5).

The techniques employed to improve changeovers equally might be applied in maintenance situations. With brief reference to case studies from the authors' research, it is further argued that focused maintenance activity can also directly influence changeover performance, particularly by ensuring that items involved during a changeover (change parts, product, and fixed machine components and consumables) were in satisfactory condition. The role of design to improve either change over or maintenance performance was also discussed. Likewise, maintenance activity to ensure that items involved in a changeover are of requisite. The company had made some set-up reductions mainly using work study related methods and in one manufacturing cell by the use of the Single Minute Exchange of Die (SMED) methodology. Mistake proofing devices in the form of fouling pins and offset holes had been developed for the family of components manufactured in this cell. Until recently the set-up times were not measured and worse still were considered as productive hours. There was a lack of awareness and motivation amongst operational personnel to reduce set-up times and knowledge of SMED was limited to a small group of individuals. This, along with the lack of investment in mechanisms to aid set-up time reductions and prevent errors, has restricted the use of this type of methods and technology. However, there was evidence that the demands made by the company‘s major customer will lead to increased efforts to put into place these types of changes (2 &3).

The 'SMED' methodology (including the sequential application of improvement techniques that are assigned to those stages) need not always represent an effective improvement route. Shigeo Shingo's 'SMED' methodology has been at the forefront of retrospective changeover improvement activity since the mid-1980s. The 'SMED' methodology's dominant objective of translating tasks into external time is also considered. It argued that the 'SMED' methodology was not sufficiently promote some important improvement options, particularly those that seek to reduce the duration of existing changeover tasks or eliminate them altogether. The published research papers indicated different methods for implementing SMED or QDC principle. The scopes of implementation of these principles are majorly process specific. In the present study a detail investigation was completed to identify the critical operations that are the key for higher setup changing time. Chute setting was identified as the key operation which took more than half of the total set up time as there were no scientific and methodical way to change the chute and setting was done manually (6). A new design for chute plate has been proposed, fabricated and implemented. Major components were analyzed using Finite Element Simulation for stress and strain at desired loading conditions (using ANSYS). Methods were proposed and designed for easy sliding and to facilitate quick assembly. Some other implementation also completed for clamping. With all the changes made the setup time was possible to reduce to only 15 minutes where as previously 228 minutes was taken for total changing of the set up (7-9).

MATERIALS AND METHODS

This chapter introduces overall design of study, which includes the methodology adopted for carrying out the work. Details of work done in each setup operation are discussed in Sheet Metal division of KANSAL INDUSTRIES at high speed press. A complete study of recorded tool change over data process and implementation of SMED principles and QDC technology to reduce set up time. A design of plan has been developed to reduce setup time (10).

1. Data collection
2. Implementation of SMED principles
3. Designing of chute plate and supporting components
4. Design improvement of other setup operations

Data Collection

Statistical data is collected and analyzed to measure the machine setup time at high speed presses. First, data check sheet is prepared or developed prior to data collection and measured by using a stop watch. The production flow and standard operation procedure is briefly reviewed before developing the data collection check sheet. Based on actual production, data is collected and video recorded on the daily basis by different type of time loss in tool die changeover process at high speed.

Implementation of SMED Principles

Initially complete tool change over data is recorded and SMED principles are implemented in recorded data. Single minute exchange of die is a philosophy to reduce setup time in less than 10 minute or single digit of minutes.

Designing of Chute Plate and Supporting Components

The chute plate setting was the critical problem it takes maximum time in one complete changeover. Then a standard chute plates is to be designed for rotor and stator chute to overcome this problem. After this design improvement there is no need to change the chute plate for all die only replace the cylinder without any clamping. A lead screw and slotted bar is to be attached with chute plates for easy sliding at bolster. In existing design chute is tied up with wires and supported with channel and wooden block for maintaining the height of chute from the pit base and this operation required more setup time and labor fatigue. To eliminate this operation a sliding support is designed for hanging the chute. Standard chute plate is designed for rotor and stator .Solid work 9.0 is used for modeling and assembly of the component (11).

Design Improvement of Other Setup Operations

The root causes of bottleneck are be founded from the process study of change over. All these causes are studied in detail and found the appropriate solution to overcome. The solutions are to be implemented step by step at all setup operation continuously. The improvement are implemented at all causes is discussed as-

1.Clamping of tool die

Threaded bolts are used to clamp the die with manual clamping and eight bolts required for clamping the die. This is also a time consuming process and required more labor fatigue. Manual clamping is to be replaced with hydraulic clamp to reduce the clamping time , and standardize the clamping slot dimension of tool die so that can be used hydraulic clamp for all die.

2. Slide setting

The press shut height varies according to die. So due this reason every time while changing tool die, press shut height has to be changed according to die. A pneumatic gun is used for shut height setting and it required more labor and time. For reducing this time and labor fatigue a motor and reduction gear box assembly is attached with slide.

3. Tool availability

After examinations of tool change over process it is found that movement of worker from machine to tool room is more than 10 times for bringing the tools regarding to changeover. To eliminate this time a tool kit trolley is designed and all

Tools and required components like spacer, feeder transmission gear assembly for new die in SMED are placed in tools trolley.

Data Collection

Statistical data is collected and analyzed to measure the machine setup time at high speed presses. First, data check sheet is prepared or developed prior to data collection and measured by using a stop watch. The production flow and standard operation procedure is briefly reviewed before developing the data collection check sheet. Based on actual production, data is collected and video recorded on the daily basis by different type of time loss in tool die changeover process at high speed presses. Initially a video is recorded of current tool changeover process and later each setup operation is examined and record the time in data check sheet. Later, a statistical pie chart is plotted to monitor and analyze the problems. These methods help to identify the main contributor to high time loss in the tool change over process and help to visualize and better understanding the root cause of the problems. All change over details are video recorded and complete work activity sequence is written down (12). Every operator‘s moves and all activities have to be recorded in detail, since any unnecessary activity contribute to obtaining even worse results. The same recording procedure should be done after implementing the method to establish the efficiency in both applying the method and achieving the result (SMED).Initially examined tool change over at all high speed presses in KANSAL INDUSTRIES.

Change over Data of SAM CHANG Press

All change over data is video recorded and complete work activity sequence is written down manually and the time of manual recorded activity is noted down with stop watch while changeover performed. The recorded average change over data of all activities at SAM CHANG (KOREA) press is shown in Table1 and activity distribution in terms of percentage is shown in Figure1.

The used die which is to be removed and new die mounted at press is progressive tool die. In the recoded data setting of chute take maximum time 31% of total change over time. This is a more time consuming operation and required more labor fatigue. This setup operation has more scope to reduce time. Second more time consuming activity is mounting of tool die it take 15% of total changeover time because the clamping of die is done manually. Mechanical feeder gear box is used to feed the sheet and setting of gear box takes 15% time of total changeover. Movement of worker from station to tool room takes 8% time and transportation takes 3% time shown in Figure 4.1 of total changeover time.

Table1: Activity duration table of SAM CHANG (KOREA) press

Sr. No.	Activity/ Operation	Actual Time (minute)
1	Dismantling of tool & die	8
2	Setting of chute plate	20
3	Die searching time	5
4	Transportation of die	2
5	Mounting on tool & die	10
6	Setting of feeder gear box	10
7	Movement of workers	5
8	Stroke setting / F.O.A	5
7	Total Time	65

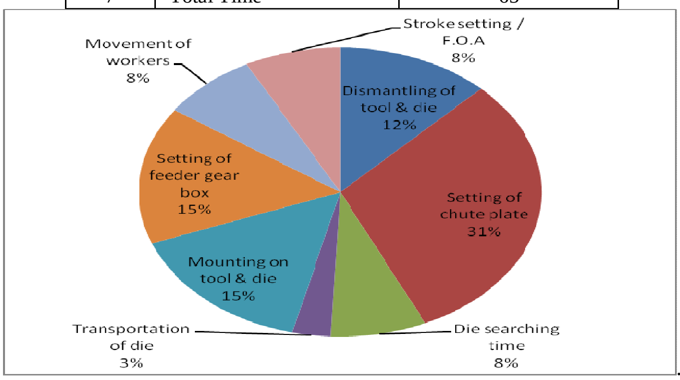

Figure 1: Activity duration distribution chart of SAM CHANG (KOREA) press

Change over Data of KAUSICO (INDIA) Press

All change over data is video recorded and complete work activity sequence is written down manually and the time of manual recorded activity is noted down with stop watch while changeover performed. The recorded average change over data of all activities at KAUSICO press is shown in Table 2 and activity distribution in terms of percentage is shown in Figure 2.

In the recoded data setting of chute take maximum time 31% time of total change over time. This is a more time consuming operation and required more labor fatigue. This setup operation has more scope to reduce time. The second time consuming activity is mounting of tool die 17% of total changeover time because the clamping of die is done by manually. The setting of feeder takes 9% of the total change over time. At this machine feeder setting takes less time compare to KAUSICO because servo feeder is used in the place of mechanical feeder, it take less time in setting. Movement of worker from station to tool room takes 9% time and transportation takes 3% time of total changeover time.

Table 2: Activity duration table of KAUSICO (INDIA) Press

Sr. No.	Activity/ Operation	Actual Time (minute)
1	Dismantling of tool & die	8
2	Setting of chute plate	16
3	Die searching time	5
4	Transportation of die	2
5	Mounting on tool & die	8
6	Setting of feeder gear box	5
7	Movement of workers	5
8	Stroke setting / F.O.A	5
7	Total Time	58

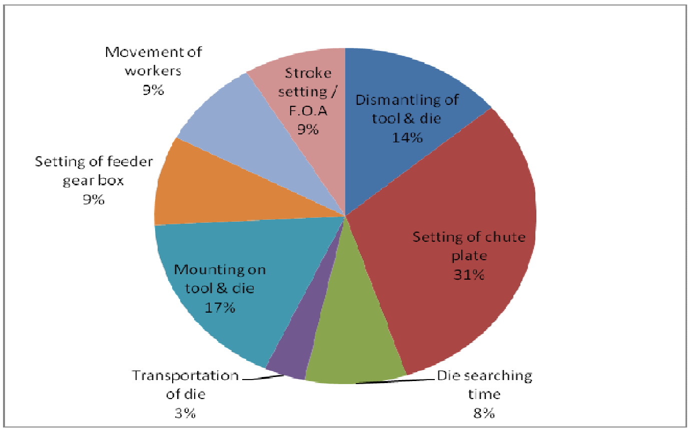

Figure2: Activity duration distribution chart of KAUSICO (INDIA) Press

Table 3: Activity duration table of ERFURT press

Sr. No.	Activity/ Operation	Actual Time (minute)
1	Dismantling of tool & die	12
2	Setting of chute plate	No Chute
3	Die searching time	5
4	Transportation of die	2
5	Mounting on tool & die	20
6	Setting of feeder gear box	5
7	Movement of workers	5
8	Stroke setting / F.O.A	5
7	Total Time	54

Change over Data of ERFURT (GERMANY) Press

All change over data is video recorded and complete work activity sequence is written down manually and the time of manual recorded activity is noted down with stop watch while changeover performed. The recorded average change over data of all activities at ERFURT press is shown in Table3 and activity distribution in terms of percentage is shown in Figure3.There is no chute used at this press the stator and rotor lamination is collected through conveyor. The maximum time taken by the activity in this changeover is mounting of tool die which is 37% of total change over time. Dismantling of tool die takes 22%. Movement of worker from station to tool room takes 4% time and transportation takes 4% time of total changeover time. The feeder setting takes 9% of the total change over time. It also take less time compare to **SAM CHANG** because it is comprises with servo feeder (13).

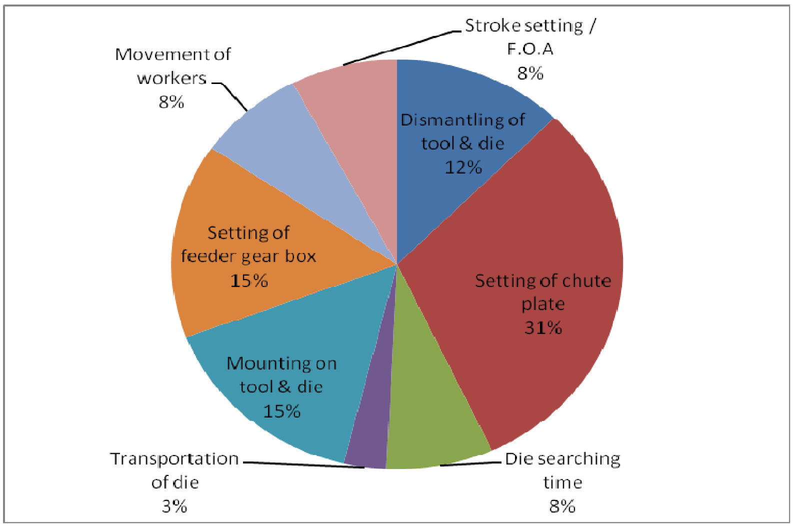

Figure3: Activity duration distribution chart of ERFURT press

Change over Data of DANLY (U.K.) Press

All change over data is video recorded and complete work activity sequence is written down manually and the time of manual recorded activity is noted down with stop watch while changeover performed The recorded average change over data of all activities at DANLY press is shown in Table4 and activity distribution in terms of percentage is shown in Figure4. In the recoded data the activity setting of chute takes maximum time, it takes 29% of total change over time. This is more time consuming operation and required more labor fatigue. The second time consuming activity is mounting of tool die it take 18% of total changeover time because the clamping of die is done by manually. The setting of feeder takes 9% of the total change over time. At this machine feeder setting takes less time compare to SAM CHANG because servo feeder is used in the place of mechanical feeder, it take less time in setting. Movement of worker from station to tool room takes 9% and transportation takes 3% of total changeover time (14).

Table 4: Activity duration table of DANLY press

Sr. No.	Activity/ Operation	Actual Time (minute)
1	Dismantling of tool & die	8
2	Setting of chute plate	16
3	Die searching time	5
4	Transportation of die	2
5	Mounting on tool & die	10
6	Setting of feeder gear box	5
7	Movement of workers	5
8	Stroke setting / F.O.A	5
7	Total Time	56

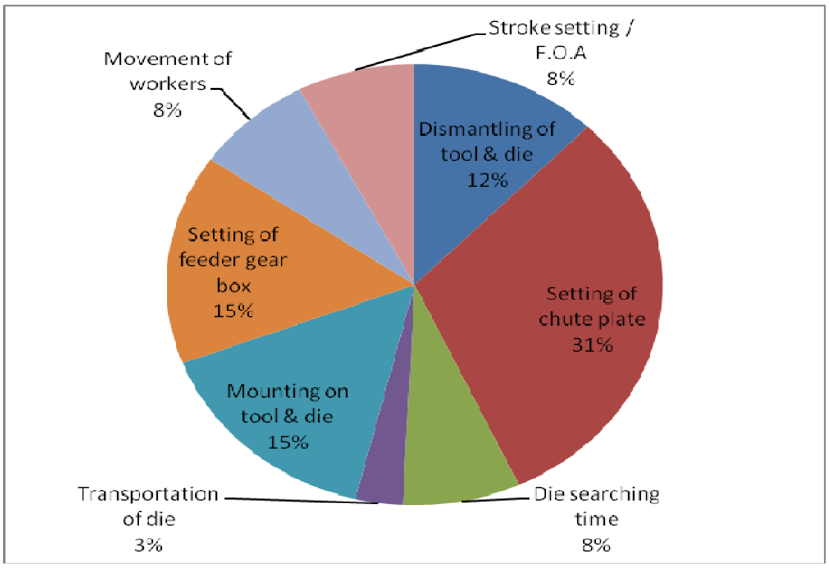

Figure 4: Activity duration distribution chart of DANLY (U.K.) press

Comparison of Tool Change over Time at High Speed Presses

It is seen from the recorded data that SAM CHANG used to takes more setup time compared to other press. It takes maximum time in feeder setting compare to other because it has mechanical feeder gear box which require large setup time. The all setting in mechanical feeder gear box is done manually. The other presses have servo feeder so it take less lime in setting. It also take maximum time in chute setting compare to other because the bed size of this press is bigger than the other machine except ERFURT but at ERFURT the chute is not used for collecting the lamination, conveyor is to be used in the place of chute. All operation at SAM CHANG takes maximum time compare to other three machines. After all this comparison the conclusion is that SAM CHANG has maximum scope of improvement so first of all SAM CHANG is focused for SMED implementation (15). The comparison of tool change over time at four high speed presses is given in Table5.

Table5: Total change over time comparison of four high speed presses

Sr. No.	Machine Name	Capacity(Ton)	Total Change over Time(Minute)
1	KAUSICO (INDIA)	300Ton	58
2	ERFURT (GERMANY)	200 Ton	54
3	DANLY (U.K.)	600 Ton	56
4	SAM CHANG (KOREA)	630 Ton	65

Causes of More Change over Time

The current setup time in all processes at high speed press was noted down and analyzed thoroughly to investigate the bottleneck process. This data analysis is vital to observe the current setup time activities and performance to identify which current setup processes need to be focused on this study before SMED can be implemented on press at actual tool change over. There are many causes of more change over time-

1. Type of Set-up operations
2. Setting of chute
3. Clamping of free end of chute
4. Clamping of tool die
5. Slide setting
6. Tool availability
7. Lack of skilled worker

Type of Setup operations

Observing changeover process it is investigated that all the operations are performed when machine is in stop condition and there is no external setup of operations. Complete change over process is recorded and all activities and movements of worker at SAM CHANG (KOREA) are noted down. Further internal external setup operations are distinguished. After implementation of first phase of SMED the internal and external setup operations are required to be separated. This process Improvement can save up to 30% of total tool changeover time (16).

Setting of Chute

Chute is a channel down for collecting and transporting falling material within guide way. At this machine two different chutes are used for collecting the rotor and stator blank individually. These chutes are attached with chute plate which is clamped on the bolster plate with a defined position varying for all models of die. Setting of chute plate requires changing while tool die changeover which is required to be aligned with the center of stator and rotor blank with an accuracy of micron. A large time is lost in alignment of rotor and stator chute plate. When the changeover is performed chute plate also have to be changed as shown in Figure5 because in rotor blank stage the coming scrap is different in size for different models of die. During the changeover the chute is full of laminations and about 2 ton weight is active on the chute plate. Allen bolts are used for clamping one chute plate with the bolster plate (17).

The operation performed while setting of the chute:-

1. Unclamp the chute plate from bolster.
2. Lift the chute above the bolster with over head crane.
3. Unclamp the chute plate from chute.
4. Change the chute plate.
5. Lower the chute and place at bolster resting.
6. Position the chute plate by sliding manually. Due to more load attached at chute plate, it is not easy to slide the chute plate. So operators are required to hammer it for sliding.
7. Then clamp the chute plate with bolster.

This complete process takes an average 18 minute and more labor involvement. Standard chute plates are designed for rotor and stator chute to eliminate the chute plate changing process for all model of die. The design study is discussed in detail later.

Figure5: Chute plate changing process using overhead crane [Kansal Industries IMT Maneser]

Table6: Activity duration of chute setting

Activity	**Time Taken by Activity**
Setting of Chute	18

Clamping of Free End of Chute
While changing the chute plate, chute is lifted with overhead crane and clamped with bolster. Wires are used to tie the free end of chute and a base support is given with a channel and wooden block. Even this process takes a considerable time to execute. A design is made for eliminate chute tie operation with wire after ever change over.

Clamping of Tool Die
After setting of chute plate over head crane is used to place the die on loading arm. Loading arm and die lifter support the die to slide smoothly at bolster and placement of die is required within precision of microns. After positioning the die at bolster it is clamped manually with threaded bolt, manual clamping required more time or labor fatigue. Two operators required to performed bolt tightening operation and time taken by complete activity is 14 minute. To reduce die clamping time QDC hardware hydraulic clamping is used in the place of manual clamping.

Table7: Activity duration of too die clamping

Activity	Activity duration (minute)
Clamping of tool & die	14

Die is clamped with two part of press-: (a) Bolster plate, (b) Ram

(a) Bolster Plate
The bolster plate (or bed) is a large block of metal upon which the bottom portion of a die is clamped, and it is stationary. Large presses have a die cushion integrated in the bolster plate to apply blank holder forces. This is necessary when a single acting press is used for deep drawing. The ram is also a solid piece of metal that is clamped to the top portion of a progressive die and provides the stroke (up and down movement) resulting in production of parts from sheet metal being fed.

Figure7: Clamping of tool die at bolster with threaded bolt [Kansal Industries IMT Maneser]

(b) Ram
Presses can be classified into mechanically driven presses and hydraulically driven presses. The most common mechanical presses use an eccentric drive to move the ram, whereas hydraulic presses use hydraulic cylinders. The nature of drive system determines the force progression during the ram's stroke. Advantage of the hydraulic press is the constant press force during the stroke. Mechanical presses have a press force progression towards the bottom

dead center depending on the drive and hinge system. Mechanical presses therefore can reach higher cycles per unit of time and are usually more common in industrial press shops.

Slide Setting

The distance in a press between the bottom of the slide and the top of the bed indicate the maximum die height that can be accommodated. This is known as shut height, which depends on different die model. Ram is required to slide up and down to maintain this height. Currently pneumatic gun is used for maintaining shut height. Three operator performed this operation due to damaged gun and improper operation. A single operator could not handle the gun due to vibration produced by individual gun. This operation requires more labor fatigue and take about 10 minute. The operation of shut height setting is shown in Figure8 and pneumatic gun used for slide setting is shown in Figure9. To eliminate the use of pneumatic gun a motor is to be attached with slide.

Table8: Activity duration of slide setting

Activity	Activity Duration (minute)
Slide Setting	2

Figure 8: Shut heights setting with pneumatic gun [Kansal Industries IMT Maneser]

Feeder Gear Box Setting

The sheet is fed through a feeder and pitch is varying for different models of die. The pitch is to be changed by a feeder gear box setting. A mechanical feeder gear box is used to change the pitch and there are four gears in this assembly which are required to change for every setting.

1. Driver
2. Driven
3. Transmission gears assembly

There are 25 Allen bolts, which are to be loosened and tightened while changing gears. This process is more time consuming and require skilled labor. Time taken by setting of feeder gear box is 35 minute. A process innovation is done in operation to reduce feeder gear box setting time which is discussed in detail later.

Table9: Activity duration of feeder setting

Activity	Activity Duration (minute)
Setting of feeder Gear Box	5

Worker Skill and Tools Availability

It is also observed that workers are not properly skilled and there is lack of coordination and timing. Benchmark studies estimate that about 20% time is spent on arranging parts. All setup operations are performed in off -line mode. After examination of tool change over process it is found that movement of worker from machine to tool room more than 5 times for bringing tools takes about 15 min.

MACHINE SPECIFICATION (SAM CHANG**)**

A CHING FONG made high speed press of 200 ton capacity is to be used for setup time reduction study. The maximum speed of press is 150 strokes per minute and stroke length is 30mm. The maximum height die can run in this press is 400mm and the bolster plate area is 1800×900mm2. The capacity of main motor which run the press is 4pole 50 horse powers (v.s.50HP×4P). The feeding pitch is varying for all die according to strip layout of tool so a change -gear type cam index feeder is attached with the press. And the feeding pitch is to be changed according to gear ratio of gear box.

Machine Layout

In this case operator A operates machine as well as tie the rotor with wire and operator B collects the stator from collection chute and tie it with wires. These wire tied packs are stored in a bin and then shifted to various places for next operation. In some cases, the stators are sent to vendor for the clearing operation. After completion of clearing operation, the same batch again comes back to the factory and dispatched to the customer.

Table 10: All activities and duration of activities performed at CHING FONG press

Sr. No.	Activity	Time (Min)	Operation	Separation
1	One operator goes to tool room and bring the spanner and sheet cutter	1	External	External
2	Cut the sheet and remove it out from the tool	1	Internal	External
3	One operator start opening bolt of tool die	4	Internal	External
4	One operator goes down in the pit and push the previous material from the chute	4	Internal	External
5	One operator again go to tool room for Allen key	4	External	External
6	Release the ram	1	Internal	External
7	Place the loading arm	1	Internal	External
8	One operator go to tool room for eye bolt	3	External	External
9	Crane remove the die from the machine	2	Internal	External
10	Again one operator go to tool room	3	External	External
11	One operator start setting of chute plate	38	Internal	Internal
12	Clean the machine bed	1	Internal	Internal
13	Insert the die lifter	1	Internal	Internal
14	Again one operator goes to tool room	2	External	Internal
15	One operator brought the gears	22	External	Internal
16	One operator brought the pneumatic gun	2	External	Internal
17	Setting of shut height	3	Internal	Internal
18	Crane place the tool die in the press	6	Internal	Internal
19	Clean the die before place at bolster plate	2	Internal	Internal
20	Remove loading arm	1	Internal	Internal
21	Setting the die (chute alignment error)	15	Internal	Internal
22	Remove the die again	9	Internal	Internal
23	Crane place the die to the machine bed	8	Internal	Internal
24	Remove the loading arm	1	Internal	Internal
25	Setting the die against measurement	5	Internal	Internal
26	Setting of shut heigh	5	Internal	Internal
27	Again one operator go to tool room	2	External	Internal
28	Fastening the die	28	Internal	Internal
29	Again one operator go to tool room	5	External	Internal
30	Make adjustment for clamping	15	External	Internal
31	Setting of sheet	14	Internal	Internal
32	Setting of shut height	4	Internal	Internal
	Total	213		

IMPLEMENTATION OF SMED

Initially complete tool change over data is recorded and SMED principles are implemented in recorded data. The steps followed in implementation are as follows-

1. Distinguish the internal and external set up operations from the recorded data.
2. Separate the internal and external setup operations.
3. Convert the internal setup operation into external setup operations.
4. At last streamline all setup operations.

Activity Classification

This step is comprised of recoded material analysis and activities divided into two groups: the internal and external ones. External activities are all the setup activities that can be performed while machine is in operation. Internal setup activities are the ones that can be performed only if the machine is not in operation. Internal activities refer to the dismantling of used tool, to the mounting of new ones and establishing communication in line machine tool (SMED). The all recorded activities during changeover at CHING FONG press is shown in Table 10.

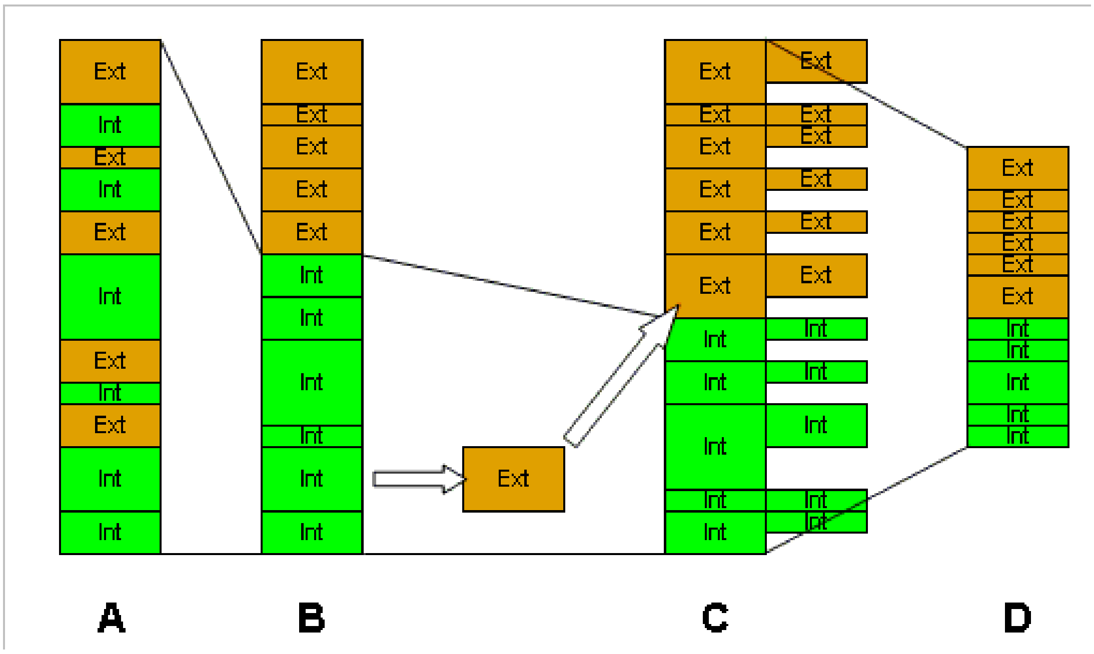

Figure 9: Four phases of SMED

A- Distinguish the internal and external setup operation
B- Separate the internal and external setup operation
C- Convert internal setup operation into external setup operation
D-Streamlining of all operations

Implementation Results

After distinguish, the external setup operation are separated from the internal one and performed these operation when the machine is in process, means completed these operation for the next run when machine is in process for previous run. The setup time is reduced 37% of the total changeover time by this process improvement only.

Chute is a channel down for collecting and transporting falling material within guide way. At high speed press chute is used for collecting the rotor and stator laminations and this chute is attached with bolster through chute plate. The position of chute at the bolster should be aligned with the centre of rotor and stator blanking stage of tool die. For different die models chute plate has to be changed and new chute plate is to be placed with an accuracy of microns to prevent the tool breakage. A solid model is a digital representation of the geometry of an existing and envisioned physical object. Solid model play a major role in discrete-part manufacturing industries where precise models of parts and assemblies are created using solid modeling software. Solid modeling impacts a great variety of design and manufacturing activities (18,19). These are includes early sketches, design decision, space allocation negotiations, detailed design, drafting, interactive visualization of assembly.

The steps followed in the design study are as-

1. First procure the drawings of strip layout for all die models mounted at CHING FONG press.
2. Noted down the size (outer diameter) of rotor and stator laminations for all models of die.
3. Determine the size of triangular scrap of all model of die.
4. Comparison of rotor O.D. and triangular scrap size.

As there is no scrap produced in stator blanking stage so there is no triangular slot in the stator chute plate. The existing design of stator chute plate shown in Figure 6.4 is flat; there is no slot for scrap. But in some models of tool die conveyor and flip slide are used in the place of chute for collecting the laminated rotor and stator. In that condition chute plate is to be removed from bolster because it creates hindrance to flow the scrap. To eliminate this chute plate removing operation a standard chute plate with removable cylinder is designed. While using conveyor and flip slide only cylinder is to be removed from the chute plate to enable scrap pass through the chute plate. While positioning it is required to slide the chute plate according to tool die stator and rotor blanking stage. For easy sliding of chute plate at bolster, needle roller bearing at the sliding surface of rotor and stator chute plate are used (15-17). The size of needle roller bearing is defined as Inner diameter-15mm, Outer diameter-21 mm, Width -12mm.

SIMULATION OF CHUTE PLATES

The setting of chute takes maximum time in one complete tool change over process and the reason of this was clumsy and non standard existing chute plate design. For eliminate these bottlenecks, design standard chute plate with interchangeable cylinders and a lead screw assembly for smooth sliding .Therefore a 3D modeling approach is being adapted to find the standard chute plate design. The software used for 3D modeling is SOLID WORK 9.0. The chute plate is attached with more weight so it is required to calculate the stresses for safe design. A simulation is done for calculating the stresses with the help of software ANSYS 11.0.Determination of the stresses of chute plates before manufacturing is important due to the design improvement

Simulation Methodology

ANSYS is a general purpose finite element modeling package for numerically solving a wide variety of mechanical problems. These problems include: static/dynamic structural analysis (both linear and non-linear), heat transfer and fluid problems, as well as acoustic and electro-magnetic problems. A fundamental premise of using the finite element procedure is that the body is sub-divided up into small discrete regions known as finite elements. These elements defined by nodes and interpolation functions. Governing equations are written for each element and these elements are assembled into a global matrix. Load and constraints are applied and the solution is then determined. In general finite element solution may be broken onto three stages-

- Preprocessor
- Solution
- postprocessor

ANSYS 11.0 is used for simulation the component and the type of analysis is used static structural for calculating the stresses.

Static Structural Analysis

A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The types of loading that can be applied in a static analysis include:

(a) Externally applied forces and pressures
(b) Steady-state inertial forces (such as gravity or rotational velocity)
(c) Imposed (nonzero) displacements
(d) Temperatures (for thermal strain)

Material selection

Material is selected on the basis of previous chute plate material. The material used for designed component is mild steel (EN8). This is medium carbon steel. EN stands for Euro Norm. The composition of EN8 is C (0.35-0.45%), Si (0.05-.35%), Mn (0.6-1.0%), sulphur and phosphorous is less than 0.06%. Properties of EN8 material is-

(a) Poison ratio-0.3
(b) Tensile stress-500 N/mm^2.
(c) Young‘s modulus-190GPa.
(d) Density –7700kg/m^3.

Simulation Results

To estimate the stresses induced in the rotor chute plate a simulation is done using structural analysis module of ansys11.0 software. The solid work file saved in IGES format is imported in ANSYS followed by applying all the boundary conditions there in ANSYS. The boundary conditions are defined as 19800 N loads in downward direction, sliding surface fixed, and displacement is free in y-direction. The material used for simulation is mild steel (EN8) and stiffness behavior is flexible.

To estimate the stresses induced in the stator chute plate a simulation is done using static structural analysis module of ansys11.0 software. The solid work file saved in IGES format imported in ANSYS followed by applying all the boundary conditions. The boundary conditions are defined as 19800 N load in downward direction, sliding surface is fixed, and displacement is free in y-direction.

DESIGNING OF SUPPORTING COMPONENTS OF CHUTE ASSEMBLY

A lead screw assembly attached with chute plate is used to slide the chute in horizontal direction with smooth and precise motion. The slotted bar permanently clamped at bolster plate at both side of bolster slot step. Assembled the chute plate inside the slotted bar (support bar), from this design constraint the upward and downward motion of chute plates. Now the chute plate is free to move only in horizontal direction

Stator Lead Screw

A lead screw also known as a power screw or translation screw is a screw designed to translate turning motion into linear motion. A square thread lead screw for stator plate is designed with the help of solid work. This lead screw is requiring for sliding the stator chute plate. The drawing, solid model and simulation results of lead screw is defined as-

Drawing

Solid works 9.0 is used for making the drawing of square thread lead screw for stator chute plate. Square threads are defined as follows by ISO standards (Sq 24×5)Where Sq designates a square thread, 24 is the nominal diameter in millimeters, and 5is the pitch in millimeters. When there is no suffix it is a single start thread. If there is a suffix then the value after the multiplication sign is the lead and the value in the parentheses is the pitch.

For example: (Sq 24×5) LH would denote two starts, as the lead divided by the pitch is two. The "LH" denotes a left hand thread. The drawing details of lead screw are shown in Figure 6.16 and specification of square thread is shown in Table 11

Thread	Nominal Dia. (D)	Minor diameter (d)	Pitch	E	R	H2	B	H1	A	H
Square	24 mm	19mm	5mm	2.5	.25	2	0.5	2.5	0.5	2.75

Rotor Lead Screw

A square thread lead screw for rotor chute plate is designed with the help of solid work. This lead screw is requiring for sliding the rotor chute plate which is attached with weight. The drawing, solid model and simulation results of lead screw is defined as-

Drawing

Solid works 9.0 is used for making the drawing of square thread lead screw for Rotor chute plate. Square threads are defined as follows by ISO standards (Sq 24×5) Where Sq designates a square thread, 24 is the nominal diameter in millimeters, and 5 is the pitch in millimeters. When there is no suffix it is a single start thread. If there is a suffix then the value after the multiplication sign is the lead and the value in the parentheses is the pitch. For example: Sq 24×5LH The"LH" denotes a left hand threads.

HYDRAULIC CLAMPING

Reduction of downtime is an important factor in increasing productivity and maximizing capacity utilization. Positional accuracy and the repeatability of clamping force also make an essential contribution to efficiency and quality improvement. The aim of Flexible machining centers is to reduced production cycle times. The placing and clamping of die on one bolster, and later removing them, was often a major time factor in the process. In order to be productive and efficient, it is important that procedures such as positioning, clamping, support and release be rapid, straight forward and safe. This is more important for larger work pieces such as tool die with relatively brief processing intervals making semi-automatic or fully automatic clamping in one fixture a profitable option. Hydraulic

Positioning and clamping is an extremely reliable and efficient technique. In existing setup operation threaded bolts were used to clamp the die with manual clamping and eight bolts required for clamping the die takes 35 minutes. When a decision is made to develop a hydraulic clamping system a logical plan will provide the best chance of success. The plan should include the following choices.

1. The clamping force and the clamping stroke of the cylinders;
2. The power source;
3. The control of the clamping system (accessories and valves)

Clamp Force
Maximum weight of die = 3 ton

No. of clamp = 4

Force required per clamp = (Maximum die weight ×4) ÷ No. of clamp (1)

= (29600×4) ÷ 4
= 29600 N

Displacement of hydraulic clamp = 8mm

Power Source
Hydraulic machinery is operated by the use of hydraulics, where a liquid is the powering medium. In this type of machine, hydraulic fluid is transmitted throughout the machine to various hydraulic motors and hydraulic cylinders and which becomes pressurized according to the resistance present. The fluid is controlled directly or automatically by control valves and distributed through hoses and tubes.

The popularity of hydraulic machinery is due to the very large amount of power that can be transferred through small tubes and flexible hoses, and the high power density and wide array of actuators that can make use of this power. The component of power source is hydraulic pump, control valve, actuator, reservoir, hydraulic fluid, filter, tubes pipes and hoses, seals, fitting and connections.

Control System
The hydraulic valves are usually very heavy duty to stand up to high pressures. Some special valves can control the direction of the flow of fluid and act as a control unit for a system. Classification of hydraulic valves in terms of function and method of activation is defined as-

(a) Classification based on function:
1. Pressure control valves
2. Flow control valves
3. Direction control valves

(b) Classification based on method of activation:
1. Directly operated valve
2. Pilot operated valve
3. Mutually operated valve
4. Electrically actuated valve
5. Open control valve

Implementation Results
The major benefit of hydraulic clamping is the enormous time saved in clamping and unclamping the components. When we compared the time required for hydraulic clamping with that required for manual clamping the gain is no less than 90 to 95%. The used of hydraulic clamping reduced cycle time‘s thereby increased manufacturing capacity significantly and reduced costs. Equally as important as the time advantage was the positional accuracy of hydraulic clamping systems. The clamping forces are constant resulting in very precise positioning and clamping. This ensures identical processing procedures and guaranteed quality. Rejection rates due to distortion will be insignificant. A

third advantage offered by hydraulic clamping is optimum use of clamping space due to compact standard components and the ability to clamp in manually inaccessible areas. This can increase the number of components that can be clamped and processed simultaneously on one fixture. There are many significant benefits achieved with hydraulic clamping systems. The major advantage of hydraulic clamping is that it significantly reduced the load and unloads times as shown in Table 12 compared to conventional manual clamping. This results in higher capacity utilization on all types of machines. Hydraulic clamping also offers improved quality due to consistent and repeatable clamping forces being applied. Clamping operation is done totally automatic with hydraulic clamping.

Table 12: Activity duration before and after placing the hydraulic clamping

Activity	Activity duration with manual clamping (minute)	Activity duration with hydraulic clamping (minute)
Tool clamping	30	4

SLIDE SETTING

Die shut height is defined as the height of the die in the shut or closed position. This height may be greater when measured on the shop floor than in the press because the die might not close completely because of die pressure systems. The press shut height for die setting purposes is the distance from the top of the bolster to the bottom of the ram or slide at bottom dead center, (BDC). It is not necessary to use a common shut height throughout the pressroom. The press shut height varies according to die. So due this reason every time while changing tool die, press shut height has to be changed according to die. A pneumatic gun is used for shut height setting. Three operator performed this operation and it took time about 15 min. For reducing this time and labor fatigue a motor and reduction gear box assembly is attached with slide.

Motor Specification

Torque required for slide movement is 100 lb-in. A 2 hp induction motor of 4 poles is used to lift the slide. The RPM of motor is 1400 which are not appropriate to move the slide. A reduction gear assembly of 20:1 reduction ratio is attached with motor to reduce the RPM. The output RPM of reduction gear is 70 attached with slide through a chain connection.

Horse power required for rotating object $HP = T \times N \div 5252$ (2)

T = Torque (lbft)
N = RPM
Length of slide = 2m, height of slide = 1m, width of slide = 0.7m;
Volume = 1.4 m^3.
Density of material = 7.86×10^3 kg/m^3.
Mass of slide = volume × density =11004 kg.

A reduction gear box is used to reduce an input speed to a slower output speed and more output torque. It is a wheel work consisting of a connected set of rotating ears by which power is transmitted or motion or torque is changed. The motor and gear box are attached through a coupling.

Implementation Results

In existing setup process a pneumatic gun was used for slide setting, it required more number of operator and labor fatigue. After this improvement only one operator could perform this operation in less time. Also the operation time with new design has been reduced to 2 minutes than with existing design i.e. 15 minutes. The improvement before and after is shown in Table 13.

Table 13: Activity duration before and after attachment of motor with slide

Activity	Activity duration before improvement (min.)	Activity duration after improvement (min.)
Slide setting	15	2

FEEDER GEAR BOX SETTING

A feeder is used to feed the sheet with desired pitch according to strip layout of tool die. This feeding pitch is varying for all tool die. To change the feeding pitch a gear box is attached with the feeder. The gear ratio is to be changed for changing the pitch. There are four gears (driver, driven and transmission gears) and 25 Allen bolt in this assembly. Two Transmission gears are mounted on a single shaft and 12 Allen bolt are required for mounting the gears on transmission shaft.

To avoid opening and closing these 12Allen bolt different transmission gear shafts (equal to number of dies running at CHING FONG) have been manufactured and preassembled for all dies. Using this new approach operation time has been reduced to 13 minutes from the 35 minutes. The activity duration after this process innovation is shown in Table 14.

Table 14: Activity duration before and after this process innovation

Activity	Activity duration before improvement (min.)	Activity duration after improvement (min.)
feeder setting	35	13

Final Results and Discussion

Due to implementation of new design of chute plate and supporting components, hydraulic clamping, design improvement of slide setting operation, SMED methodology, the changeover time is reduced from 228 min to 15min. The results of this proposed method application has improved the machine flexibility and increased the different part production capacity due to reduced tool exchanges in controlled time period. The results before and after improvement in terms of time and machine capacity increased in terms of strokes are shown in Table15. The existing time of complete changeover was 228 minute after all improvement is reduced up to 15 minutes and saving of time in one setup is 213 minutes. The minimum changeover required per month is 16 according to past production record of plant and average speed of machine is 120 SPM .The machine strokes per month is increased 4.08 lacks shown in table 15 and machine availability in terms of monthly basis is increased 21% while the average stroke per month of machine from the past recorded data is 19.30 lacks.

Table 15: Results after implementation of design modifications in setup operations

Condition	Time for one setup (minute)	Total no. of setup/month	Total time lost /month (minute)	Strokes/ month (lacks)
Before	228	16	3648	19.30
After	15	16	240	23.38
Saving	213	16	3408	4.04

CONCLUSION

The chute plate setting was the critical problem it takes maximum time in one complete changeover. There were separate chute plates for every tool die and needed to be replaced every time die is changed. So a standard chute plates was required to design for rotor and stator chute to overcome this problem. This new design of chute plate has helped reduced the multiple chute plates to only one standard chute plate. A lead screw and slotted bar was attached with chute plates for easy sliding at bolster. The static structural analysis of this newly designed chute plate is done and it is found safe at maximum load (2 ton). To eliminate wires tie operation of free end of chute a sliding support was designed for hanging the chute. As a conclusion it has been observed that design of new chute plate and supporting components of chute plate assembly have reduced the critical time period of about an hour to few minutes. The design concept of this chute developed is so versatile that it can be implemented not only on this particular press but also on other high speed presses improving the efficiency of production rate. A QDC hardware hydraulic clamping was implemented that benefited the process as it significantly reduces the load and unloads times compared to conventional manual clamping and also reduces the manpower needed to clamp the die resulting in higher capacity utilization of press. Hydraulic clamping also improved quality due to consistent and repeatable clamping forces being applied. An induction motor and a reduction gear assembly attached with the slide for improving this setup operation. SMED methodology was also involved along with the new designs and Improved the setup time reduction.

Future Prospects:

Present improvements are not final one, since implementation of new and innovative tool gives the space for further improvement. Besides, this new approach uses methods independent of industry field which make them applicable to other complex technological processes. The target of this project was to complete the all setup operation less than 10 minute or in single digit of minute. We could achieve up to 15 minute with the integration of SMED and QDC still more scope in time to reduce setup time less than 10 minutes. Beside of SMED a new technology is arose OTS (one touch exchange of die), the target of this technology is to perform the complete changeover less than one minutes. Feeder setting still takes 13 minute to eliminate this time replace the mechanical feeder gear box with servo feeder. In the conventional clamping system, the actual clamps go where they make a sense to hold the range of dies on the press. The mechanical clamping require more time and labor fatigue and hydraulic clamping require more maintenance, if the pressure of clamp is drop down due to some reason the break down may take place. To overcome this problem can use a magnetic clamping technology. This technology is based on the principle of electro-permanent magnet. It provides the safely clamping while the power failure. Electric power is needed only 2-3 second to magnetize and demagnetize the die. There is no modification requiring in die and machine directly bolted the plates in the existing holes of machine bed. The benefits of this technology are that if the smallest movement in the die will cause stop to machine so greater safety of machine and die. In the present design there is no optimization is done. There is a wide scope of optimization in designed chute plate to reducing material cost and weight.

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