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Analysis of M-212 Conveyor Belt Modification at Raw Material Warehouse

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Abstract **- This study discusses the effects of the modifications to the conveyor belt on the Warehouse loading system according to CEMA standards. In this case, the specifications observed are belt width, idler selection, and material cut area. Then from the calculation of these specifications it can be calculated the performance of the conveyor belt in the form of carrying capacity, tensile force and power used on the M-212 conveyor belt in accordance with CEMA standards. The results of the analysis in this study showed that there was a reduction in the capacity of the M-212 conveyor belt after the modification. In addition, this modification also has an impact on the power required. After the modification, the required power usage is reduced from the initial 4 hp to 1.44 hp.**

Keywords: conveyor belt, loading system, CEMA, conveyor belt capacity, conveyor belt power.

I. INTRODUCTION

In the current industrial era, technological developments are taking place so fast. This can be seen from the industry's need to produce on a very large scale. The transportation of production results must be considered in order to increase efficiency in its distribution[1]. In an industry there are various types of materials which are sometimes very heavy so that it is dangerous to be transported by humans. Thus it is necessary to have transportation aids to transport these materials. Materials transported are influenced by the capacity of materials, types of materials, and the purpose of transportation[2].

Conveyor Belts is a means of transporting materials from one location to another. Conveyor belts have a high load carrying capacity, very long hauling distances, simple design, easy maintenance, and high operating reliability. Conveyor belts are widely used to handle bulk materials over distances due to their high transport efficiency compared to other transportation methods[3].

An ongoing cause-and-effect analysis is conducted to determine how reliable conveyor transport systems are [4], [5]. A belt with sufficient durability is required for a belt conveyor to function properly [6].

Numerous engineering, structural, and operating factors affect belt life [7], [8]. But a belt frequently wears out too soon [9]. The conveyor belt is the component that is most susceptible to wear due to its operating conditions, constant movement, interaction with rotating parts (mostly idlers), and material being transported[10].

At the warehouse there is a loading system that functions to transport raw materials from the loading hopper to the lump crusher via the M-258, M-211 and M-212 conveyors. At the raw material warehouse, land reduction will be carried out so that on the old loading system a modification is needed in the form of deactivating the M-258 and M-211 conveyors and modifying the length and upstream position of the M-212 conveyor. These modifications were also made to reduce the operating costs of the belt conveyor.

II. EXPERIMENTAL SETUP

2.1 Research framework

1. Literature Review

Literature review is carried out by studying and reviewing theories that are used as references related to research and as a support to reach solutions to existing problems. A literature review is carried out by examining references in the form of books, journals, and information relating to the topic of the problem in this study.

2. Observation

Conduct research and data collection by reviewing through direct interviews with field supervisors. In addition, direct observation of the condition of the conveyor from the raw material warehouse was also carried out. Understanding of the problems that occur is done by referring to the relevant literature.

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3. Problem Formulation

The problem formulation stage is the result of the problem recognition stage. The topics of mentoring and mentoring problems that have been obtained are used as a reference for determining the formulation of the problem which is the focus of the research.

4. Protection of Research Purposes

The next stage is to determine the purpose of the research conducted. This is very important to do to get a reference in determining the level of success of a study.

5. Data Collection

The data collection that was carried out was company data related to the research topic. The data taken is in the form of M-212 Conveyor belt specification data before and after undergoing modification, as well as specifications for the raw material carried, namely urea. These data are used to determine the appropriate method used in research.

6. Data Processing and Analysis

The data processing is done by processing the M-212 Conveyor belt specification data and the raw materials transported using calculations according to the relevant literature.

7. Conclusions and Suggestions

The final stage of the research is to provide conclusions and suggestions from the research that has been done for a case study analysis of the efficiency of the modification of the M-212 conveyor belt in the raw material warehouse.

2.2 Method of collecting data

The data used in the research and completion of this report is:

1. Primary data

Primary data is data obtained from direct observation such as interviews with those who work directly at the raw material warehouse. Interviews or questions and answers as well as consultations with people who are competent or who understand the object under study. Field studies (observations) or observations are carried out guided by field supervisors to obtain the necessary data by observing objects indicated by field supervisors.

2. Secondary data

Secondary Data is data obtained from company documents. The data included in this category is the M-212 conveyor belt specification data before and after modification.

2.3 Data analysis

From the calculation of the specifications obtained from the M-212 conveyor belt before and after undergoing modification, an analysis was carried out to find differences in the two conveyor belts. The analysis includes the calculation of the belt width according to CEMA standards, the calculation of the area of material slices, the idler distance, the calculation of belt speed, and the calculation of the tensile force. Then the results of these calculations are used as a reference to see how effective the performance of the M-212 conveyor belt is at raw material warehouse before and after undergoing modifications.

III. RESULTS AND DISCUSSIONS

3.1 Modification of the M-212 Conveyor Belt

Before modifying the loading system at the raw material warehouse, the M-212 conveyor belt had a length of 35-40 m and had a position above the ground level of 3.7 m which can be seen in Figure 1.

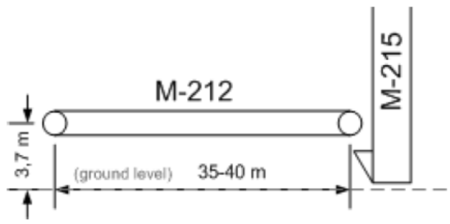

Figure 1: M-212 conveyor belt before modification

After modifying the loading system at the raw material warehouse, the M-212 conveyor belt was shortened to 25-28 m and adjustments were also made by lowering the M-212 upstream conveyor belt position to 2 m below ground level which can be seen in Figure 2.

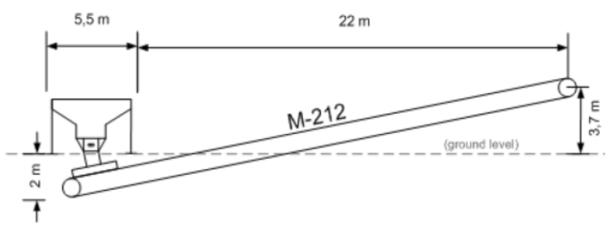

Figure 2: M-212 conveyor belt after modification

The specifications for the M-212 conveyor belt before and after modification can be seen in table 1.

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Table 1: M-212 Conveyor belt specifications

No	Specification	Before modification	After modification
1	Conveyor length	40m	28m
2	Material handled	Urea	Urea
3	Material density	1.323 tonnes/m^3	1.323 tonnes/m^3
3	Conveyor capacities	250 tph (60% load)	150 tph (60% load)
4	Belt speeds	1.5 m/s = 295.276 fpm	1.5 m/s = 295.276 fpm
5	power	2 hp	4.1 hp
6	Belt width	0.8m = 800mm	0.6m = 600mm
7	Idler spacing	2 ft	2 ft
8	Surcharge angle	20°	20°
9	Angle of repose	30°	30°
10	Idler diameter	6 inches	6 inches
11	Conveyor belt inclination angle	0°	11-13°

3.2 Belt width calculation

a) Belt width calculation before modification

The conveyor belt capacity before modification was obtained from design data of 250 tph. 100% capacity is obtained by the calculation below.

$$Q = \frac{\text{tph} \times 2000}{\text{material density}}$$

$$Q = \frac{416{,}67\ \text{tph} \times 2000}{82{,}57\ \frac{\text{lb}}{\text{ft}^3}}$$

$$Q = 10092{,}53\ \frac{\text{ft}^3}{\text{hr}}$$

Conveyor belt speed obtained from the data is 1.5 m/s or 295.276 fpm. Then convert the cubic feet per hour to the equivalent capacity at a speed of 100 fpm, so that the conveyor belt equivalent capacity becomes.

$$Q_{eq} = \left(\frac{\text{ft}^3}{\text{hr}}\right) \cdot \left(\frac{100}{\text{actual belt speed (fpm)}}\right)$$

$$Q_{eq} = \left(10092{,}53\ \frac{\text{ft}^3}{\text{hr}}\right) \cdot \left(\frac{100}{295\ \text{fpm}}\right)$$

$$Q_{eq} = 3421{,}19\ \frac{\text{ft}^3}{\text{hr}}$$

b) Belt width calculation after modification

The capacity of the conveyor belt after modification is obtained from the design data of 200 tph. 100% capacity is obtained by the calculation below.

$$Q = \frac{\text{tph} \times 2000}{\text{material density}}$$

$$Q = \frac{250\ \text{tph} \times 2000}{82{,}57\ \frac{\text{lb}}{\text{ft}^3}}$$

$$Q = 6055{,}47\ \frac{\text{ft}^3}{\text{hr}}$$

The speed of the conveyor belt obtained from the data is 1.5 m/s or 295.276 fpm. Then convert the cubic feet per hour to the equivalent capacity at 100 fpm, so the conveyor equivalent capacity becomes.

$$Q_{eq} = \left(\frac{\text{ft}^3}{\text{hr}}\right) \cdot \left(\frac{100}{\text{actual belt speed (fpm)}}\right)$$

$$Q_{eq} = \left(6055{,}47\ \frac{\text{ft}^3}{\text{hr}}\right) \cdot \left(\frac{100}{295\ \text{fpm}}\right)$$

$$Q_{eq} = 2052{,}70\ \frac{\text{ft}^3}{\text{hr}}$$

c) Analysis of belt width calculation data

Based on the results of the conveyor equivalent capacity values, the belt width can be determined based on table 2.

Table 2: The ratio of the width of the belt according to the cross-sectional area and capacity of the conveyor

Belt Width (in)	A_{sc} Cross Sectional Area (ft^2) Surcharge Angle (deg)							Capacity (ft^3/hr) at 100 fpm Surcharge Angle (deg)						
	0	5	10	15	20	25	30	0	5	10	15	20	25	30
18	0.144	0.161	0.178	0.195	0.212	0.230	0.249	864	965	1,066	1,169	1,274	1,381	1,492
24	0.278	0.310	0.341	0.374	0.406	0.440	0.475	1,668	1,858	2,049	2,242	2,438	2,640	2,848
30	0.456	0.507	0.558	0.610	0.663	0.717	0.773	2,733	3,039	3,347	3,658	3,976	4,301	4,636
36	0.676	0.751	0.827	0.903	0.981	1.061	1.143	4,059	4,508	4,961	5,419	5,886	6,364	6,858
42	0.941	1.044	1.149	1.254	1.362	1.472	1.585	5,645	6,266	6,892	7,525	8,169	8,830	9,512
48	1.249	1.385	1.523	1.662	1.804	1.950	2.100	7,491	8,312	9,138	9,974	10,826	11,699	12,599
54	1.600	1.774	1.950	2.128	2.309	2.495	2.686	9,599	10,646	11,701	12,768	13,855	14,969	16,119
60	1.994	2.211	2.430	2.651	2.876	3.107	3.345	11,966	13,269	14,580	15,906	17,258	18,643	20,071
72	2.914	3.230	3.548	3.869	4.197	4.533	4.879	17,484	19,379	21,286	23,216	25,182	27,197	29,275
84	4.007	4.440	4.876	5.317	5.766	6.227	6.702	24,043	26,642	29,256	31,902	34,598	37,361	40,210
96	4.941	5.474	6.011	6.554	7.107	7.673	8.258	29,647	32,846	36,064	39,321	42,639	46,040	49,548
108	6.715	7.438	8.165	8.901	9.651	10.420	11.212	40,290	44,627	48,990	53,408	57,907	62,518	67,274
120	8.329	9.225	10.126	11.038	11.967	12.919	13.901	49,976	55,349	60,754	66,226	71,799	77,512	83,404

Based on table 2, on the beltconveyorsM-212 before modification obtained a capacity of 3421.19 ft3/h and a surcharge angle of 20°, the belt width that corresponds to this capacity is 30 inches or 0.762 meters, while the specification data is 0.8 m. Thus, the results of calculations with actual specification data for the M-212 conveyor belt before modification are appropriate.

On belt conveyors M-212 after modification obtained a capacity of 2052.70 ft3/h and a surcharge angle of 20°, the belt

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width that corresponds to this capacity is 24 inches or 0.602 meters, while the specification data is 0.6 m. Thus, the calculation results with the actual specification data for the M-212 conveyor belt after modification are the same.

3.3 Idler Selection

Troughing angle 35° has become the most widely used type. Design specifications on the M-212 conveyor belt before and after being modified using a troughing angle of 35°. After knowing the width of the belt, the idler distance can be determined from the table, which is 4.0 ft as shown in table 3.

Table 3: Comparison of idler distance, material weight, with belt width

Belt Width (in)	Troughing Idler Spacing (S_i) Weight of material Handled, lbf/ft³						Return Idlers
	30	50	75	100	150	200	
18	5.5	5.0	5.0	5.0	4.5	4.5	10.0
24	5.0	4.5	4.5	4.0	4.0	4.0	10.0
30	5.0	4.5	4.5	4.0	4.0	4.0	10.0
36	5.0	4.5	4.0	4.0	3.5	3.5	10.0
42	4.5	4.5	4.0	3.5	3.0	3.0	10.0
48	4.5	4.0	4.0	3.5	3.0	3.0	10.0
54	4.5	4.0	3.5	3.5	3.0	3.0	10.0
60	4.0	4.0	3.5	3.0	3.0	3.0	10.0
72	4.0	3.5	3.5	3.0	2.5	2.5	8.0
84	3.5	3.5	3.0	2.5	2.5	2.0	8.0
96	3.5	3.5	3.0	2.5	2.0	2.0	8.0

Based on the table above, the specified idler distance is 4 ft for a belt width of 30 inches and 24 inches with a material weight of 150 pcf. The M-212 conveyor belt specification data before and after the modification obtained is 2 ft. An idler distance that is too large will result in not being able to properly support or support the belt. The idler spacing that is too close will increase the conveyor construction costs and this can also increase the power consumption of the conveyor.

3.4 Area Material Slices

a) Area Material Slices before modification

The area of the material section is the sum of the areas of the isosceles triangle (A1) and the trapezoid (A2). The following is the resulting calculation

$$A_1 = \frac{bh}{2} = \frac{1}{2}(0{,}8B \times 0{,}5(0{,}8B)\tan\emptyset) = 0{,}16B^2 \tan\emptyset$$

$$A_2 = \frac{1}{2}(0{,}4B + 0{,}8B) \times 0{,}2B \tan\alpha = 0{,}12B^2 \tan\alpha$$

Where B is the width of the belt in the installed condition according to the scheme shown in Figure 3.

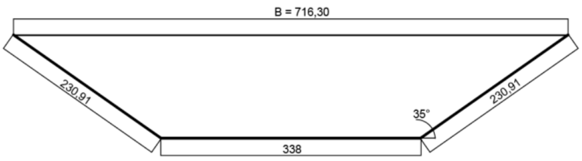

Figure 3: Dimensions of the M-212 conveyor belt before modification in the installed condition

$$B = 338 + 2\,(\text{Cos}\,35\,.\,230{,}91) = 716{,}30\ \text{mm}$$

$$A_1 = 0{,}16\,.\,(716{,}30^2)\tan(20^\circ) = 29879{,}73\ \text{mm}^2$$

$$A_2 = 0{,}12\,.\,(716{,}30^2)\tan(35^\circ) = 43112{,}07\ \text{mm}^2$$

$$A = A1 + A2 = 72991{,}80\ \text{mm}^2 = 0{,}07299180\ \text{m}^2$$

So the total area obtained on the M-212 Conveyor belt before and after modification is 0.07299180 m^2.

b) Area Material Slices after modification

The area of the material section is the sum of the areas of the isosceles triangle (A1) and the trapezoid (A2). The following is the resulting calculation. Where B is the width of the belt in the installed condition according to the scheme shown in Figure 4.

$$A_1 = \frac{bh}{2} = \frac{1}{2}(0{,}8B \times 0{,}5(0{,}8B)\tan\emptyset) = 0{,}16B^2 \tan\emptyset$$

$$A_2 = \frac{1}{2}(0{,}4B + 0{,}8B) \times 0{,}2B \tan\alpha = 0{,}12B^2 \tan\alpha$$

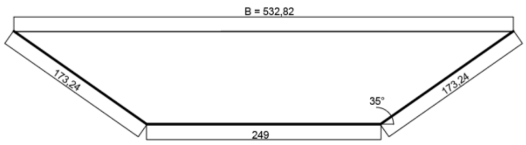

Figure 4: Dimensions of the M-212 conveyor belt after modification in the installed condition

$$B = 249 + 2\,(\text{Cos}\,35\,.\,173{,}24) = 532{,}82\ \text{mm}$$

$$A_1 = 0{,}16\,.\,(532{,}82^2)\tan(20^\circ) = 16532{,}81\ \text{mm}^2$$

$$A_2 = 0{,}12\,.\,(532{,}82^2)\tan(35^\circ) = 23854{,}43\ \text{mm}^2$$

$$A = A1 + A2 = 40387{,}24\ \text{mm}^2 = 0{,}04038724\ \text{m}^2$$

Then the total area obtained on the M-212 conveyor belt after modification is 0.04038724 m^2.

3.5 Calculation of conveyor belt capacity

a) Calculation of the capacity of the M-212 conveyor belt before modification

Belts conveyor M-212 before modification has a capacity of 200 tph. The transported material is urea and has a density of 1.323 ton/m^3 or 1323 kg/m^3. The belt speed is 1.5 m/s. From the specification data obtained the calculation as below.

$$Q = \frac{3600}{1000} \times A \times V \times \gamma$$

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$$Q = \frac{3600}{1000} \times 0{,}07299180 \times 1{,}5 \times 1323$$

$$Q = 521{,}468018 \text{ tph}$$

The calculation results obtained a transport capacity of 521.468018 tph which is a transport capacity of 100%. In the data design, the load percentage of material transported is 60% so that the carrying capacity becomes

$$Q' = 60\% \times 521{,}468018 \text{ tph}$$

$$Q' = 312{,}88 \text{ tph}$$

b) Calculation of the capacity of the M-212 conveyor belt after modification

Conveyor belt M-212 after modification has a written capacity of 150 tph in the specification data. The transported material is urea and has a density of 1.323 ton/m^3 or 1323 kg/m^3. The belt speed is 1.5 m/s. From the specification data obtained the calculation as below.

$$Q = \frac{3600}{1000} \times A \times V \times \gamma$$

$$Q = \frac{3600}{1000} \times 0{,}04038724 \times 1{,}5 \times 1323$$

$$Q = 288{,}53 \text{ tph}$$

The calculation results obtained a transport capacity of 288.53 tph which is a 100% transport capacity. In the data design, the load percentage of material transported is 60% so that the carrying capacity becomes

$$Q' = 60\% \times 288{,}53 \text{ tph}$$

$$Q' = 173{,}12 \text{ tph}$$

c) Analysis of conveyor belt capacity data

Based on field specification data, the belt conveyor before modification with a load percentage of 60% has a larger capacity than after modification, which is 250 tph compared to 150 tph. Then in the calculation according to the CEMA standard, the capacity of the belt conveyor with a load percentage of 60% before modification is 312.88 tph, while the capacity of the belt conveyor with a load percentage of 60% after modification is 173.12 tph. In this case, there is a decrease in performance in terms of capacity due to a modification of 44.67%.

3.6 Calculation of Tensile Force and Conveyor Belt Force

In calculating the tensile force of the belt, it is necessary to value the weight of the material per unit meter length of the conveyor belt with the calculation below.

a) Calculation of the tensile force and power of the M-212 conveyor belt before modification

$$W_m = \frac{Q}{v}$$

$$W_m = \frac{250 \text{ tph}}{6400 \text{ mph}} = 39{,}06 \text{ kg/m}$$

By following the CEMA standard, the weight of the belt (Wb) with a belt width of 800 mm is obtained at 16 kg/m so that the calculation of the effective tensile force (Te) becomes

$$T_e = W_m \times H + 0{,}04\ (2 \times W_b \times W_m) \times L$$

$$T_e = 39{,}06 \times 0 + 0{,}04\ (2 \times 16 \times 39{,}06) \times 40$$

$$= 1999{,}87 \text{ N} = 449{,}39 \text{ lbs}$$

- Power Calculation

The amount of power on the conveyor can be found by the following formula

$$P = \frac{T_e \times v}{33000}$$

$$P = \frac{449{,}39 \text{ lbs} \times 295{,}276 \text{ fpm}}{33000}$$

$$P = 4{,}02 \approx 4{,}1 \text{ hp}$$

b) Calculation of the tensile force and power of the M-212 conveyor belt after modification

$$W_m = \frac{Q}{v}$$

$$W_m = \frac{150 \text{ tph}}{5400 \text{ mph}} = 27{,}78 \text{ kg/m}$$

By following the CEMA standard, with a belt width of 600 mm, the belt weight (Wb) is obtained at 9 kg/m, and has a height difference of 5.7 m, so that the calculation of the effective tensile force (Te) becomes

$$T_e = W_m \times H + 0{,}04\ (2 \times W_b \times W_m) \times L$$

$$T_e = 27.28 \times 5{,}7 + 0{,}04\ (2 \times 9 \times 27{,}78\ ) \times 28$$

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$$= 718{,}39\ \text{N} = 161{,}500\ \text{lbs}$$

- Power Calculation

The amount of power on the conveyor can be found by the following formula

$$P = \frac{T_e \times v}{33000}$$

$$P = \frac{161{,}50\ \text{lbs} \times 295{,}276\ \text{fpm}}{33000}$$

$$P = 1{,}45\ \text{hp} \approx 1{,}5\ \text{hp}$$

c) Conveyor belt power data analysis

From the calculation of the power on the conveyor belt, it is shown that the power used on the conveyor belt before modification is 4.1 hp which is greater than the power after modification which is 1.5 hp. This shows that after the modification, the power required on the conveyor belt is less than before and will affect operating costs which will also be reduced.

IV. CONCLUSION

Based on the calculations and analysis that has been carried out on the conveyor belt M-212 Warehouse, before and after modification, the conclusions are:

1) The capacity of the M-212 conveyor belt before modification according to field specifications was 250 tph, while in calculations according to CEMA standards it was 312.88 tph. Then on the M-212 conveyor belt after modification, the field specification data is 150 tph, while the calculation according to the CEMA standard is 173.12 tph. This shows that the M-212 conveyor belt experienced a decrease in performance in terms of capacity after modification of 44.67%
2) From the calculation results, the effective tensile force of the M-212 conveyor belt before modification is Te = 1999.87 N, then the required power is 4.1 hp. As for the M-212 conveyor belt, after modification, the effective force is Te = 718.39 N, then the required power is 1.5 hp. Based on the calculation of the power obtained, the operational costs for the M-212 conveyor belt after the modification will be smaller than before the modification because less power is used.

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