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Design of Belt Conveyor System for Variable Demand Supply

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Abstract - Warehouse automation increasingly relies on advanced conveyor systems to streamline material handling, reduce labor costs, and enhance operational safety. This study focuses on the design and development of conveyor systems with an emphasis on induct and merge functionalities. Various types of conveyors—including belt, roller, chain, screw, and overhead—are examined in terms of their structure, applications, and operational roles. A major challenge identified is the excessive energy consumption resulting from conveyors operating at peak speeds during low-demand periods. To address this, the study integrates Variable Frequency Drives (VFDs) to dynamically adjust motor speeds based on real-time demand. A detailed case study of an Induct-Merge system is presented, incorporating CAD modeling, parametric calculations, and motor selection tailored to varying operational scenarios. The results demonstrate that appropriate motor sizing and VFD implementation effectively accommodate fluctuating loads while minimizing power consumption. The research concludes that adaptive control through VFDs significantly enhances energy efficiency and cost-effectiveness in warehouse operations.

Key Words: Conveyor system, Induct and merge, Throughput optimization, Warehouse automation.

1.INTRODUCTION

Warehouse conveyor systems are essential tools in modern material handling, enabling the efficient and automated movement of goods throughout a facility. By reducing manual labor, improving safety, and accelerating workflows, these systems play a key role in enhancing productivity and operational efficiency across all stages—from receiving to shipping.

2. OBJECTIVE

In warehouse system, the merging functionality is selected for system design. A conveyor system is proposed to merge products from operator area, with key parameters like belt speed, load capacity, and dimensions defined based on typical warehouse inputs.

To handle fluctuating demand and improve energy efficiency, a Variable Frequency Drive (VFD) is integrated. It allows dynamic speed control of the conveyor motor based on real-time load and supply requirements.

Selection of optimal motor speed, power rating, and VFD frequency range—ensuring smooth operation, flexibility, and efficiency in the warehouse environment.

3. CAD Model

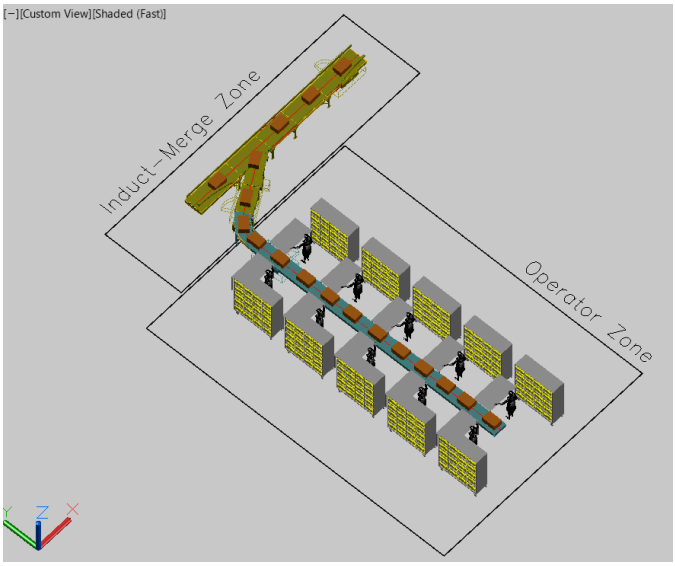

Figure -1: CAD model of Induct Merge Area

4. Conveyor Design for Variable Demands

In the warehouse, supply fluctuates throughout the day shift based on demand. During some shifts, the demand is quite low, while in others, it can be significantly high. Operations can determine the necessary capacity depending on the number of available operators for each specific shift. Based on this, let's assume the demand per shift is as follows:

Table 1: Variable Demand/Capacity per shift

Shift Time	Supply demand	Capacity (cartons/hour)	Minimum number of operators required
6am - 12 pm	Low	400	4
12pm - 6pm	High	880	10
6pm - 12 am	Medium	600	6

4.1 Low supply demand

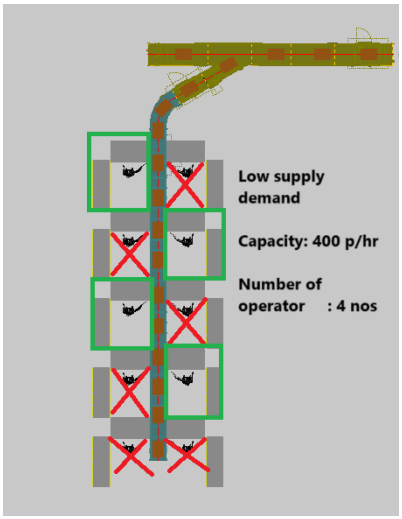

Figure 2 - Low Demand Need

4.2 Medium supply demand

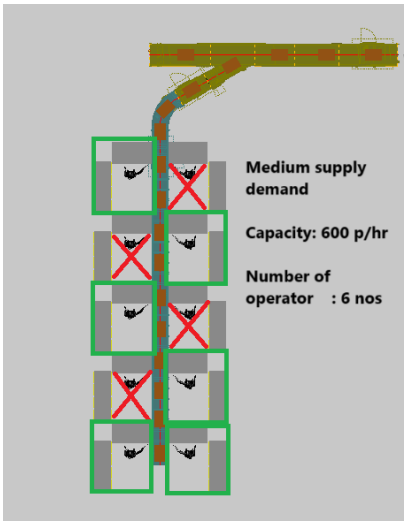

Figure 3 - Medium Demand Need

4.3 High Medium supply demand

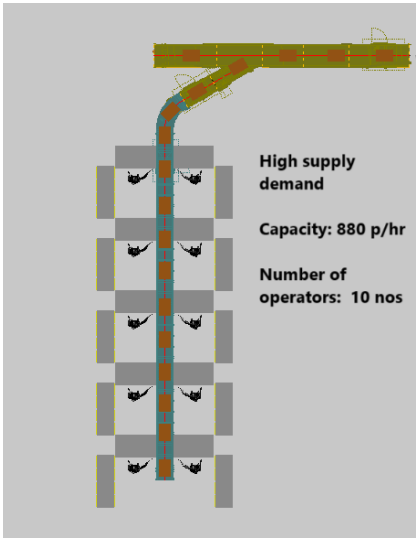

Figure 4 - Medium Demand Need

3. CONCLUSIONS

From the analytical calculations, various design parameters of a conveyor, such as speed and motor power, are determined.
Based on the inputs for specific area or zone calculations, the functionality of the conveyor, whether it inducts, or merges is achieved.
The conveyor system can achieve the required capacity.
By using a variable frequency drive unit, we can effectively manage the fluctuating demand and supply across different shifts.
Looking into the various calculated parameters from below table, the highlighted are concluded variables.

Table 2: Outcome of calculation

	Parameters	Abbreviation	Low demand	Medium demand	High demand	Units
	Capacity	C	400	600	880	p/hour
Loading conveyor:	Belt speed	Vb	10	15	22	m/min
	Nominal Speed	Vnom	20	20	**20**	m/min
	Required motor power	Pb	0.08	0.12	0.17	kW
	Standard chosen motor	Pnom	0.18	0.18	**0.18**	kW
Induct Conveyor	Discharge belt speed	Vd	23	33	53	m/min
	Nominal Speed	Vnom	30	45	**60**	m/min
	Required motor power	Pb	0.07	0.1	0.17	kW
	Standard chosen motor	Pnom	0.25	0.37	**0.55**	kW
Merge conveyor:	Belt speed	Vb	20	29	46	m/min
	Nominal Speed	Vnom	30	30	**45**	m/min
	Required motor power	Pb	0.09	0.14	0.22	kW
	Standard chosen motor	Pnom	0.25	0.25	**0.37**	kW

The loading conveyor, which has a motor power of 0.18 kW and a nominal speed of 20 m/min, can meet all supply demands.

The induct conveyor, with a motor power of 0.55 kW and a nominal speed of 60 m/min, is capable of handling varying demand levels, from low to high.

Similarly, the merge conveyor operates with a motor power of 0.37 kW and a speed of 45 m/min, which allows it to fulfill all fluctuating load capacities.

The frequency of variable frequency drive should range from 20Hz to 55Hz

Table 3: VFD for Loading conveyor:

Speed m/min	10	20	22
Frequency	25Hz	50Hz	55Hz

Table 4: VFD for Induct conveyor:

Speed m/min	23	53	60
Frequency	23Hz	44Hz	50Hz

Table 5: VFD for Merge conveyor:

Speed m/min	20	45	46
Frequency	22Hz	50Hz	52Hz

Since the conveyor operates at a lower frequency, the motor's current input is minimized. This method can significantly reduce power consumption and electricity costs.

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