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Modification of L- Shape Gravity Roller Dispatch Conveyor with Turn Table Arrangement

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Abstract

This study presents the conceptual framework and practical implications of modifying an L-shape gravity roller dispatch conveyor with a turntable arrangement. The motivation for this modification is to enhance the efficiency and flexibility of material handling and logistics operations within industrial settings. The proposed system involves the incorporation of a turntable at the corner of the L-shaped conveyor, allowing for a seamless change in the direction of materials being transported. A control system is implemented to coordinate material routing and ensure accurate alignment on the turntable. Sensors and sorting mechanisms are utilized for precise material handling, while the flexibility of this modified conveyor system enables a variety of material flow configurations. The study explores the potential advantages of this modification, including improved workflow, reduced manual intervention, and optimized space utilization. By providing a comprehensive overview of this innovative conveyor system adaptation, this research contributes to the ongoing efforts to enhance the efficiency and adaptability of material handling processes across industries.

Key Words: *VTU-varying touch unit, PFA-Production flow analysis, Turn Table- turns and transfer at* 90^0*, CAD-Computer Aided Design*

1. Introduction

For the selection of material handling equipment, there is no one-size-fits-all solution applicable to all manufacturing and storage facilities due to the inherent variability in layouts. This study focuses on the development of an L-shape conveyor system using Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) software to tailor a suitable solution for material movement [1]. The aim is to replace the conventional L-shaped conveyor with a turntable arrangement to achieve several key objectives:

Seamless Operation: The primary goal is to ensure unobstructed and efficient material flow on the dispatch conveyor from its starting point to the endpoint. The turntable integration is intended to eliminate any operational obstacles.

Enhanced Production Flow: By introducing the turntable arrangement, this work seeks to optimize the overall production flow within the facility. This modification can lead to a smoother and more streamlined manufacturing process.

Labor Cost Reduction: One of the anticipated benefits is a reduction in labor costs. The turntable automation eliminates the need for manual material handling and labor-intensive tasks, contributing to cost savings.

Operator Fatigue Mitigation: The incorporation of a turntable not only enhances efficiency but also reduces operator fatigue. By automating the material transfer process, it minimizes the physical strain on workers.

The proposed solution involves the implementation of a turntable arrangement to facilitate material transfer at right angles. This not only resolves material handling challenges but also has the potential to significantly improve the overall production flow. This study represents a step toward the customization of material handling solutions tailored to specific facility layouts, addressing operational efficiency, labor costs, and operator well-being in the context of manufacturing and storage facilities [2].

1.1 Problem Description

In the assembly section of a prominent farm equipment manufacturing facility situated in central India, a significant issue has arisen during the transfer of assemblies on the gravity-type roller 90-degree dispatch conveyor assemblies come to a halt at the curve. This unforeseen stoppage of assemblies has triggered a cascade of problems, including potential damage to the halted assembly due to collisions with others, disruptions in the production flow, and the necessity of additional labor to manually push the halted assembly along. These complications have far-reaching consequences, encompassing a decline in product quality, an upsurge in rejections, increased rework requirements, and a direct adverse impact on overall productivity [3].

The Figure 1 diagram illustrates the cause-and-effect relationships associated with this issue and the imperative need for a suitable solution. The assemblies in question possess a rigid and substantial structure, making the handling process particularly challenging. Moreover, it is imperative to account for ergonomic considerations and environmental factors, including space constraints and the prevalence of unsafe assembly practices within the working environment. Addressing these multifaceted issues is of paramount importance to rectify the production inefficiencies and quality concerns plaguing the assembly line.

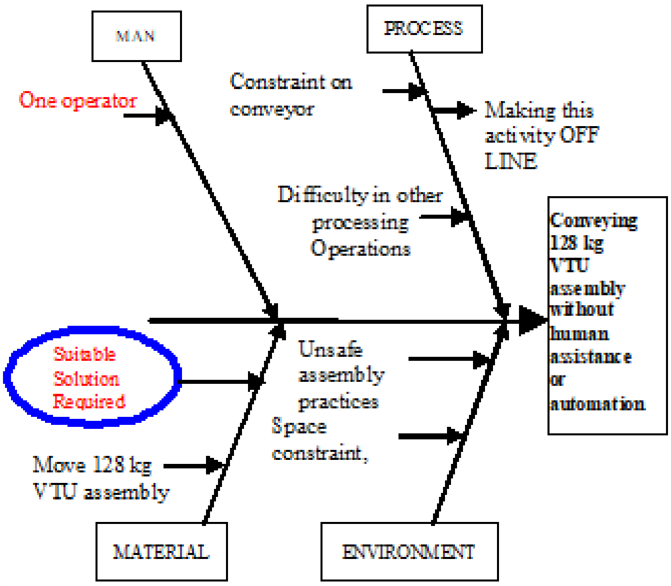

Figure 1 Causes and Effect Diagram

As depicted in Figure 1.1, the primary objective is to facilitate the conveyance of a substantial 128 kg VTU (Variable Transmission Unit) assembly without the need for human intervention. To achieve this, it is imperative to identify and implement an appropriate and effective solution tailored to the specific requirements and constraints of the assembly line. This endeavor underscores the importance of addressing the challenges associated with handling such heavy and unwieldy components within the manufacturing process. By identifying and implementing a suitable solution, we aim to enhance operational efficiency, mitigate the risk of damage or delays, and ensure the smooth and autonomous conveyance of the VTU assembly, ultimately contributing to improved productivity and product quality [4].

2. Related Work

Modifying an L-shape gravity roller dispatch conveyor with a turntable arrangement encompasses various advancements in conveyor and material handling technologies, as well as the integration of automation and control systems. Prior research has demonstrated the benefits of incorporating turntables into conveyor systems, particularly for material reorientation and redirection, leading to improved operational efficiency [1]. Existing literature emphasizes the importance of seamless integration between the turntable and the conveyor, highlighting the role of sophisticated control systems and sensors to ensure precise material handling and sorting [7]. Additionally, related work explores the use of automation and robotics in conveyor systems, suggesting potential enhancements in terms of increased throughput, reduced labor requirements, and enhanced safety [2]. Furthermore, research in conveyor system modifications often focuses on industry-specific applications, such as manufacturing, warehousing, and distribution, each presenting unique challenges and opportunities for optimizing material flow [3]. Collectively, these studies provide valuable insights into the design, implementation, and benefits of integrating turntable arrangements with conveyors, offering a foundation for the development of efficient and adaptable material handling solutions across various industries [4].

3. Production Flow Analysis

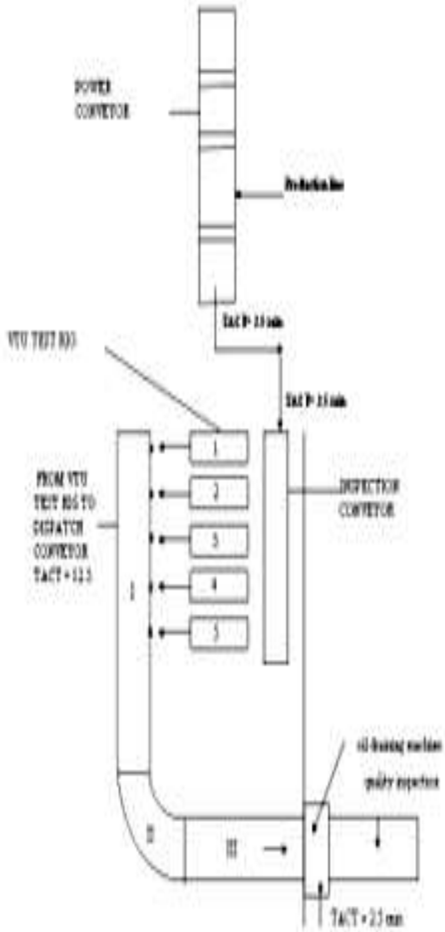

Figure 2: Layout of the Varying Touch Unit

Figure 2 provides a visual representation of the operational workflow within the facility. This setup comprises a power conveyor integrated with the production line responsible for the assembly of VTU (Variable Transmission Unit) components. The VTU assembly is assembled in a swift 2.5-minute cycle with the assistance of nine operators within the production line. Subsequently, a hoist is employed to facilitate the manual transfer of the VTU assembly to the inspection conveyor, requiring the involvement of a single operator. The VTU assembly undergoes a series of critical inspections, commencing with hydraulic inspection on the first inspection machine within the VTU test rig [11]. The assembly sequentially progresses through the second, third, fourth, and fifth inspection machines for thorough hydraulic inspection, necessitating a total processing time of 12.5 minutes across the five test rigs. Operators are responsible for manually unloading the assemblies from these inspection rigs, and a hoist is employed to facilitate the transfer of the assembly to the dispatch conveyor. The assembly's journey continues through the dispatch conveyor, as illustrated in figure 2. However, when the assembly reaches the starting point of the curved section, it comes to a halt. At this juncture, the intervention of an operator becomes necessary to manually push the assembly through the curved section, ensuring its progress to the endpoint. At Part III of the workflow, the final inspection and top plate fitting procedures are carried out by a single operator within a brisk 2-minute timeframe. Subsequently, the assembly is transferred to the oil draining machine, where the oil is efficiently drained from the VTU assembly within 2.5 minutes. Finally, the assembly proceeds to the quality inspection conveyor for further evaluation and quality assurance. This comprehensive workflow captures the various stages and intricacies involved in the production and inspection process of VTU assemblies within the facility.

3.1 Problem Definition

The task of conveying assemblies through the curvature represents a significant operational challenge, necessitating the constant presence of an operator to manually push the assembly along the entire curved section. Upon a detailed analysis of the production flow, it becomes evident that there is a critical issue concerning the accumulation of VTU (Variable Transmission Unit) assemblies at this curvature when the worker is temporarily absent. Regrettably, none of the existing facilities or arrangements within the operational setup are found to be adequately equipped to address this specific challenge.

At the curvature section, the indispensable presence of a worker for continuous manual pushing of the assembly raises concerns related to worker fatigue and unsafe working conditions. This manual intervention not only places physical strain on the worker but also introduces a potential safety hazard. Furthermore, the interruption of the assembly's movement at this point gives rise to a cascade of operational issues, including the risk of damage to the halted assembly due to collisions with other assemblies, disruptions in the overall production flow, and the need for an additional operator to manually push the halted assembly forward. These operational complexities invariably result in a multitude of quality-related problems, such as an increase in product rejections and the need for costly rework procedures. These issues, in turn, have a direct and detrimental impact on overall productivity levels within the facility.

4. Methodology

4.1 Specification of existing conveyor

Gravity given 5 inch per 10 feet
Type: - Gravity type roller bearing conveyor
Dimensions: -
Length: -78.5 feet –23.926 m
Width:- 1.45 feet-0.4419m
Starting height:-3.90 feet:- 1.888 m
End height:- 2.48feet:-0.756 m
Gravity given for total conveyor: -1.132 m
Loading Capacity :- To withstand and transmit a load of 5 tone

4.2 Data collection

The measurement process involves determining heights at various positions above the ground level along a conveyor with a total length of 78.5 feet (approximately 23.92 meters). To ensure accurate measurements, the conveyor is divided into 16 equally spaced points. Table 1 provides a detailed breakdown of these measurement points, indicating the respective heights recorded at each point. Notably, the heights are measured from the base of the conveyor using pipe level measurement techniques. Upon close examination of the data in Table 1, several observations become apparent. Firstly, there is a discernible difference between the inner and outer heights at points 1, 2, 4, 6, 7, 8, 9, 11, 12, 13, 14, 15, and 16. This variation suggests that the heights at these points are not uniform and exhibit fluctuations between the inner and outer edges of the conveyor. Additionally, points 7, 8, and 9, as well as points 12 and 13, exhibit identical height measurements, indicating a level consistency at these specific locations despite the overall height disparities observed along the conveyor. These findings highlight the importance of accurately documenting and analyzing the height differentials at various points along the conveyor to ensure its optimal functionality and alignment.

Table 1. Data collected at Number of Points

Points	Length in meter	Inner height in meter	Outer height in meter	Difference in meter
1	1.91	1.188	1.170	0.018
2	3.83	1.137	1.132	0.005
3	5.74	1.062	1.062	0.000

4	7.66	1.023	1.020	0.003
5	9.57	0.971	0.971	0.000
6	11.49	0.915	0.910	0.005
7	13.41	0.885	0.885	0.000
8	14.53	0.885	0.885	0.000
9	15.66	0.875	0.885	0.000
10	16.76	0.870	0.870	0.000
11	17.92	0.865	0.870	0.005
12	19.04	0.840	0.840	0.000
13	20.53	0.840	0.840	0.000
14	21.47	0.813	0.810	0,003
15	22.69	0.780	0.784	0.004
16	23.92	0.756	0.750	0.006

4.3 Problem Areas

The curved section of the conveyor presents several operational challenges due to issues such as improper joints, inconsistent gradient, and height discrepancies. These problems are particularly evident in the height measurements recorded at defined points along the conveyor, where variations in inner and outer heights are observed. This inconsistency in height measurements contributes to the stoppage of assemblies at the curved section, leading to undesirable consequences. One of the contributing factors to this issue is the presence of improper joints within the curved section, which disrupt the smooth movement of assemblies. Additionally, the gradient of the curved section appears to be insufficient based on the data collected, as the measurements indicate a need for a more gradual incline. The insufficiency of the gradient is particularly notable in Figure 3, where it becomes evident that the curvature's design does not adequately account for the assembly's smooth transition through this section of the conveyor. As a result of these challenges, assemblies frequently strike against the curved section, causing stoppages and delays in the production flow. Addressing these issues necessitates a thorough evaluation and potential modifications to the conveyor's design, ensuring that proper joints, appropriate gradient, and consistent height measurements are incorporated. These improvements are essential to mitigate assembly stoppages and optimize the conveyor's performance.

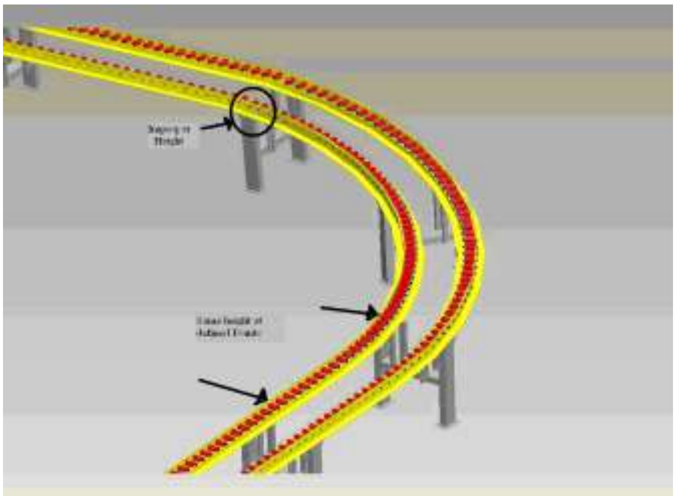

Figure 3 CAD Model for Analyzing Problem areas

Upon analyzing the data collected and conducting calculations, it becomes evident that the gradient of the curvature in the conveyor system is insufficient, leading to operational issues. The cause-and-effect diagram further emphasizes the necessity for a suitable solution at the curvature to address these challenges. In-depth examination of the CAD model reinforces the notion that the curvature is the precise location of the problem. Considering all these factors and the complexities associated with the curvature, we are exploring alternative solutions to rectify the issue. One potential approach involves the removal of the curved section and its replacement with a turntable or another alternative method that can effectively resolve the problem. Such a modification holds the promise of not only eliminating the need for a worker's constant presence but also significantly enhancing both productivity and product quality. By focusing on these alternative solutions, we aim to optimize the conveyor system's performance, alleviate the operational challenges linked to the curvature, and create a more efficient and seamless workflow within the assembly process. This strategic shift has the potential to yield substantial benefits, aligning with our overarching goal of improving productivity and elevating product quality standards.

5. Implementation

In response to the need for smoothly conveying the VTU (Variable Transmission Unit) assembly at a 90-degree angle, we are in the process of developing a specialized table designed for this purpose shown in figure 4. This development is particularly relevant within the hydraulic unit department, where the availability of pneumatic power is a valuable resource. Our choice of pneumatic power as the input power source for this mechanism is based on several key considerations:

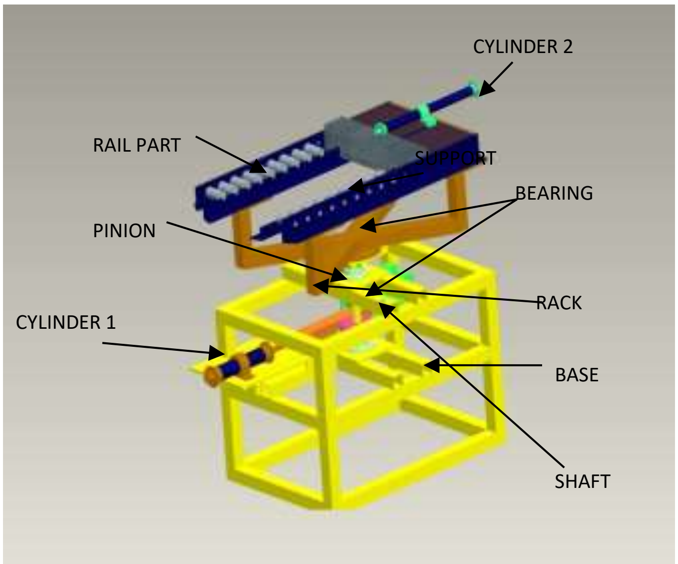

Figure 4 CAD Model of Turn Table

Low Cost Automation: A primary objective is to implement a solution that achieves automation while remaining cost-effective. Pneumatic power offers a cost-efficient means of achieving automation in material handling processes.

Minimization of Manpower: By harnessing the capabilities of the pneumatic system, we aim to minimize the need for manual labor in the assembly and conveyance of VTU units. This not only streamlines operations but also reduces labor costs. **Minimization of Time Loss:** An essential goal is to minimize any time losses associated with material handling. Efficient and rapid conveyance of VTU assemblies is critical for maintaining a smooth production flow. The core principle underlying the design of this turntable mechanism is the conversion of linear motion into rotary motion. To accomplish this, we have chosen to incorporate a rack and pinion gear system as the fundamental mechanism. The key components of this turntable include a shaft, a rack and pinion gear arrangement, and push rod cylinders.

By utilizing this innovative turntable concept, we are poised to enhance the efficiency of material handling, reduce manual intervention, and optimize the overall workflow within the hydraulic unit department. This development reflects our commitment to integrating technology and automation to meet operational objectives while maintaining cost-effectiveness.

5.1 Working

In the implementation of our turntable mechanism, we employ a double-acting pneumatic cylinder with a diameter of 16 mm and a stroke length of 400 mm. This cylinder plays a pivotal role in orchestrating the forward and backward motions of the system, facilitating the precise alignment of the rail part with the conveyor sections. During this phase, the push rod of the pneumatic cylinder extends, applying force to the rack meshed with the pinion gear. The rotational movement of the pinion, which is securely mounted on the shaft, comes into play.

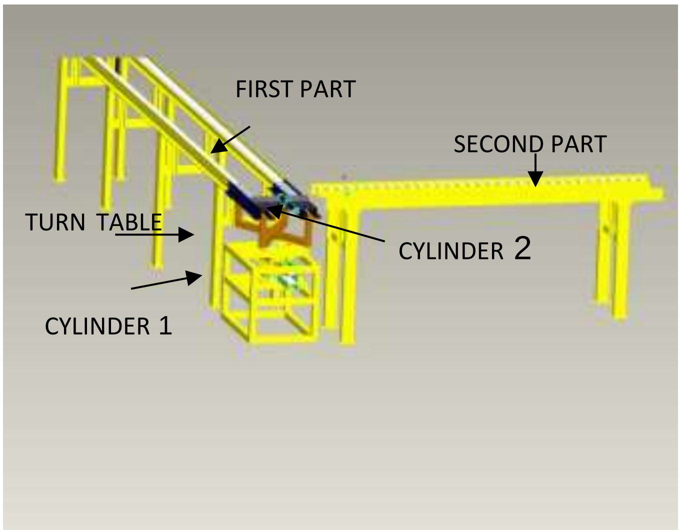

Figure 5 Working of Turn Table

As the pinion rotates, it imparts its motion to the shaft itself. The rotation of the shaft, in turn, causes angular displacement in the rail part, resulting in a precise 90-degree turn. This alignment of the rail part ensures that it is synchronized with the second part of the conveyor. The figure denoted as 5 illustrates the actual position of the turntable during this stage, with the rail part successfully aligning with the conveyor's first section. As the assembly moves from the first part onto the turntable, the process continues. The push rod of cylinder 1 comes into action, exerting force on the rack meshed with the pinion. The rack's linear motion is efficiently translated into the rotary motion of the pinion. The pinion, intimately coupled with the shaft, imparts its rotary motion to the shaft itself, leading to its rotation. As the shaft rotates, it causes the rail to move, quartering its position and achieving alignment with the second part of the conveyor. Subsequently, the push rod of cylinder 2 facilitates the transfer of the assembly to the second part of the conveyor, thereby completing the forward motion cycle. This intricately designed process ensures the smooth and precise conveyance of assemblies between the various conveyor sections, exemplifying the efficiency and effectiveness of our turntable mechanism.

6. Conclusion

The primary objective of this work was two-fold: first, to achieve a reduction in labor costs, and second, to optimize the analysis of production flow. This strategic approach was aimed at realizing significant cost savings, notably in terms of labor expenses (amounting to Rs. 10,000 per month or Rs. 120,000 per annum), as well as mitigating rework and damage-related costs. Through a systematic study and the application of industrial engineering principles, it was demonstrated that the role of an industrial engineer is pivotal in enhancing the overall productivity of the organization and subsequently increasing the production rate. This systematic approach involved analyzing and optimizing various aspects of the production process. The integration of computer-aided design (CAD) software played a crucial role in visualizing and conceptualizing ideas. CAD not only streamlined the creative process but also facilitated a comprehensive understanding of the proposed solutions. Furthermore, the application of analytical mechanics provided a rigorous and evidence-based approach to addressing the identified problem. This analytical methodology ensured that the solutions implemented were precise and effectively resolved the operational challenges. In summary, this work underscores the significance of systematic analysis and the role of industrial engineers in enhancing organizational productivity. By harnessing the power of CAD and analytical mechanics, the project successfully identified, visualized, and addressed the problem, ultimately leading to a reduction in labor costs, improved production flow, and increased overall efficiency within the organization.

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