An improvement to integrated model of electro pneumatic circuit for material handling in a manufacturing cell

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DEDICATION

To:

All Muslimin and Muslimat

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Abstract

Pneumatic circuit are very widely used in automating plants especially manufacturing plants. These circuits are implemented for material handling, process control and general automation. Selecting an effective design, components and appropriate system will be a critical item in installing an effective and efficient system. One sure way of acquiring this is the application of software especially those that have comprehensive analytical capability. In this project the author used Automation Studio to study the effect of adding extra component and valve to a three cylinder integrated material handling system. The evaluation has shown that adding components have shown some positive effect on the system. However some components provide advantages some do not. Automation Studio has prove to be an effective tool to determine this.

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Abstrak

Penggunaan sistem pneumatik sangat banyak digunakan dalam loji automatik terutamanya dalam sektor pembuatan. Ianya banyak diguna pakai untuk pengangkutan barangan, proses kawalan dan kegunaan automasi. Pemilihan untuk rekabentuk yang berkesan, komponen dan sistem yang baik adalah perkara yang kritikal ketika pemasangan hendak dilakukan untuk kecekapan sistem tersebut. Suatu penyelesaiannya ialah dengan menggunakan 'software' yang berkebolehan untuk menganalisa secara komprehensif. Projek ini menggunakan 'Automation studio' untuk menganalisa kesan terhadap penambahan komponen dan injap pada tiga selinder dalam sistem rangkaian pengangkutan barangan. Dapatan yang diperolehi menunjukan bahawa dengan menambah komponen dan injap telah mendatangkan kesan kepada sistem tersebut. Walaubagaimanapun, ada komponen dan injap yang dipasang itu mendatangkan kebaikan dan ada yang tidak. Penggunaan 'Automation studio' ini menunjukan salah satu kaedah yang sangat berkesan dalam kajian projek ini.

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CHAPTER I

Introduction

1.1 Introduction of pneumatic material handling

Pneumatic technology is very important in automation. This is especially important in manufacturing industries. Pneumatics like hydraulic in an industry is used to move material, control movement and assist in automatic process and operation. Thus pneumatic is an important source of power in material handling. Certain characteristics of compressed air have made this medium quite suitable for use in modern manufacturing and production plants.

As a key component of manufacturing systems, material handling interacts with the facility layout and system control or scheduling problems. The material handling system requires the logical and physical aspects of material flow and equipment to justified from both performance and economic perspectives.

The work takes into account the various of material handling operations that take place during manufacturing like the processing machines, equipments and character of the part types. It is an integrating of operation allocation problem and the considerations of material handling systems.

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1.2 Problem overview

Pneumatics is low cost alternative to material handling tasks in term of support and service available in the manufacturing system. The potential of this drive medium is now recognized, particularly for linear motion application. However, a number of problem and challenges still remain for it to realize for industrial control motion.

Pneumatic cylinder in an integrated form can perform a lot of task and assist engineer in operation. However normally it is difficult to ensure optimization because one need the right combination of valve, control and circuit to obtain optimization. This research will observe one aspect of the optimization or improvement of a pneumatic system. Three cylinder controlled by an additional valve may smoother the operation or may hinder an efficient system. This project will focus on one aspect of this improvement.

1.3 Objective of the project

1. To study the effect of additional component on a three cylinder integrated pneumatic system for material handling.
2. To compare performance of the above system and suggest the best combination.
3. To identify the best additional component for the system.

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1.4 Scope of the project

Below are the scopes of the project:

1. The project will be focused on three cylinder material handling pneumatic system.
2. The project will also be limited to five types of additional valves or components added to the system and also the circuit selected are not modified throughout the experiment.

1.5 Definition of pneumatic

"The English word pneumatic and its associate noun pneumatics are derived from the Greek pneuma meaning 'breath'. Originally coined to give a name to the science of the motions and properties of air, pneumatics has been adopted by engineers to identify the branch of physics treating of the mechanical properties of air and other gases, now used somewhat more restrictedly to refer to the phase of fluid mechanics dealing with the properties, actions and applications of gases, but chiefly air, at pressures higher or lower than atmospheric".

(Werner Deppet and Kurt Stoll, 1975:7)

The technology of pneumatics deals with the behavior and application of compressed air. The science of air was known and used in industry before the beginning of the Second World War (1939-44). During the war, many industries like western countries started switching more automatic equipment and machineries. Many of these were operated by pneumatically and use in manufacturing and other activities. This was the present the concept of pneumatic material handling system to use compressed air in production plants.

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1.5.1 Definition of material handling

Materials handling involves the loading, moving and unloading of materials. The loading, moving and unloading of ore from a mine to a mill and of garments within a factory are examples of materials handling. There are hundreds of different ways of handling materials. These are generally classified according to the type of equipment used. For example, the International Materials Management Society has classified equipment as (1) conveyor; (2) cranes, elevators and hoists; (3) positioning, weighing and control equipment; (4) industrial vehicles; (5) motor vehicles; (6) railroad cars; (7) marine carriers; (8) aircraft and (9) containers and supports.

Every materials handling problem starts with the material - its dimensions, its nature and its characteristics. Engineers who fail to start here usually end up trying to justify equipment rather than achieving safe and economical movement of the material. The quantity to be moved both in total and in rate of moving desired is next in selecting the appropriate handling method. Then comes the sequence of operations or the routing. Basically, this what, when (how much and how often) and where is the minimum information needed to evaluate or determine any handling system or equipment.

Materials handling is both a planning and an operating activity. These two activities are generally separated in industry, an analytical group designs or selects the system or equipment and the operating group puts it to use.

(Mel Schwartz, 2002: Second Edition)

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1.6 History of pneumatic

3000 B.C.	:	▪ Air pressure (wind) has been used to power ships since the beginning of civilization bellows were used to produce bursts of compressed air to start fires.
1700	:	▪ Musical instruments were controlled by mechanical drums which operated valves to switch in pipes of different pitches.
1800s	:	▪ Pneumatic controls using perforated cardboard strips and by attaching long strips which could play the programmed melody. ▪ Several railroads were built in Europe which operated by pneumatic power and pulled loads as fast as 42 mph. ▪ Air brakes are used on most large vehicles today including trucks.
1858	:	▪ Compressed air drills were being used in mining. ▪ Make good quality cylinders allowed progress to be made in the development of pneumatic equipment as well as the steam engine.
19 centuries	:	▪ Great deal of development took place utilizing air as a power source and also as a means of control.
1950s	:	▪ Much fluid logic technology was developed in the mid 1950s at Oklahoma State University.
1960s	:	▪ Pneumatic systems were used primarily as power sources.

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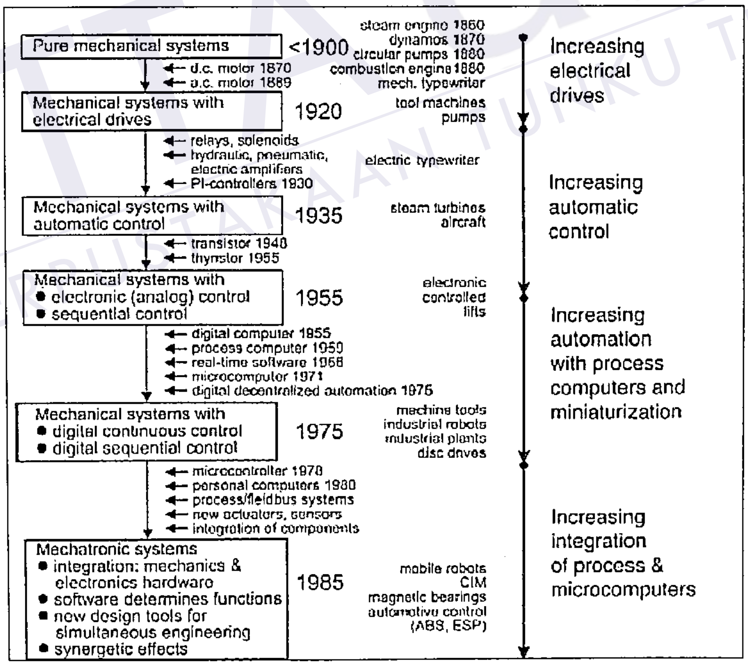
1.7 Application of pneumatics

With the introduction of pneumatics in the manufacturing process, the industry is benefited with a cheaper medium of material handling which easy to used and bring down the cost of production to a much lower level. Therefore, today air operated tools and accessories are a common in industry.

Few decades ago as shown in **Table 1.1** maximum application of pneumatics was probably in the field of construction where the main source of power for tools like power hammers, drills, nut runners, riveting and hammers. Now, compressed air is used in industrial such as starting with pneumatic cranes to the use of air in the brake system of automobiles, railway coaches, wagons and printing presses.

Table 1.1 : Historical development of mechanical, electrical and electronics system



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The basic features that make application of pneumatics in industries more advantageous and suitable in material handling system because of the following features:

1. Wide availability of air.
2. Compressibility of air.
3. Easy transportability of compressed air in pressure vessels, containers and in long pipes.
4. Fire proof characteristics of the medium.
5. Simple construction of pneumatic elements and easy handling.
6. High degree of controllability of pressure, speed and force.
7. Possibility of easy but reasonably reliable remote controlling.
8. Easier maintenance.
9. Explosion proof characteristics of the medium.
10. Comparatively cheaper in cost than other systems.

Therefore in my opinion, pneumatic system has better operational advantages and accuracy are concerned in manufacturing system. In areas of hazards, probably air will be a better medium than the hydraulic system.

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CHAPTER 2

Literature review

2.1 Overview of pneumatic material handling system

Air is drawn from the atmosphere via an air filter and raised to required pressure by an air compressor (usually driven by electric motor). Before the air can be used it must be cooled and condensation. The air compressor must be followed by a cooler and air treatment unit. Compressibility of a air makes it necessary to store a volume of pressurized gas in a reservoir to be drawn on by the load. When the pressure rise by the opened valve, the results is slow cylinder movement carried the load, W from A to B as shown in Fig. 2.1. The basic actuator is a cylinder with the force on the rod being determined by air pressure and piston cross sectional area.

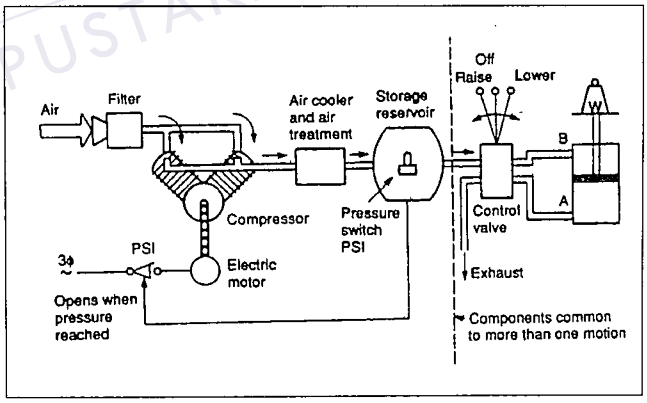

Fig. 2.1 : Pneumatics material handling system

A pressure switch fitted to the air reservoir to starts the compressor motor when pressure falls and stops it again when pressure reaches the required level. Many factories produce compressed air properties shown in **Table 2.1** at one central station and distribute an air ring main to all places on the site.

Table 2.1 : Properties of pneumatics material handling system

	Pneumatic material handling system
Energy source	Electric motor or diesel driven
Energy storage	Good (reservoir)
Distribution system	Good. Can be treated as a plant wide service
Energy cost	Highest
Rotary actuators	Wide speed range. Accurate speed. Control difficult
Linear actuator	Cylinders medium force
Controllable force	Controllable medium force
Points to note	Noise

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2.1.1 Interpretation of particle air motion

The air motion is effected of wall collisions and wall roughness on the behavior of particles with different size and a density of ρ_p = 2.5 g/cm^3 in a horizontal channel of 35 mm height and a length of 6 m is analyzed. The air flow which is the velocity and turbulence was prescribed according to the measurements of Laufer (1950) for a fully developed channel flow with an average velocity of 18 m/s and two way coupling was neglected. The gas density was given a value of 1.18 kg/m^3 and the dynamic viscosity was selected to be 18.8 x 10^{-6} Ns/m^2. The behavior of spherical glass beads with different diameter in a channel without and with wall roughness is illustrated in Fig. 2.2. The wall without wall roughness (Fig. 2.2 a and b) whereby wall roughness has a strong effect on the motion (Fig. 2.2 c and d).

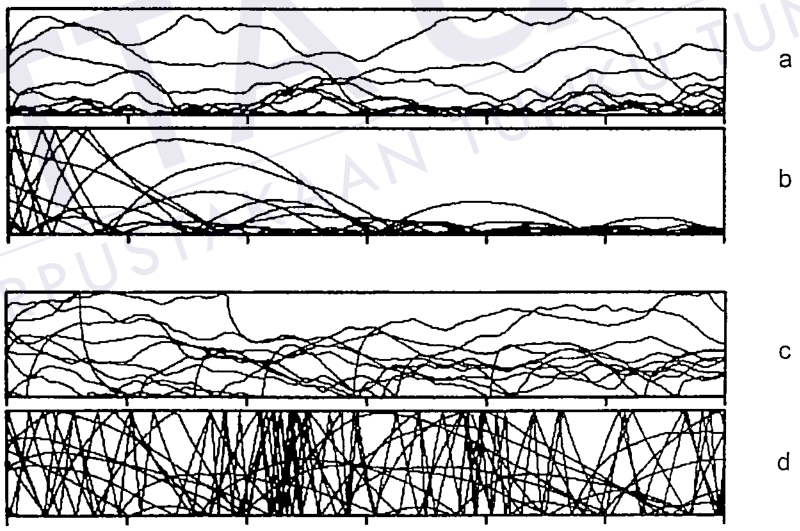

Fig. 2.2 : Particle trajectories in a channel flow (channel height 35 mm and length 6 m)
Without wall roughness : a) 30 μm and b) 110 μm
With wall roughness : c) 30 μm and d) 110 μm

2.1.2 Investigation by theoretical analysis of air motion

The present investigation deals with the effects of the motion of small particles of air flow in boundary layers near horizontal and vertical surfaces. These effects are important for the prediction of particle motion inside the cylinder of the pneumatic system. The equations of particle motion are derived using the expressions forces of lift and drag acting on a small particle near a surface. These theoretical analysis shown the initial particle shear and gravity effects in upward and downward surfaces affects its motion.

Shear and gravity effects

Consider a particle moving in air. Hence, particle density is very large compared with that of the fluid, which makes it possible to neglect the buoyancy forces in the solution. Consider the particles in the range 0.1-10 μm in diameter in fully developed turbulent channel flows with shear rates exceeding 10^5 s^{-1}. The viscous sublayer thickness in such flows is of the order of several tens of micrometers. Hence, the small particles are fully submerged in it. The Reynolds number based on particle radius a, and relative velocity u_r, $Re_p = u_r a/v$ is in the range 10^{-2}-10^0. Consider particle motion in unbounded shear flows. The dimensionless equations of motion are linearized and solved by analytically.

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The equations of particle motion in shear flow and gravity near a horizontal surface are given as

$$m_p \frac{d^2x}{dt^2} = F_{DX} \qquad (2\text{-}1a)$$

$$m_p \frac{d^2y}{dt^2} = -F_{DY} + F_l - m_p g \qquad (2\text{-}1b)$$

where,

F_{DX} and F_{DY} = The components of the drag force in the parallel x and normal y directions respectively

F_l = The lift force

m_p = The mass of the particle

For the drag and lift forces acting on a small particle resting on a surface or moving near it. Consider small particles, the drag force is derived from the Stokes law and assumed in this study that the flow is not influenced by the particles.

The following dimensionless variables are introduced

$$x = \frac{x}{a},\ y = \frac{y}{a},\ u = \frac{u}{\dot{\gamma} a},\ \upsilon = \frac{\upsilon}{\dot{\gamma} a},\ t = t\dot{\gamma} \qquad (2\text{-}2)$$

where $\dot{\gamma}$ is the shear rate.

The asymptotic analysis leads to the following equations of particle motion

$$\frac{d^2x}{dt^2} = -C_{Df}\left(\frac{dx}{dt} - y\right) \qquad (2\text{-}3a)$$

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List of glossary

A part of this glossary has been extracted from the American Standard Glossary of Terms for Fluid Power *(ASA B93.2-1965) from The National Fluid Power Association.*

ACTUATOR - A device that converts fluid power into mechanical force and motion.

AIR COMPRESSED - Air at any pressure greater than atmospheric pressure.

COMPRESSOR - A device that converts mechanical force and motion into pneumatic fluid power.

CONTROL CYLINDER - A control in which a fluid cylinder is the actuating device.

CONTROL PNEUMATIC - A control actuated by air or other gas pressure.

CYCLE - A single complete operation consisting of progressive phases starting and ending at the neutral position.

CYLINDER DOUBLE ACTING - A cylinder in which fluid force can be applied to the movable element in either direction.

CYLINDER SINGLE ACTING - A cylinder in which the fluid force can be applied to the movable element in only one direction.

EFFICIENCY - The ratio of the output power to the input power, generally expressed as a percentage.

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ENERGY - The ability or capacity to do work.

FORCE - The action of one body on another tending to change the state of motion of the body acted upon.

FRICTION - The action of one body or substance rubbing against another such as fluid flowing against the walls of pipe, the resistance to motion caused by this rubbing.

GRAVITY - The force that tends to draw all bodies toward the center of the earth. The weight of a body is the resultant of gravitational force acting on the body.

PNEUMATICS - Engineering science pertaining to gaseous pressure and flow.

VALVE DIRECTIONAL CONTROL - A valve whose primary function is to direct or prevent flow through selected passages.

VALVE FLOW CONTROL - A valve whose primary function is to control flow rate.

VELOCITY - The rate of motion in a particular direction. The velocity of fluids is usually expressed in feet per second.

WORK - The transference of energy from one body or system to another. That which is accomplished by force acting through a distance.

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