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Bladder Inventory Management for Tyre Curing Process Optimization

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ABSTRACT

Curing Bladder plays a key role in the optimization of tire production. Cure bladders act as a membrane to transfer hot steam and water pressure and temperature onto the green tire. The bladder also plays an important role in the shaping and cooling process depending on the product recipe. The Bladder needs to be replaced for multiple reasons apart from the periodic changeover. This paper focuses on identifying the factors that cause bladder changeover and finding the root cause to reduce the changeover. Lean-based tools and analytical tools help in improving the wastage of the bladder as well as in regulating the overall workflow. A Pareto-based analysis based on frequency is used to identify the main factors and root causes.

Keywords: Bladder, Pareto, Fishbone, Regression, 5 Why, Bladder Impression, Ice Blast

Introduction

Tire Curing is the process in which a green tire is converted into a cured final tire with the aid of hot steam, water as well as cooling. Every Tire type has its own recipe and it lasts for more than ten minutes.[2] The process of curing happens in 4-5 steps. In each step, hot or cold steam is transferred onto the green tire by means of a CMC Cylinder. The CMC cylinder is enclosed by a rubber membrane called bladder. The bladder acts as a medium to transfer the hot or cold fluid onto the green tire. Every Bladder has a life and it refers to the number of tires that we can cure in that particular bladder. Once life is over, we need to change the bladder but mostly bladder will be changed even before it reaches the full life cycle and it is mainly due to bladder rupture, impression, and buckle. In this project, we identify the factors that affected bladder life and implement solutions to solve the same, and make an analysis of the inventory management.

The early failure of the bladder affects production run in multiple ways. Firstly, it will cause wastage of the bladder and related expenses. Secondly, it reduces the production count as bladder changeover takes more than 30 minutes to complete and 15 minutes for warm-up. Early Failure of the bladder also affects the quality of the tire for example bead buckle and bead bend are a result of improper functioning of the bladder. These issues have a minimal impact on tires but will affect future tires in an exponential fashion. The work schedule also will be affected by this kind of bladder failure and affect regular changeover.

2. Literature Review

[1] Lean-based tools play a key role in the modern production system. The lean system aimed at reducing eight types of waste. These wastes are transportation, inventory, motion, overproduction, overprocessing, waiting, defect, and underutilization of human resources. The lean tools like value stream map, Kanban, kaizen, and takt time aid the production plan and in reducing wastage. The tools like a fishbone diagram helps to identify the root causes as well as solutions to tackle the same. [5]The concept 5 WHY aimed on finding the root cause by asking iterative questions one after another. 5 Why helps to trace the final root cause and help in finding the potential impact.

3. Methodology

3.1 Bladder Changeover Analysis

The Bladder changeover reasons are recorded on MES and the data is analyzed with excel software. From the past 200 bladder changeovers, four factors play an integral role in the changeover. Bladder impression, Bladder cut, and bead buckle play a significant role along with the life over of the bladder. Bladder cut affects the quantity of tire than its quality but bladder impression and bead buckle affect the quality of the tire. A small bead buckle will affect the tire in long term. [4]The figure 1 shows the changeover reason as a pie chart. The Life over is a regular process of changing the bladder when it completes a fixed number of tire curing. The life of tire curing depends on different sizes. Small tire sizes like 11 or 10 inches have more life than bigger sizes like 17 or 18-inch tires. The life over happens based on a periodic plan but production plan change and unexpected mould change will affect the regular plan and delay the changeover time.

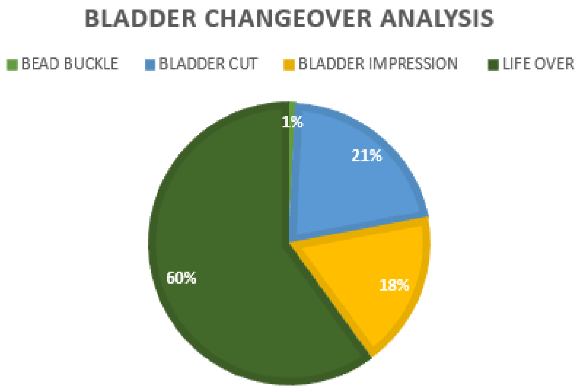

Figure 1: Pie chart showing the bladder changeover reason in the last 200 changeovers.

3.2 Bladder Cut Analysis

The bladder cut refers to the rupture of the bladder membrane during the curing process or during the loading or unloading time. The bladder cut is a generalized problem and can't be summarized in a single source. [3]A fishbone diagram as shown in figure 2 will helps to make a summary of the issue. From the diagram, it is clear that man, machine, material, and method played an important role in the number of bladder cuts that occurred in that month.

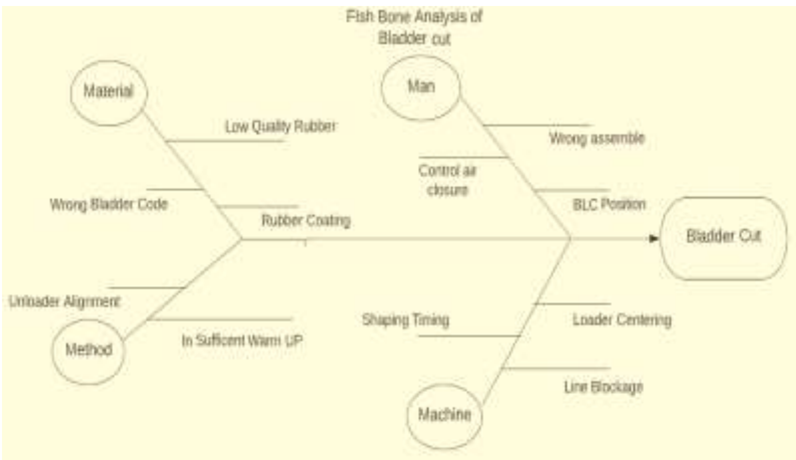

Figure 2: Fish bone analysis of bladder cut.

The operator plays a key role in bladder cuts. The control air closure affects bladder change shaping and hence holes will happen. The bladder has 5-6 subassembly parts. The improper assembling will affect in the long run. It leads to instability as well as improper functioning. The bottom loading cylinder plays a main role in the low ring movement. Improper sitting affects the bladder in many ways, especially in shaping. The insufficient warm-up also affects the rubber membrane and will lead to sudden rupture. The unloader arm used to pick a cured tire need to be aligned properly and needs to be checked periodically. Failure to align properly will result in bladder failure due to unloader finger contact.

The curing press also needs to be updated regularly on PMS. Line Blockage will elevate the steam pressure and the bladder won't survive the temperature. Shaping pressure time also needs to be checked regularly. If the time exceeds the spec, then it causes more load on steam in long run. The loader arm alignment also affects the GT position as well as the finger contact. The incoming material also affects the life of the bladder but such kinds of issues happen very less frequently.

3.3 Bladder Buckle Analysis

Bladder buckle or its after-effect bead buckle refers to the irregular wrapping of bead around the tire. The issue affects the overall traction and stability of the tire. The conicity factor of the tire is also affected by the bead buckle issue. Ineffective shaping is the major reason behind bead buckles. The five why analysis about the problem to trace out the root cause is as shown in figure 3. From the five why analysis it is clear that improper shaping happened because of pressure variation from I to p. I to P is a device that controls the control pressure by means of voltage. I to p employs a diaphragm-based system in which the opening and closing are controlled by means of a diaphragm. The I to p regulation can be controlled by adjusting the diaphragm. The diaphragm can be maintained by regular changing of the seal so that leak can be corrected.

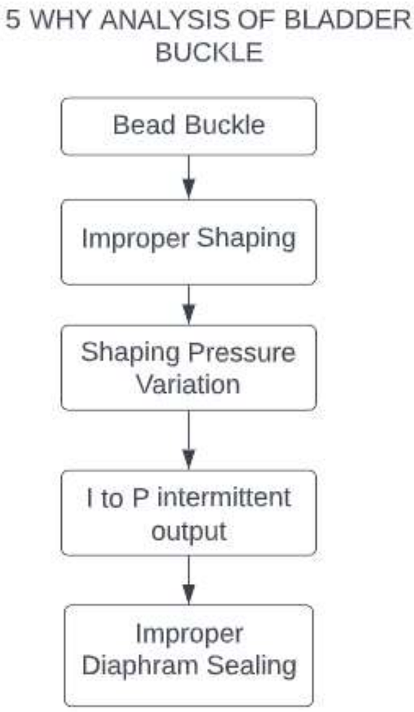

Figure 3: 5 Why analysis of bladder buckle

I to P variation is just one of the reasons behind the pressure variation. The leakage in airline and control valve failure can also result in pressure variation. The control valve failure can be traced to the diaphragm and such kind of issues happen very rarely.

3.4 Bladder Impression

Bladder Impression is one of the top reasons behind yield reduction. The impression affects the tire finish as well as usability. The bladder impression and mold impression can be reduced by ice blast but doing ice blast is an expensive process. In order to optimize the ice blast frequency, a prediction model can help to reduce the cost. Ice blast is a process by which solid carbon dioxide is applied directly to a mold. The ice blast frequency depends on many factors. Firstly, it depends on press opening and closing delay as it will result in under-cure and off-cure issues. The unloader alignment can also affect the tire curing. If alignment is not right meaning rubber will wrap around the unloader fingers. The loader alignment also affects tire position as well as the curing process. The GT contamination is also a main reason as the defective GT affects tire overall curing as well as mould impression.

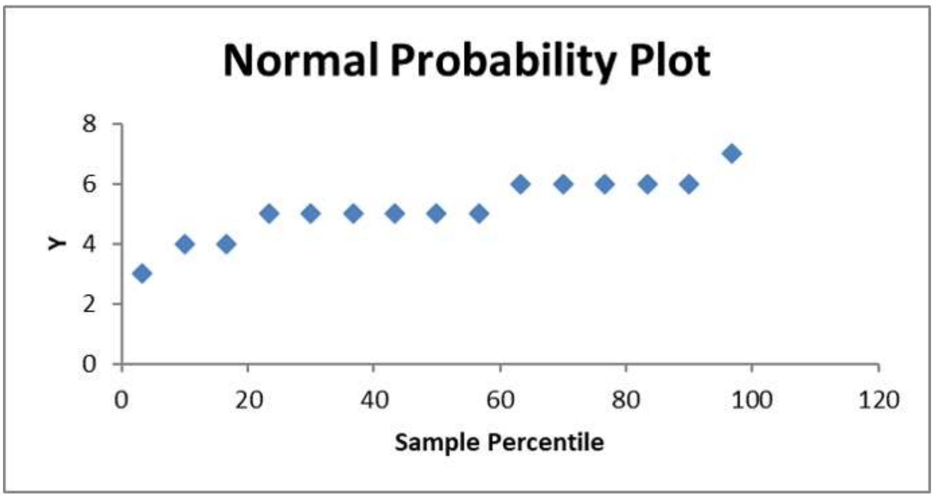

Figure 4: Normal Probability Plot of the regression analysis

In order to identify what factor affects the most, a regression analysis was carried out. Based on the multivariate regression analysis, it is found that GT contamination affects the most with an r square value of 0.69. The unloader alignment issue has a negative correlation but is not practically significant.

The loader alignment shows a strong correlation coefficient factor of 0.89 and thus the loader alignment needs to be corrected. Figure 4 shows the normal probability plot of the regression analysis.

3.5 Improvement Methods

Based on the lean and analytical methodology the following improvement measures were taken as follows.

- The loader centering was carried out regularly with PMS Checklist.
- Poka Yoka was implemented to reduce the number of misalignments.
- Unloader stuck up was reduced by adjusting the sensors
- Warm-up timing was adjusted as a jidoka methodology.
- The number of ice blasts in the MCR curing press was adjusted based on the prediction model.
- The root cause analysis and 8D report were created
- Shaping pressure was monitored continuously and outliers are identified.
- The contaminated GTs are sorted
- The loader and unloader stuck up are reduced

Result and Discussion

The bladder failure was recorded before and after the measures were implemented. From the data, it is clear that small tires experienced significant progress compared to larger tires. Ten inches experienced almost fifty percent reduction in bladder failure. Seventeen inches tires are from the radial tire category and those tires also experienced a significant reduction. Figure 5 shows the significant reduction in bladder inventory across four type of tire manufacturers.

Figure 5: The bladder failure across different tire sizes based on improvement measures.

Conclusion

In this project, bladder failure was analyzed and the main reasons are listed. From the reasons, it is found that bladder cut plays a significant role in the overall bladder failure. The bladder cut failure was analyzed with the aid of a fishbone diagram. In the fishbone diagram, it is found that man, material, machine, and method play a significant role. On the material side, rubber quality affects life, and the way assembling the bladder also plays a significant role. The machine failures are analyzed and the blockage in the line, as well as control air issues, are identified. The bladder impression, as well as mould impression issues, can be solved with the aid of ice blasting. A regression-based prediction model was developed and the influence of each factor is identified. The root cause analysis of bead bend was traced out with the aid of 5 why the analysis was done. The impact of I to p was identified. The improvement measures were made based on lean methodology and then the key performance indices were computed and analyzed.

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