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Load Effect on Wall Attachment Fluidics Amplifier Performance

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Abstract

An experimental work has been conducted on wall attachment fluidics amplifiers, one of them to study the effect of output pressure or load on the amplifier performance. The output load has been simulated as a piston connected to the device output and the piston can be loaded accordingly. The results shows that the output volume flow rate increases as the supply pressure increases under different load and the output pressure remains constant as the supply pressure increases under constant load.

Key Words: wall attachment, amplifier performance.

Introduction

For many years engineers have used fluids for transmitting force and energy in mechanical systems. For example, the flexibility and great power offered by hydraulic actuators and motors make them attractive for use in many control systems, even when the systems are essentially electrical or electronic. The predominance of electronic techniques in computations and in control systems may give the impression that such systems can function only electronically. In fact Babbage's calculating 'engine' which was perhaps the earliest digital computers, with essential conceptual features of present day machines, was purely mechanical [1], and various simple, completely pneumatic control systems, such as automatic pressure control, have been in commercial use for many years. It is only comparatively recently, however, that techniques have been developed for using fluid as a medium for computation and for carrying significant information in control systems.

Hydraulic and pneumatic circuits which use valves have been developed for many automatic processes for examples those requiring a controlled sequence of events. The conventional valves used in such circuits have mechanical moving parts and may be classed as static device. The term arises because forces are developed by the static pressure of the fluid, power being expended only intermittently when the fluid is in motion.

A new class of fluid circuit element has now been added which may be referred to as dynamic. This elements called fluidic element, one of them is the wall attachment amplifier. In dynamic elements the kinetic energy of the flowing fluid is all-important and in them power is expended continuously, (1). An important aspect of such elements is that, they need not depend on moving parts for their operation, another advantage can be claimed for fluidics elements, simplicity loading to high reliability to operate in extreme conditions of temperature, resistance to shock and vibration, safe operation in explosive atmospheres, freedom from interference from radiation, and so on.

Additionally, the cost of the elements is potentially low. All these feature makes them attractive to use in control system than the others.

Thee Wall Attachment Principle

When a turbulent of fluid emerges from a nozzle, as shown in Fig (1-a), it continues to move downstream and is not deflected in one direction or the other. It is found that the turbulent motion of the jet entrains particles from the surrounding fluid causing it spread out as it moves downstream. If the entertainment flow on one side of the jet is reduced due, say the existence of an adjacent wall, the pressure on that side of the jet is reduced due to the differential entertainment, causing the jet to be drawn toward the low-pressure region.

If the wall is positioned correctly, as in Fig (1-b), the jet is deflected until it touches the wall. Between the jet and the wall is low-pressure vortex bubble known as the separation bubble or re-attachment bubble. Stable condition occur in the bubble when the amount of fluid entertained into the bubble from the jet, at the point at which the jet attaches to the wall, is equal to the amount of fluid reround to the jet by the vortex flow inside the bubble.

Two important parameters in the design of any wall attachment device. These are the set back and the wall angle. For wall attachment to take place the set back should be small; a large set back results in the jet detaching from the wall at low values of flow. The wall angle also affects wall attachment since, with very large wall angles, attachment may not be possible, or may only be achieved with difficulty. The effects of wall angle and set back are discussed more fully in experimental work [1].

If an additional source of fluid can be admitted to the separation bubble, by the port shown by the broken lines in Fig. (1-b), the steady-state operating conditions can be controlled. The net result of increasing the quantity of entertained fluid on the wall side of the jet, is that the jet attachment point moves further downstream. If the fluid flow through the additional port becomes sufficiently great, the jet can be forced to detach from the wall. This is the most commonly used technique of controlling the jet in wall attachment devices. A good example of this method of control is found in the wall attachment S-R flip-flop type.

The simplest form of wall attachment device is the diode, atypical profile being shown in Fig(2). When an input signal is applied to port 1, the jet attachment to the curved wall due to its gentle gradient, and the pressure recovery at port 2 is approximately 95 percent of the input pressure. If the signal is applied to port 2, most of the input fluid escapes through the vent opposite of port 2, since the inclination of the wall angle to port 1 is too great to permit wall attachment. When used in this mode the pressure recovery at port 1 is approximately 5 percent of the pressure applied to port 2[2].

Literature Review

The first projects on fluidics in Britain were those started at the universities of Birmingham and Nottingham and at the college of aeronautics at cranfield in 1962, the cranfield project used kearffot type hall valve in a circuit designed by charnley and bidgood (2), while the first work at

Birmingham and Nottingham was another turbulent reattachment amplifier (3), (4). After that a lot of research has been done on fluidics logic element. Madellan Mitchell and turabull (5), gave experimental results for a jet attaching to the piston face of hydraulic spool valve at small control ports openings and examined the effect of cavitation on the bubble formation while herman viets (6), working on new nozzle development program was under taken to produce a time. Dependent flow at nozzle exit, the oscillatory character of the flow was achieved without the use of moving parts by incorporating a fluidic feed back loop in to the nozzle design.

Description of Apparatus

1- Construction of Wall Attachment Device

Wall attachment device is often small in size but in the present work a mid-size one has been designed. The device consists of the following parts, see Fig. (3):

i. Device Base

The device base is design in a way allowing to fixed all the parts of device on it by using glue and bolts as shown in Fig.(4). Where the base have (235 mm) length, (165 mm) width and (5 mm) thickness.

ii. Power Jet (main jet)

This is essential part of an amplifier have rectangular cross section area (8 mm) width and (16 mm) depth. The supply pressure should be generally maintained constant and steady. When the supply pressure and ambient pressure ratio is less than a bout (2), the jet is sub-sonic [7]. This is usually the situation for most bistable amplifiers.

iii. Control Jets

One or two control jets are required to control the direction of the main jet. The control jets generally are located at the exit plane of the power jet, which have rectangle cross sectional area. The width of the control jet can be changed from (2.5 mm) to (5 mm) and have (1 mm) depth.

iv. Splitter

The splitter is very important part of an amplifier. Its function to separate the two receiving parts. The splitter is generally wedge shaped. The end of the wedge can be rounding, pointed, and blunt or cusp shaped. A sharp splitter (used in present work) tends to have a higher gain and fast responding but it can cause edge tone type oscillation as shown in Fig. (5).

v. Side Walls

The side walls are also important parts of wall attachment amplifier type S-R Flip Flop because depend the attach of the fluid flow on the angle of side wall and setback distance. The shape of side walls are shown in Fig.(5).

vi. Receiving ducts

The size and shape of the receiving ducts can influence greatly the power output. Where the width of receiving ducts (13 mm) and the depth (16 mm).

2- Construction of Loading System (Pneumatic Piston)

The load system consists of a pneumatic cylinder have inside diameter of (46 mm), outside diameter of (50 mm) and length of (125 mm). There is a piston inside the cylinder connected to a shaft with a diameter of (46 mm) as shown in Fig.(6). The shaft of piston connected to plate form for loading. The cylinder have two holes one at the bottom of the cylinder where the output of device connection, while the second hole near the top of the cylinder as shown in Fig.(7). The circular which is imposed at the bottom of the cylinder to give uniform distribution of pressure on the piston seal to reduce the leakage between the piston and cylinder as shown in Fig.(7).

3- Compressor

A compressor is used to provide the rig with air at pressure in the range [0-1000KPa]. A Burdon type pressure gauge is used to read the pressure in cylindrical of compressor. The volume flow rate and pressure that at the rig input are regulated by a suitable valve.

4- Valves and Flexible Hose

The valves used in this experimental work are of type (gate valve). This type is used because there ability to change the pressure and volume flow rate. Flexible hoses are used to join the parts of the rig.

Results and discussion

The experimental work has been done to study the effect of load changing on wall attachment fluidics amplifier performance. In the work the experimental data recorded represent the supply pressure, output pressure and output volume flow rate, the device tested under variable load by using pneumatic piston connected to output of wall attachment amplifier. The relation between the output volume flow rate and the supply pressure for different load are shown in Fig.(8). Where the relation between the output pressure and supply pressure for different load are shown in Fig.(9). From the results it is shown that the output volume flow rate (i.e. the input volume flow rate), increases gradually as the supply pressure increases for different constant load, see Fig. (8). In the case of output pressure and supply pressure, see Fig.(9). In this case it is shown that the output pressure increases until it reaches a specific value, after that the output pressure remains constant under different constant load, that means the load has no effect on the device function, the effect is only on the time response of the device.

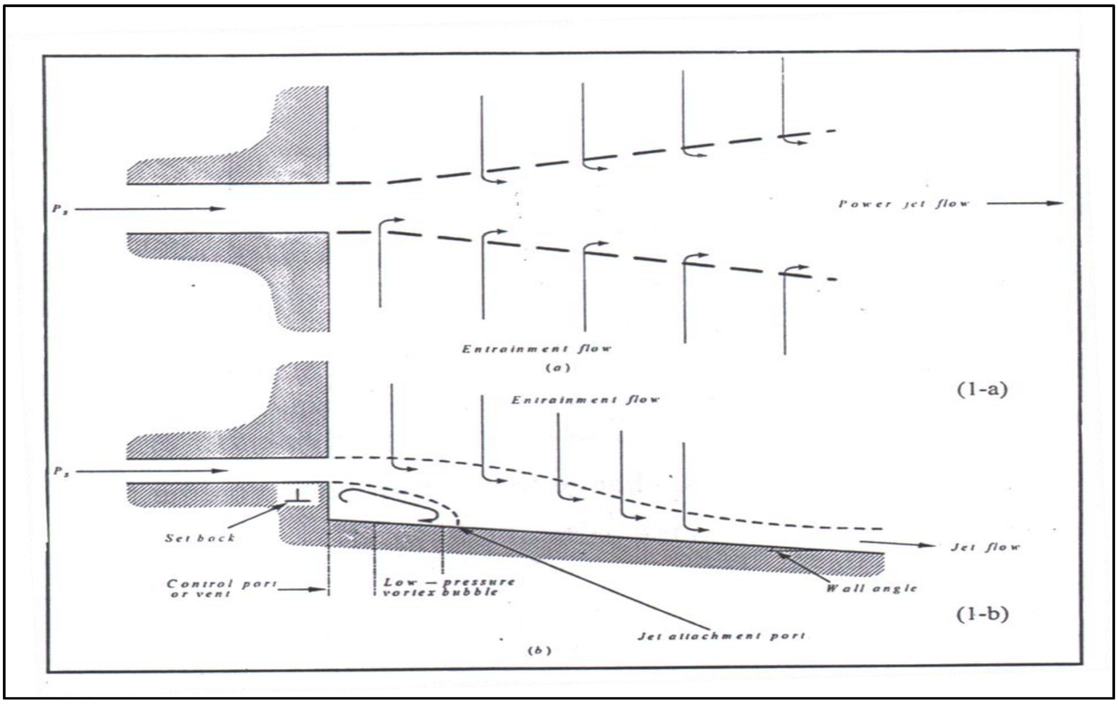

Fig. 1, (a) an unbounded turbulent jet entrains fluid particles on all sides (b) a side wall causes the jet to deflect towards it

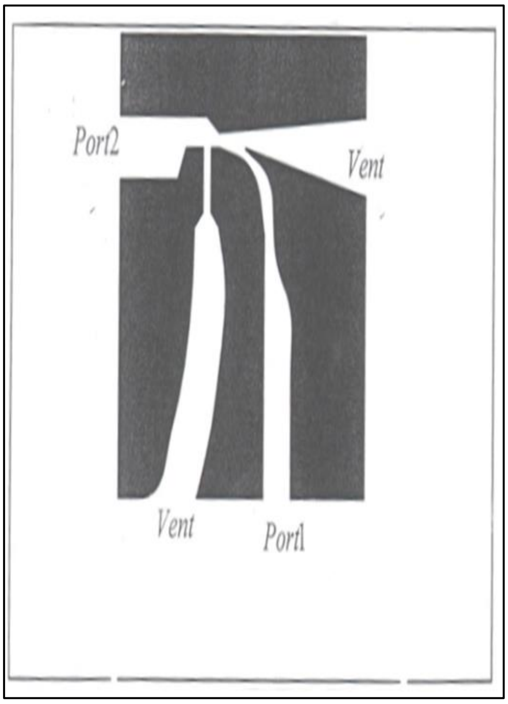

Fig. 2, a profile of a wall attachment diode

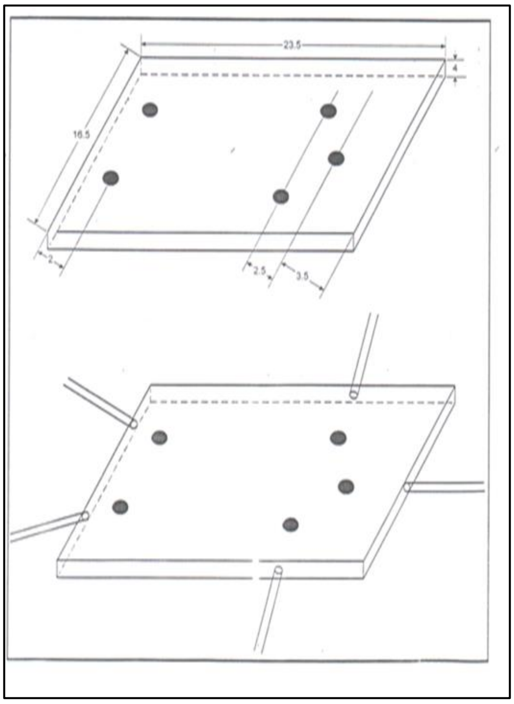

Fig. 4, the base of wall attachment device

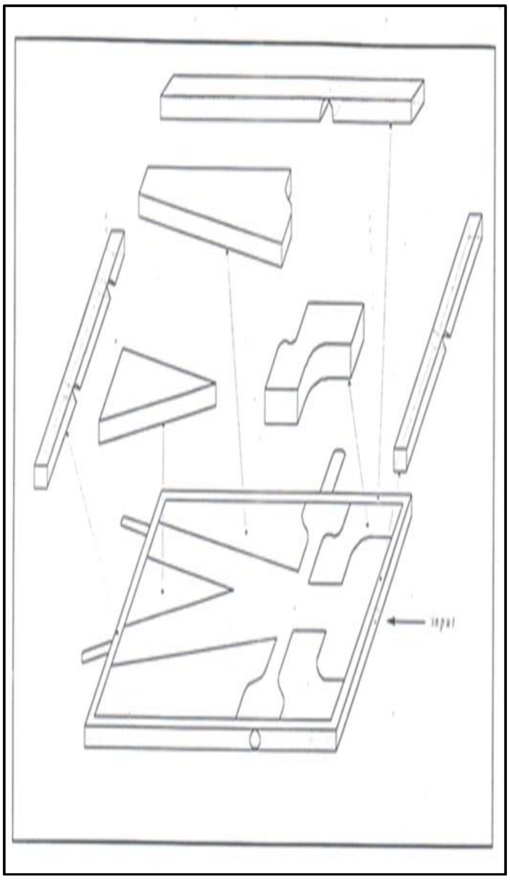

Fig. 3, Main parts of wall attachment device

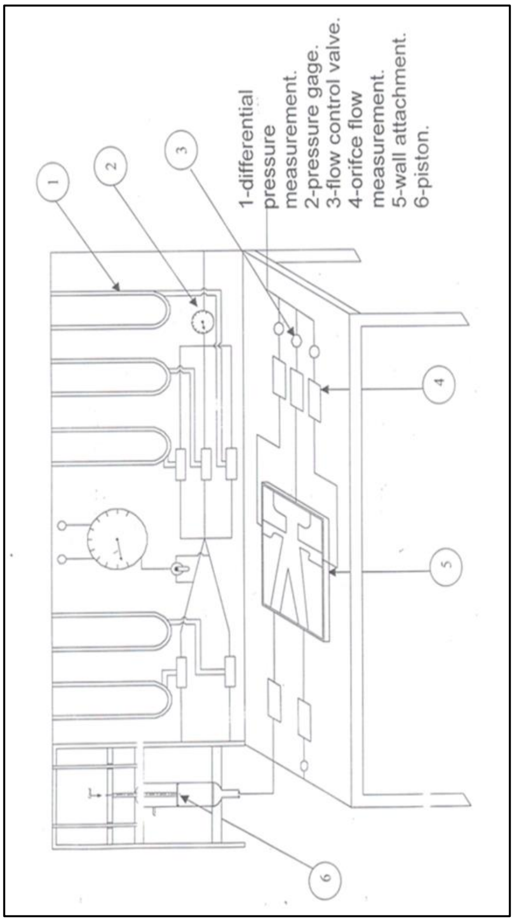

Fig. 5, Wall attachment device control unit

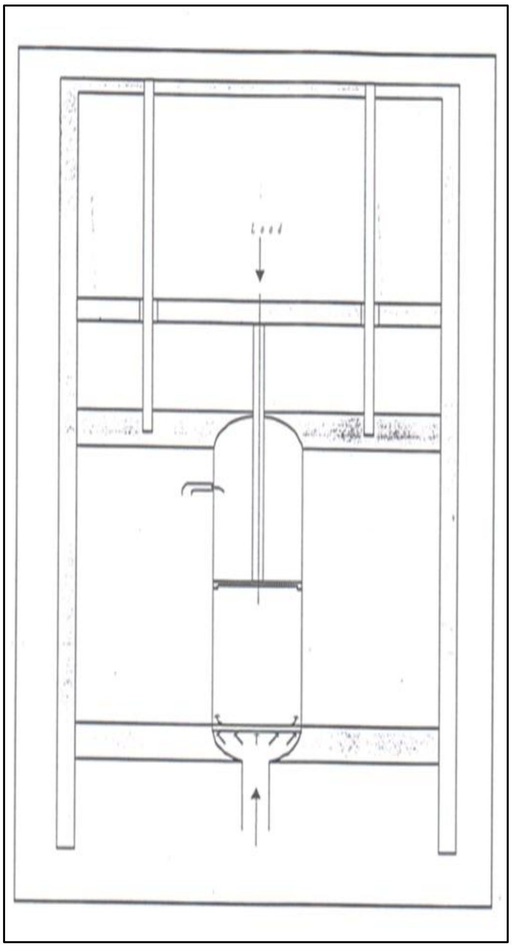

Fig. 6, Load system pneumatic piston

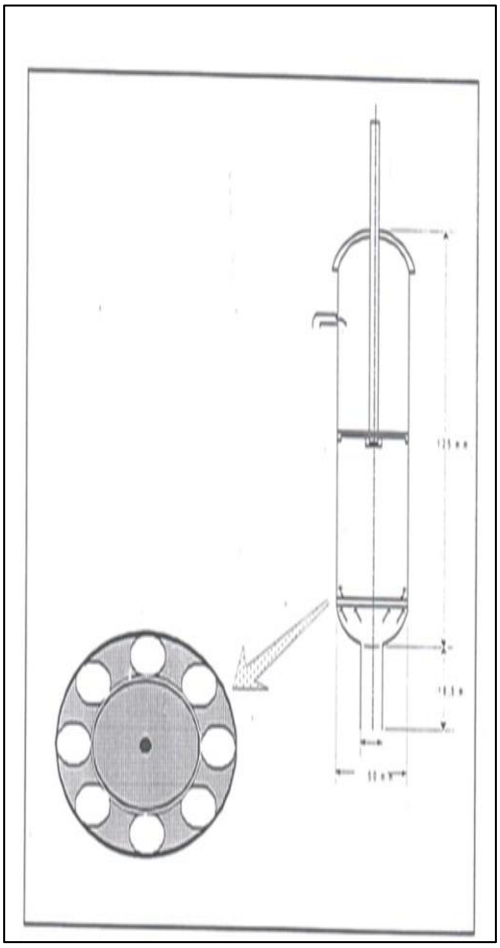

Fig. 7, Pneumatic piston

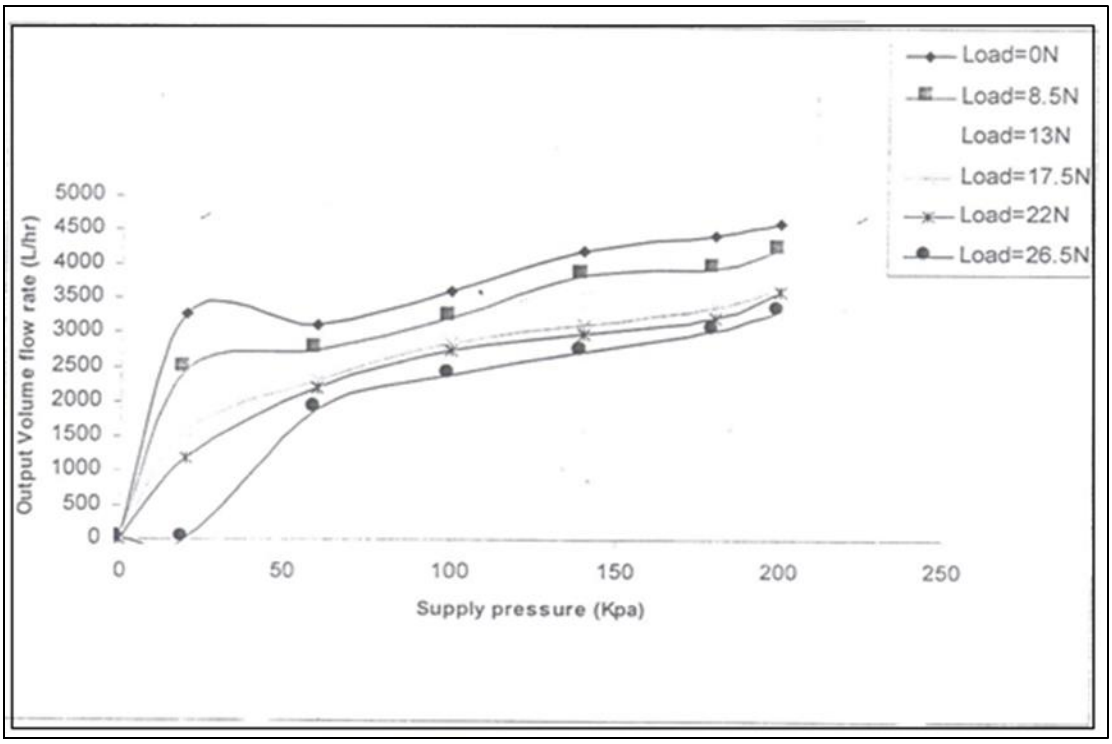

Fig. 8, The Relation Between supply pressure and Output Volume flow rate

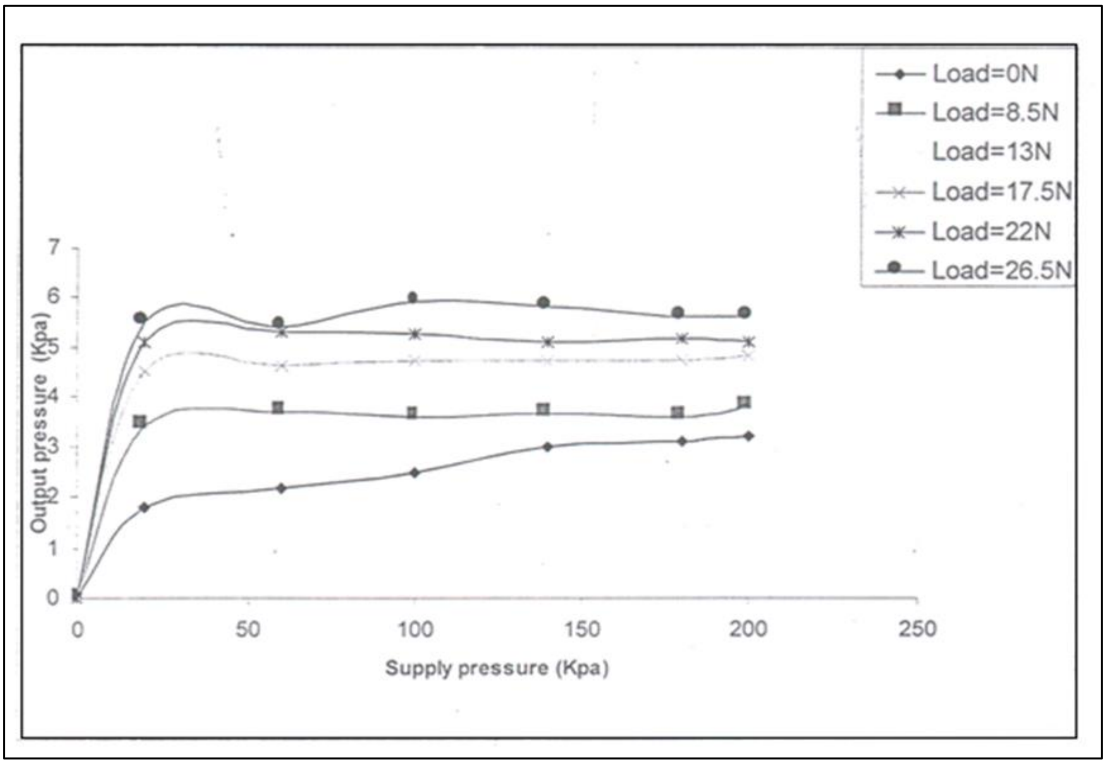

Fig. 9, The Relation Between supply pressure and Output pressure

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