DESIGN OF LINEAR CONVEYOR FOR PARTS FEEDING TO COMAU ARTICULATED ROBOT

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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotics and Automation) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation) (Hons.). The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRAK

Penghantar adalah alat mekanikal yang biasa digunakan untuk menggerakkan barangan di dalam kilang. Penghantar dalam industri pembuatan digunakan secara meluas di pelbagai jenis sektor pembuatan seperti pembungkusan, pemindahan barangan, *pick* dan *place* (memilih dan meletak), dan lain-lain. Objektif projek ini adalah untuk mereka bentuk penghantar linear bagi hantaran bahan kerja kepada Robot COMAU Articulated. Idea mereka bentuk penghantar adalah berdasarkan sebahagian atau bahan kerja yang akan memilih dan meletakkan oleh lengan robot. Perisian untuk mereka bentuk penghantar juga telah dipilih berdasarkan pengetahuan penulis. Reka bentuk beberapa idea telah dihasilkan dan dibahagikan kepada dua komponen iaitu bingkai *belt* dan kaki penyokong. Dari lakaran idea ini, perbandingan telah dibuat untuk memilih idea rekabentuk yang lebih baik. Idea yang dipilih telah direka dengan perisian SolidWorks di mana setiap bahagian penting penghantar direka berdasarkan spesifikasi dan kehendak untuk hantaran bahan kerja kepada Robot COMAU Articulated. Penyenaraian semua *parts* yang perlu di proses dan *parts* yang standard dibentangkan dalam laporan ini. Reka bentuk pemasangan dan struktur pokok penghantar untuk pemahaman yang lebih baik mengenai struktur pemasangan penghantar turut dibentangkan. Bahagian terperinci dan spesifikasi dibentangkan dalam model pejal dengan dimensi yang memenuhi keperluan untuk proses selanjutnya. *Finite Element Analysis* (FEA) telah digunakan untuk menganalisis rekaan. Tekanan , anjakan, ubah bentuk dan faktor keselamatan telah diperolehi daripada analisis dan dibentangkan. Untuk pembangunan masa hadapan , ia dicadangkan untuk penambahbaikan toleransi bahagian-bahagian yang di reka bentuk dan pengiraan semula penggunaan kuasa motor.

ABSTRACT

A conveyor is a common mechanical apparatus for moving items inside a factory. The conveyors in manufacturing industries are widely used for various types of manufacturing activities such as packaging, transferring goods, pick and place, etc. The objective of this project is to design of linear conveyor for parts feeding to COMAU Articulated Robot. The idea of designing the conveyor is based on parts or workpiece that will be picked and placed by a robot arm. The software for designing the conveyor is chosen based on the author knowledge. Several designs ideas have been generated and divided into two components which are the frame belt and the support legs. From this designed ideas, the comparison has been made to choose the best design idea. The chosen idea has been designed in SolidWorks. The important conveyor parts are designed based on the specification and requirement for parts feeding to COMAU Articulated Robot. The list of all parts needs to be fabricated and the standard parts are presented in this report. The assembly design and structure tree of conveyor to have better understanding on the conveyor assembly structure are also presented. Detail parts and their specifications are presented in solid model with the dimension which fulfils the requirement for further development. Finite element analysis (FEA) has been used to analyse the design. The stress, displacement, deformation and factor of safety are obtained from the analysis and presented. For future development, it was suggested to improve the parts tolerance in the design and recalculation of the motor power consumption.

DEDICATION

Specially dedicate to my beloved family Mr. Ahmad Rabuan and Madam Aminah who have supported me. I also dedicated this thesis to my sisters Hartini, Nor Afiza and my younger brother Ahmad Akmar who have inspired me. To beloved friends Faiz, Rafi, Hafiz, Hazwan, Qayyum, Amirul, Ridhwan, Naquiddin and all friends of 4BMFA who have been with me through my journey in education. Also thank you for all the motivation and their beliefs towards me.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

COMAU	-	COnsorsio MAcchine Utensili
CAD	-	Computer-Aided Design
3D	-	Third Dimension
CAM	-	Computer-Aided manufacturing
AC	-	Alternating Current
DC	-	Direct Current
PLC	-	Programmable Logic Controller
CNC	-	Computer Numerical Control
2D	-	Two Dimension
PTC	-	Parametric Technology Corporation
FOS	-	Factor of Safety
rpm	-	revolution per minute
FEA	-	Finite Element Analysis
BOM	-	Bill of materials
ISO	-	International Organization for Standardization
UV	-	Ultra violet
PA	-	Polyamide
IR	-	Infrared
LED	-	Light-emitting Diode
mm	-	Millimetre
kg	-	Kilogram

CHAPTER 1

INTRODUCTION

1.1 Background of study

A conveyor is a mechanical apparatus for moving items or bulk materials, usually inside a facility. Conveyors are used when material must be moved in relatively large quantities between specific locations over a fixed path, which may be in the floor, above the floor or overhead. Conveyors are either powered or nonpowered. In powered conveyors, the power mechanism is contained in the fixed path, using chains, belts, rotating rolls, or other devices to propel loads along the path. Powered conveyors are commonly used in automated material transport systems in manufacturing plants, warehouses, and distribution centres. In nonpowered conveyors, materials are moved either manually by human workers who push the loads along the fixed path of mechanical power provided in the fixed path or by gravity from one elevation to a lower elevation (Groover M. P., 2008).

This project will only focus on powered conveyor and basically it's automated with the uses of sensors, motors, belts, support and roller. The conveyor must be interface with COMAU Articulated Robot so the part or workpiece can be reach by robot end of effector. To solve this problem, ideas of designing a linear conveyor should be generated and refined.

1.2 Problem statement

The problem on the present COMAU Articulated Robot is that there is no part feeders such as conveyor and indexing table provided to the robot. This cause problem and delay in feeding parts to the robot for performing task such as pick and place, assembly, etc. At present manual feeding of parts is used where it is tedious, time consuming and dangerous to operators. To solve this problem, a linear conveyor is to be designed to automate the parts feeding process to the robot.

1.3 Objectives

1. To design a linear conveyor for parts feeding to COMAU Articulated Robot.
2. To develop a soft prototype of the above designed linear conveyor.

1.4 Scope of the Project

1. To design a linear conveyor for COMAU Articulated Robot using suitable Computer-Aided Design (CAD) software to feed the following size and weight of parts:
    i. For round workpiece: Diameter = 30mm (max), Length = 100mm (max), Weight = 0.19 kg (max)
    ii. For rectangular workpiece: Width= 30mm (max), Thickness = 30mm (max), Length = 100mm (max), Weight = 0.24 kg (max)

2. To develop a soft prototype of the designed conveyor using the most suitable 3D CAD/CAM software.

CHAPTER 2

LITERATURE REVIEW

This chapter provides literature review where the sources and information are obtained from website, books, journals, articles, conference and magazine. In this chapter, it will elaborate more on the design of linear conveyor for parts feeding to COMAU Articulated Robot.

2.1 Conveyors

A conveyor is a mechanical apparatus for moving items or bulk materials, usually inside a facility. Conveyors are used when material must be moved in relatively large quantities between specific locations over a fixed path, which may be in the floor, above the floor or overhead (Groover M. P., 2008). In other word, a conveyor is a machine that moves materials from one location to another location. It is most popular in material handling and packaging industries. It has two categories which is powered and nonpowered. Powered conveyors consist of power a mechanism that contains part such as chains, belts, rotating rolls and other device. While nonpowered conveyors use a human workforce to operate by push or used of gravity from one to the lower elevation.

2.2 Types of conveyors

Basically conveyors have many types that designed according to their functions or needs in different industries. For this design project the suitable types of conveyor is belt conveyor. This is because in order to complete a robot pick and place task, the belt itself should be flat which made the belt conveyor most suitable. Figure 2.1 shows the types of conveyors.

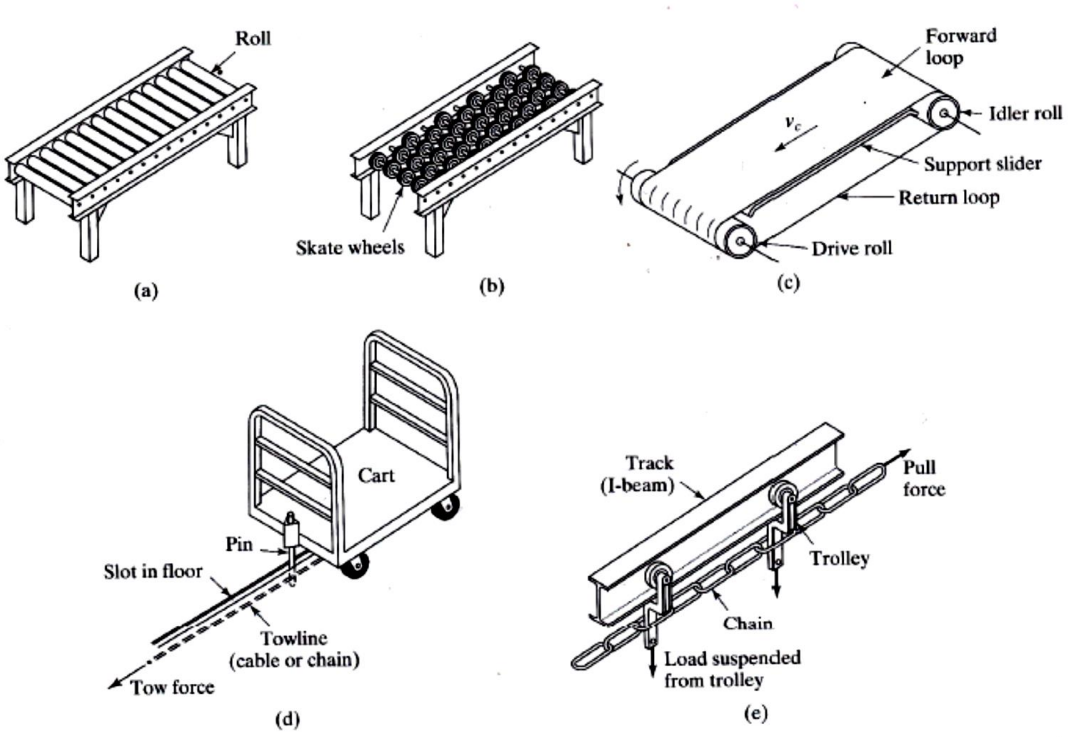

Figure 2.1: (a) Roller conveyor, (b) skate-wheel conveyor, (c) belt (flat) conveyor (support frame not shown), (d) in-floor towline conveyor, and (e) overhead trolley (Source: Groover M. P., 2008)

2.2.1 Roller conveyor

Consist of tubes (rollers) as shown in Figure 2.1 that are perpendicular to the direction of travel. Rollers attach to fixed frame that moves and this will cause the loads move forward. Both powered and nonpowered are available but due to non-flat surface it is not suitable for pick and place task for robot interface and integration.

2.2.2 Skate-wheel conveyors

Almost same as roller conveyor but it use skate wheels rotating on shafts connect to a frame. Figure 2.1 shows, that this conveyor only suitable to roll pallets, tote pans, and other containers. The application is similar to roller conveyor except the loads must be lighter since the contact between the loads and the conveyor are more concentrated. This conveyor is not considering for this project because of non-flat surface that suitable for pick and place task by robot.

2.2.3 Belt conveyors

It consists of continuous loop where half of its length is used to delivering materials and the other half to return run purpose. Usually the belt made of reinforced elastomer (rubber) to ensure its flexibility but low extensibility. Belt conveyors are powered conveyor within a drive roller that attach at the one end of the conveyor. The belt is support either from rollers or support sliders along its ward loop as shown in Figure 2.1. There are two types of belt conveyor: (1) flat belts for pallets, individual parts or certain types of bulk material; and (2) troughed belts for bulk materials. The first one is considered to this project because of flat belts that suitable for pick and place task by robot. For the second, it's usually used in coal industries or any other similar particulate materials and its shape more to V shape rather than flat belt.

2.2.4 In-floor towline conveyor

Moving chains or cables powered the four-wheel carts that located in trenches in the floor in industries as shown in Figure 2.1. This conveyor disadvantage is it needs a trench where floor in industries need to be modify in order to make it available. This makes it only suitable for application in manufacturing plants and warehouses.

2.2.5 Overhead trolley conveyor

Wheel carriage running on overhead rail known as trolley in material handling which the loads can be suspended. It consists of multiple trolleys that equally spaced a long a fixed track. It connected together and moved along the track by a chain or cable that forms a complete loop. Generally used in delivery and storage. Any other application is to move parts and assemblies between major production departments.

2.3 Belt conveyor components

A belt conveyor consists of a driving pulley, a tail pulley, the tensioning device (if necessary), a conveyor belt and the supporting structure with the belt support (slider bet or carrying roller). Every part of its component is important to make sure the belt conveyor work properly. Driving pulley used to move the conveyor belt that is tensioning between it and tail pulley. Motor used to drive the driving pulley as a power transmission. While the conveyor belt start to move, the supporting structure and belt support act against force from weight or force from product without fail.

Some of the components does not need in the design of belt conveyor depending of its length or width. Although having them in the design is more reliable such as tension pulley or guiding pulley. The system components required to complete this design is illustrated in Figure 2.2.

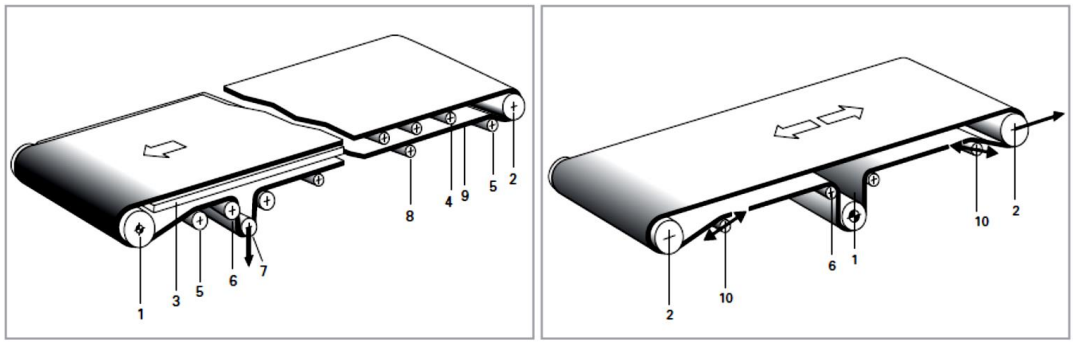

Figure 2.2: System components in belt conveyor
(Source: <www.habasit.com/en/download.htm#Conveyor_belts>)

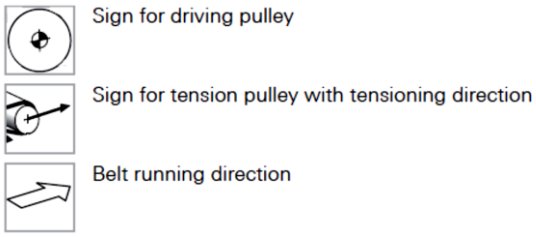

Figure 2.3: Sign for system components
(Source: <www.habasit.com/en/download.htm#Conveyor_belts>)

There are two types of simple conveyor that usually used in industry. The left side of Figure 2.2 is Head-driven conveyor and the right side is Centre-driven conveyor. The components are numbered as in Figure 2.2 and Figure 2.3 shows the sign for it:

1. Driving pulley
2. Head or tail pulley
3. Slider belt
4. Carrying roller
5. Snub pulley
6. Deflection roller (idler)
7. Tension pulley
8. Carrying roller (on the return side)
9. Conveyor belt
10. Guiding pulley

2.4 Support structure

The support structure is part where it must be a rigid, must not distort or flex from the forces it is subjected for example belt tension and the product being move by conveyor. It will be almost impossible to track the conveyor belt if without rigid structure. Besides the supporting structure must be align accurately in all planes. A good conveyor movement must be able to move from one side to another side without interference of any fixed components. So the pulleys or rollers are of sufficient length, and the supporting structure has ample clearance from the belt edges.

For the material of support structure, the most suitable want in term of cost, weight and reliable is Aluminium alloy profile. Aluminium alloy profile is widely used in industry nowadays. It has a slot and a hole that make it easily to attach with its kind. Figure 2.4 shows the support structure from Aluminium profile with conveyor.

Figure 2.4: Support structure made of Aluminium profile
(Source: <http://www.alusic.com/EN/belt_conveyors.htm>)

For the design purpose, the Aluminium Profile is more preferable compare to other type of structure. Compare to steel, it is more lightweight than steel or any other type of steel such as mild steel. Figure 2.5 shows the design of Aluminium Profile.

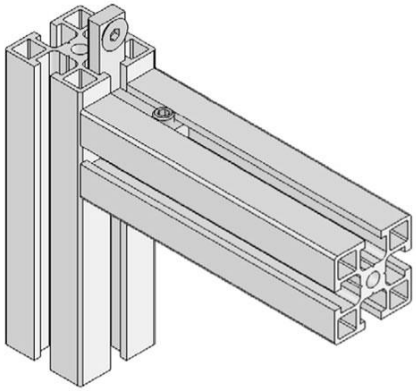

Figure 2.5: Aluminium Profile design
(Source: <http://www.aluminiumprofile.com.au/>)

2.5 Pulley and roller fixing

Pulley and roller fixing is the important component or part to ensure the smoothness conveyor belt when it move. Usually, the driving pulley can't be adjustable and with other rollers and pulleys it should be aligned at the right angle to the belt running axis. Figure 2.6 shows the method of pulleys, rollers and driving pulley mounted. It is important to familiarize with this component in designing belt conveyor.

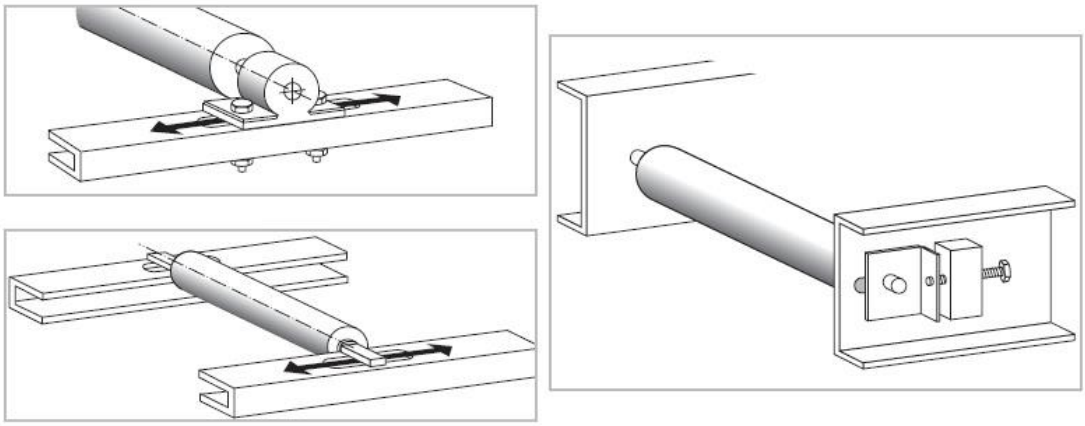

Figure 2.6: Adjustable bearing, slotted mount and belt conveyor adjustment at head or tail of conveyor
(Source: <www.habasit.com/en/download.htm#Conveyor_belts>)