Improving productivity by the application of systematic layout plan and work study

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Abstract—Importance of efficient methods for developing the production layout has grown tremendously over the last decades and is likely to continue to do so. Although several other technologies and models are developed in the field of layout planning, we have still many areas that lack the attention from specialized research. The aim of this thesis is to test and develop a model for re-layout planning intended for the heavy steel industry. The creation of the model and identification of proper tools was entirely based on research. This means that all parts of the model are previously well established academic point of view. These were chosen so that the final model would be well adapted for the intended environment. The evaluation model was set up so that it permitted several parameters to be evaluated against each other. Even though the model was built to consider a tight investment budget, a capacity increase of 7.7% proved to be possible. Furthermore, nearly two hours of per day operator time could be saved and the production bottleneck up-time could be decreased with 1.1%. The eventual model proved to be well applicable for the case company and the final layout solution that was generated showed that improvements were possible.

Index Terms— SLP (systematic layout planning), Work study, Productivity.

I. INTRODUCTION

Optimize the material flow in the finishing section and dimension the process for the upcoming changes while considering all limitations. The Jindal Steels consists of two great halls; a rolling operation and a finishing operation. After this the material is loaded on either train carriage or rack to be operated by forklift. The future situation for the finishing section is currently unknown. This new situation must therefore be mapped so that production up-time is established for all activities in the process. The final layout must then be based on this data so that the optimization is made according to the future state, and not according to the current state. The desired outcomes that are to be achieved by carrying out this thesis works in general and specific are the followings:

1. To develop an appropriate model for the improvement of productivity of Steel industry.
2. To initiate and prepare the foundation for future research works related to Steel Industries.
3. The aim of the thesis is to develop a model for designing new production layouts in the heavy steel industry. The model will be applied on a real case scenario in the intended environment.

Procedure

1.1 Theoretical Method for Establishing a Layout

This section describes how a layout is established according to SLP. This includes tools and focus in the gathering of data as well as a description of how the data could be turned into a layout.

1.1.1 Systematic Layout Planning (SLP)

What could be argued to be the most organized and systematic technique to develop a layout plan is Systematic Layout Planning or SLP. This technique was developed by Richard Muther for over 50 years ago. The method has got various face lifts and improvements, but the overall strategies are still the same. According to Richard Muther & Associates a layout planning must never be a subject to uncoordinated continuous improvements, but rather a systematic approach where all factors at the same time are taken into consideration. Meyer clarifies that the key to getting this technique profitable is to collect and analyze data. If this is done correctly the final blueprint will only be a graphical representation of this works, and quickly made when the work already is done. He states a common mistake is to start with the actual blueprint, and says this would be just as "reading the last page of the book first". The part of this case study regarding SLP is based on the techniques as presented by Muther. The same approach could be found in Meyer, Yang, Su and Hsu, Wilde as well as in several other sources. Additional sources, such as Chien bases their models on the same approach, but incorporates modifications due to the surrounding environment. A layout process must according to Muther pass through a series of phases, a number of steps that through SLP has been standardized and inserted into a framework. This technique is well used and proven to work countless of times due to its systematic approach. But the technique could also be said to be nothing more than a standardized process analysis. Every time a process is deeply analyzed, certain steps must be covered to gain understanding for the process. Before there is any possibility to know where to go too, one must have a deep understanding for where to go from. This includes the following steps;

- Define process boundaries
- Map the process flow with all its activities and interrelations
- Calculate capacity and intensity for each step in the process
- Identify bottlenecks and evaluate further limitations to consider
- Improve the process based on the previous analyses

While going through this method, a lot of different diagrams and charts have to be used to keep a lot of data in an analyzable manner. To go through these systematic steps is what the very core of SLP is about, a systematic and standardized approach.

1.1.2 The Basic Elements of SLP

The basic elements of which a layout problem rests on are Product, Quantity, Routing, Supporting Service and finally Timing. That implies, “what is actually produced”, “how much is produced”, “what does the routing schedule look like”, “what support backs up the process” and “when will the items be produced”.

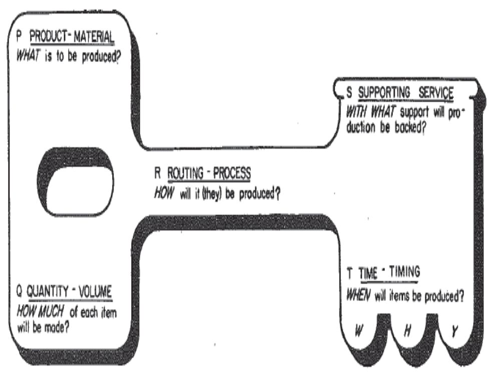

Figure 1. A visualization of the key to unlock the ultimate layout plan

1.1.4 The SLP Framework

The approach is divided into four phases:

- Phase1: Location- Which areas should the layout consider
- Phase2: Overall Layout- Establish flow patterns and areas allocated
- Phase3: Detailed Planning- Planning of each machine and the different activities
- Phase4: Installation- Physical implementation and installation of the layout

A layout plan always rests on three fundamentals.

- Relationships- Relative closeness desired and required
- Space- The necessary area that needs to be allocated
- Adjustment- Rearrangement of the plan into a realistic solution

The contribution of SLP is, as a standardized framework; offer a systematic approach to solve these questions, based on the data given for each situation. This framework looks the same for every layout project. The methods and tools for gathering of data and to make the analyses differ however greatly.

2.1 Present operation process sequence

According to the present Plant layout; coil transfers to the pickling department from the warehouse. After pickling process coil transfers to the rolling mill. After rolling process coil transfers to the annealing department than it sent to the skin pass. The slitting operation and color coating performed finally than coil transfers to the packing department.

Pickling Process: The rolling coil transfers to the pickling department from the warehouse by coil trolley. At the pickling department the coil unloaded from the trolley and loaded on the coiler of pickling machine.

Rolling Process: After the pickling process the coil transferred to the rolling mill department by coil trolley. The coil is unloaded to the mill department with the help of cranes. In the rolling process the thickness of the coil is reduced.

Annealing Process: After the rolling process the coil is transferred to the Annealing department. There are

internal stresses are generated inside the metal sheet. To remove these stresses annealing operation is performed. *Skin passes***:** Skin pass is a rolling process. After annealing process coil transfers to the skin pass department. After the annealing coils may require a final rolling called skin pass.
CR Slitting, color coating & Packing: After skin pass coil sent to slitter to cut in required width, after color coating it sent to the packing department.

2.2 Present Plant Layout

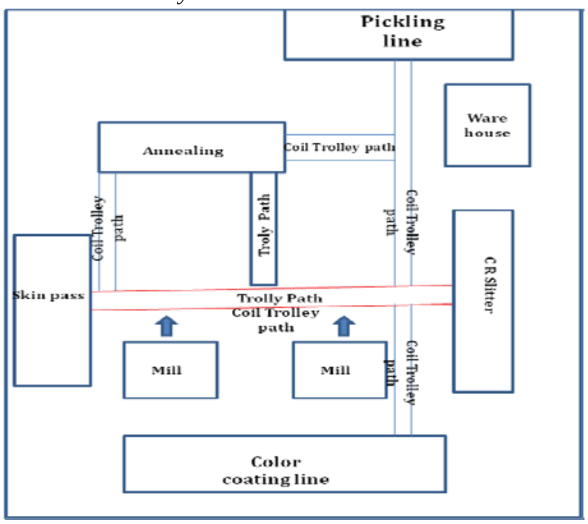

Figure 2: Present plant layout

2.3 Flow process chart According to existing process

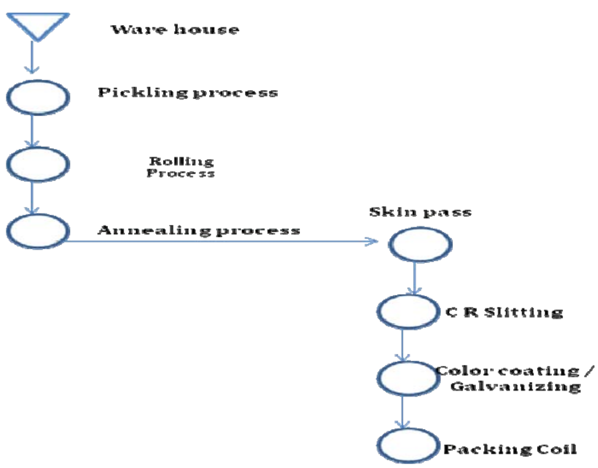

Figure 3: Existing flow process chart

According to the existing plant layout; as we have seen in the above process chart, there are different operations performed on the rolling coil. According to the process chart the coil transfers to the pickling department from the warehouse. The coil unloads to the pickling department and pickling process performed on it. After the pickling process the coil again loaded on the trolley and transfers to the rolling mill path. When the coil riches to the rolling mill path it unloaded from the pickling line trolley and loaded to the trolley of mill path. Now the coil riches to the mill by the mill path and coil unload to the rolling mill. After the rolling process the coil transfers to the annealing path. The coil is unloaded from the trolley and loaded to the trolley of the annealing path trolley and riches to the annealing department. After the annealing process the coil transfers to the skin pass department. Now coil transfers to the slitting department. The slitting is the final process of the coil. After cutting, coil transfers to the packing department. As we have seen in the above process when the coil is transferred to the mill from the pickling department, the coil has to unload from the current trolley to the another trolley because of the different path of rolling mill that's why the coil unloaded and loaded to the different path and the time required to send the coil to the mill from the pickling department is increased. After the rolling process the coil sent to the annealing department and the same problem is there i.e. the coil is again unloaded and then loaded to the trolley of annealing path and again the time increased to sending the coil from the mill to the annealing department. After the annealing process the coil is transferred to the skin pass and then to the C R slitting department. Finally the coil transfers to the packing department. According to the TABLE-A, total distance covered by the coil is **180 Meter** and the total time required to cover the distance is **90 Minutes** by the existing method.

2.4 Limitations of existing plant layout

There are some limitations of the present plant layout which decrease the efficiency and productivity of the plant. As we understand from the above methodology that a large part of time in working hours is only spent on traveling the coils and in its loading and unloading. This time can be reduced by introducing some improved planning and some machines. In every industry there are some limitations of every planning and it is the fact that all the limitations cannot be eliminated, but it can be reduced by some improved planning and ideas. As we have seen in the above flow process chart after the pickling process the coil has to again unloaded from the trolley of pickling path and loaded to the trolley of the rolling mill path. Therefore, because of the change of the path the extra time is spent for unloading and loading the coil to the path of the rolling mill. This time can be saved by improving the existing plant layout. Same as after the rolling process the coil is transferred to the annealing path and the coil loaded to the trolley of annealing department which required the extra time again.

There are five major limitations of the existing plant layout of NCRM Division

1. The distance between the pickling department and warehouse is too large. In the existing plant layout the distance between the warehouse and pickling department is 40 meters.
2. There is not a direct path between the pickling department and rolling mills and same as from the rolling mills to the annealing department. Because of this, there is extra time required for loading and unloading coil which is wasting the time.
3. The distance between the rolling mill and cold rolling slitting machine is too large therefore the coils which are direct transfer for the C R slitting after rolling have to travel a large path.
4. The coils which are required skin pass after the rolling process have to travel a long path, although a new path can be installed between the empty passage between skin pass and rolling mill.
5. The distance of empty passage between skin pass and rolling mill can be reduced so that the proposed path can reduce.

The data were collected and the number of tools/ equipment for manufacturing was counted in terms of the direction for raw materials and product. The operation process chart, flow of material and activity relationship chart have been used in the analysis. The problem of the plant was determined and analyzed through SLP method to plan the relationship between the equipments and the area. The framework of SLP is shown in Fig. 16. Based on the data such as product, quantity, route, support, time and relationships between material flow from –to chart and activity relation chart is displayed. From the material flow and relationship, activity in foundry production, the relation between each operation unit can be observed. Then the results were drawn through the comparison between the existing manufacturing process and the proposed way. In this study, the steel roll as production was mostly made to the customer's order. The manufacturing process was shown in Fig. 24 along with the flow of the operation process. The size of the equipment was relational to the area as shown in Table below. According to the original plant layout, the flow of the material, the utility of the area in the plant and material handling equipment could be discussed as follows:

TABLE -1 RELATIONSHIP BETWEEN EQUIPMENT SIZE AND AREA

Department	Equipment type	Number of equipment	Equipment area/Working area (m2	Total working area(m2
Pickling	Pickling line	1	90	100
Rolling	Mill	2	09	10
Annealing	Bell annealing	1	134	134
Skin pass 1	2 Hi-Mill	1	09	10
Skin pass 2	2 Hi-Mill	1	09	10
Slitting	Slitting line	6	10	10
Galvanizing	Zinc coating line	1	60	
Color coating	Color coating line	1	144	150
Packing	Packing	1	120	120

TABLE- 2DISTANCE TRAVELLED BY COIL IN NCRM

S. No	Actions	Required Time(Minutes)	Distance covered (Meter)
1.	Coil transfer from warehouse to pickling	20	40
2.	Transfer to diff. Path	05	10
3.	Transfer coil to mill	05	10
4	Transfer to annealing path	05	10
5.	Transfer to Annealing	05	10
6.	Coil Transfer to skin pass	15	20
7.	Coil transfer to C R Slitting	15	20
8.	Coil transfer to color coating line	20	30
9.	Transfer to packing Dept.	20 (transfer by crane)	30
	Total	**90 minutes**	**180 meters**

2.5 Analysis

2.5.1 The Flow of Materials: Raw materials were carried with long distance and that means a waste in time and energy, resulting in high cost as shown in Table 1, 2 such as moving the steel roll from warehouse to pickling line, resulting wasted time and more energy. According to TABLE-2, in the existing plant layout the distance between the pickling department and warehouse is 40 meters. This distance can be reduced. According to the new plant layout the distance traveled by the coil from warehouse to pickling department can be reduced and the travelling time of the coil will be saved.

2.5.2 Utility of the Area: The area was not used to the full potential because old machine and remaining materials were still there in the working area, resulting in a useless area of the plant. The department of maintenance was still large, huge and adjacent to the area where the raw materials were kept, resulting in a limited area for storing raw materials. The area to store raw materials was limited before moving to the process of dividing billet, so the area could contain only 60 rolling coils per day. The plant needed to move the raw materials inside regularly until there were 6 rolling coils per day. Thus, this affected the cost of energy.

2.5.3 Material handling equipment: The equipment for material handling of the raw materials was not sufficient, that is to say, loading trolley was used to move in one direction and the pathway was not adaptable enough due to this untidy arrangement of the things. This was the cause why the raw materials were to be carried for a long distance.

2.5.4 Storage area of rolling coils: Actually warehouse for the raw materials was 1,020 square meters. One rolling coil took up 36 m2 so the plant could contain rolling coil for 9,310 tons per month. The plant at the present time could contain only 8,000 tons per month. It had more space to contain billet or raw materials, after the improvement.

2.6 Analysis of plant layout based on SLP

According to the study of the manufacturing process, it was found that the long distance could be reduced for moving raw materials and the problem about the useless area could be solved. The way to improve the plant was to apply SLP method to make the work flow continually by adjusting the important sequence of the manufacturing. Then the relationship of every activity in closeness area was considered to make the relationship of each activity in the graph from – to – chart as shown in Fig 3, and the closeness values are defined as A = absolutely, E = especially important, I = important, O= ordinary closeness, U= unimportant. The details for each activity were described in Table 3, as follows

TABLE-3

A: WARE HOUSE
B: PICKLING PROCESS
C: ROLLING PROCESS
D: ANEALLING PROCESS
E: SKINPASS 1
F: SKIN PASS 2
G: SKIN PASS 3
H: SLITTING PROCESS
I: GALVANIZING PROCESS
J: COLOUR COATING
K: INSPECTION

TABLE-4: THE WORKFLOW OF THE MANUFACTURING PROCESS

Product	Routing
Color coated coil	A-B-C-D-E-F-G-H-I-J-K

The important sequence of every activity was reposition or rearranged from the most important one to the least important one as shown in Fig 4. The intensities of flow from each activity to another were developed in Figure 4.

K
J
I
H
G
F
E
D
C
B
A

Figure 4: The sequence of activities in the manufacturing process

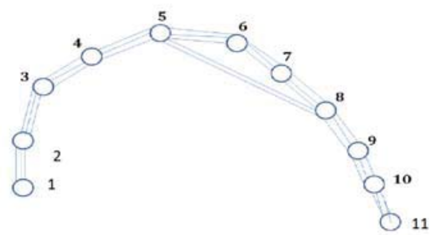

Figure 5: The intensities of flow in the manufacturing process Based on modifying plant layout and practical limitations, a number of layouts were developed. There were 2 choices to improve the plant layout as shown in Fig 26. The original plant layout represents the figure 23, while modifying plant layout represents figure 26.

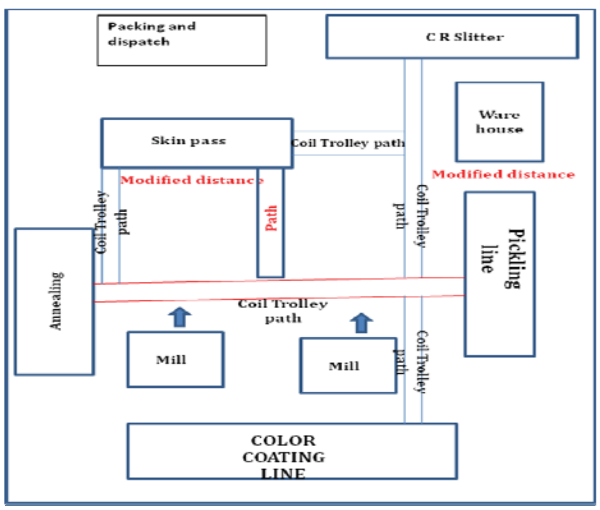

Figure 6: Modified plant layout

III. RESULTS AND DISCUSSION

3.1 Time required performing operations:

Time of travelling of one coil from warehouse to packing department = 110 Minutes

The distance covered by one coil from warehouse to packing department = 180 Meter

After all the allowance in the one shift of 8 hours average 2 coils are passed through these processes.

Total travelling time of 2 coils in one shift = 2×110 = 220 minutes (03.66 hours)

IV. CONCLUSION

The model proved to perform well in the environment where it was tested. The different tools that were used were all capable to gather and systematize a sufficient amount of data. A layout project will always reach a “creative phase” where it is due to the experience possessed by the user of the model, how good the result will be. In this project the traverse lifts came to prove crucial, but also a potential for improvements. In another company this would have been different. This makes it obvious that a good model can be very helpful, especially in the early stages of the project, but it is not sufficient to reach an optimal solution. This research has shown that there are potential for significant improvements without huge investments. The distance travelled by the coil for major operations can be saved **30 minutes /shift.** The time required to transfer coil from rolling mills to skin pass can be saved up to **150 minutes/ shift**.

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