International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS)
Volume V, Issue VI, June 2016 | ISSN 2278-2540

Design and Fabrication of Pneumatic Arm for Pick and Place of Cylindrical Objects

Santosh C[1], Manoj C S[2], Akshay Peddarajula[3], Abhishek R Shetty[4]

[1]*Assistant Professor, Department of Mechanical Engineering, PESIT-BSC, Bangalore-560100*
[2,3,4] *Graduate Scholar, Department of Mechanical Engineering, PESIT –BSC, Bangalore -560100*

***Abstract* - This project aims to Design and fabricate pneumatic arm for pick and place of cylindrical objects. The handling of materials and mechanisms to pick and place of objects from lower plane to higher plane and are widely found in factories and industrial manufacturing. There are number of pneumatic arms are available which consists of so many mechanisms hence becomes expensive. The designed pneumatic arm consists of two cylinders, a shaft works with lead screw mechanism capable of converting motion of piston to rotational motion of arm with help of using compressed air. The designed processes are carried out based on integrated information of kinematics dynamics and structural analysis of the desired robot configuration as whole. The highly dynamic pneumatic arm model can be easily set at intermediate positions by regulating the pressure using the flow control valve. It can be used in loading and unloading of goods in a shipping harbour as the movement of goods is done from lower plane to higher plane.**

***Keywords* – Pneumatic arm, Work volume, Cylindrical objects, Steel shaft A1 Cylinders, C-45 pistons, pilot valve, grippers.**

I. INTRODUCTION

1.1 Material Handling System

Material handling is a necessary and significant component of any productive activity. It is something that goes on in every plant all the time. Material handling means providing the right amount of the right material, in the right condition, at the right place, at the right time, in the right position and for the right cost, by using the right method. It is simply picking up, moving, and lying down of materials through manufacture. It applies to the movement of raw materials, parts in process, finished goods, packing materials, and disposal of scraps. In general, hundreds and thousands tons of materials are handled daily requiring the use of large amount of manpower while the movement of materials takes place from one processing area to another or from one department to another department of the plant. The cost of material handling contributes significantly to the total cost of manufacturing. Handling and storing materials involve diverse operations such as hoisting tons of steel with a crane; driving a truck loaded with concrete blocks; carrying bags or materials manually; and stacking palletized bricks or other materials such as drums, barrels, kegs, and lumber. The efficient handling and storing of materials are vital to industry.

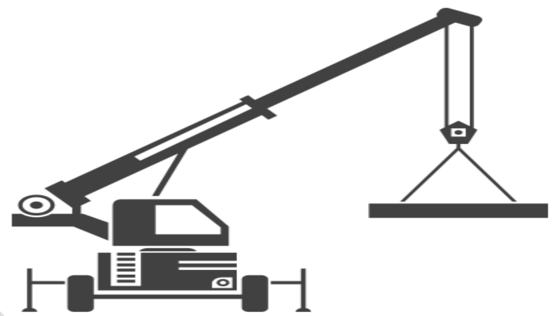

Fig 1 Material handling system

The primary objective of a material handling system is to reduce the unit cost of production. The other subordinate objectives are reduction in manufacturing cycle time, delays and damage, Promotes the safety and improve working conditions, maintain or improve product quality Promote productivity, reduces tare weight, control inventory, promote increased use of facilities.

1.2 Pneumatics in Material Handling

Pneumatic systems usually operate at much lower pressure than hydraulic systems do, pneumatics holds many advantages that make it more suitable for many applications**.** Because pneumatic pressures are lower, components can be made of thinner and lighter weight materials, such as aluminium and engineered plastics, whereas hydraulic components are generally made of steel and ductile or cast iron. Hydraulic systems are often considered rigid, whereas pneumatic systems usually offer some cushioning, or "give." Pneumatic systems are generally simpler because air can be exhausted to the atmosphere, whereas hydraulic fluid usually is routed back to a fluid reservoir.

Fig 1.2 Pneumatic in material handling system

Pneumatics also holds advantages over electromechanical power transmission methods**.** Electric motors are often limited by heat generation. *Heat generation is usually not a concern with pneumatic motors* because the stream of compressed air running through them carries heat from them. Furthermore, because pneumatic components require no electricity, they don't need the bulky, heavy, and expensive explosion-proof enclosures required by electric motors. In fact, even without special enclosures, electric motors are substantially larger and heavier than pneumatic motors of equivalent power rating. Plus, if overloaded, pneumatic motors will simply stall and not use any power. Electric motors, on the other hand, can overheat and burn out if overloaded. Moreover, torque, force, and speed control with pneumatics often requires simple pressure- or flow-control valves, as opposed to more expensive and complex electrical drive controls. And as with hydraulics, pneumatic actuators can instantly reverse direction, whereas electromechanical components often rotate with high momentum, which can delay changes in direction.

II. OBJECTIVES AND METHODOLOGY

The main objective of our proposed work is

- Design and fabricate a pneumatic arm
- With Work volume 0.6 m^3
- With 180^0 base rotation
- To pick and place cylindrical objects from lower plane to higher plane,by using Steel shaft Al cylinders,C-45 Pistons, manual operated pilot valve and grippers.

The Project planning and methodology involved the following steps;

*Study of existing pneumatic arms***:** In this step we observed the existing material handling system in the market. We observed the mechanism of the holding the material, lifting and placing it on plane. For instance the working we observed was run by a couple of motors 3-4 pneumatic cylinders which was very expensive.

Selection of mechanism for threshing action: By observing the existing material handling machines about how they displaces the metal/material we came to a conclusion of adopting a helical slot on shaft which will convert linear motion of lifting cylinder into rotational motion of arm.

Preparation of project plan: In this stage we started preparing the machine design and the concept. The way our Arm would look was decided and studied thoroughly. The first conceptual plan is as shown and various changes were made to improve the performance and to make cost effective.

Selection of appropriate materials: Selection of appropriate material is necessary to build an efficient system where both performance and cost were accountable. The materials were selected such that it would withstand vibrations and varying load acting on it. Materials used to build the system were almost mild steel and nylon- cotton for belt.

Design calculations and 3D Modelling: calculations were carried out for design of shaft, arm, griping cylinder and lifting cylinder. Accordingly 3D model of the components were prepared using Modelling Software CREO 2.0. The 3D model of components and the Assembly model gave the dimensional pictorial view of the Pneumatic arm which was to be fabricated.

Fabrication and Assembly of the Machine: After preparing the 3D model of the machine using CREO 2.0 operations like Arc Welding, Drilling, Boring, Step turning, Threading, Grinding, Sheet metal cutting, and mounting of bearings were carried out. The full arm was assembled using permanent fastening like welding and temporary fastenings like bolt and nuts.

Various components are used in the fabrication of Pneumatic arm are listed below

2.1 Pneumatic cylinder

Double acting cylinder is considered to be as a main actuator in any pneumatic systems. Double acting cylinders are more expensive than single acting cylinders, but double acting cylinders are superior than the single acting cylinders by any other important measure. Double acting cylinders are faster and stronger. In industrial applications, single acting cylinders are also used if possible, but when speed and force are important double acting cylinder are employed. Applications include opening and closing doors, taking things off conveyor belts and putting things on conveyor belts.

Figure 2.1(a) Double acting cylinder

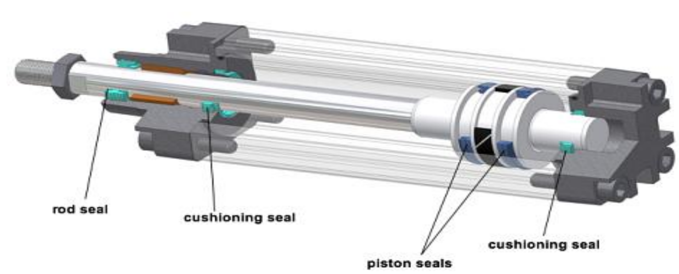

Figure 2.1(b) Sectional view of Double Acting Cylinder

2.2 Direction Control Valve

A 5/2 way direction control valve, from the name itself has 5 ports equally speed and 2 flow positions. It can be used to isolate and simultaneously bypass a passage way for the fluid which for example shoud retract or extend a double acting cylinder. There are variety of ways to have this valve actuated. A solenoid valve is commonly used, a lever can be manually twist or pinch to actuate the valve, an internal or external hydraulic or pneumatic pilot to move the shaft inside, sometimes with a spring return on the other end so it will go back to its original positions when pressure is gone, or a combination of any of mention above.

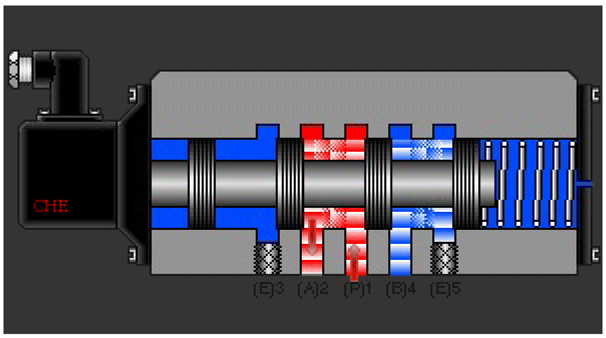

Figure 2.2 5/2 Direction Control Valve

In the Illustration given, a single solenoid is used and a spring return is installed in the other end. The inlet pressure is connected to (P)1. (A)2 could possibly be connected to one end of the double acting cylinder where the piston will retract while (B)4 is connected to the other end that will make the piston extend. The normal position when the solenoid is de-energized is that the piston rod is blocking (B)4 and pressure coming from (P)1 passes through (A)2 that will make the cylinder normally retracted. When the solenoid is energized, the rod blocks (A)2 and pressure from (P)1 passes through (B)4 and will extend the cylinder.and when the solenoid is de-energized, the rod bounces back to its original position because of the spring return. (E)3 and (E)5 is condemned or used as exhaust.

2.3 Flow control valves

A pneumatic system, energy that will be used by the system and transmitted through the system is stored as potential energy in an air receiver tank in the form of compressed air. A pressure regulator is positioned after a receiver tank and is used to position out this stored energy to each leg of the circuit. A pressure regulator is a normally open valve. With a regulator positioned after a receiver tank, air from the receiver can expand through the valve to a point downstream. As pressure after the regulator rises, it is sensed in an internal pilot passage leading to the underside of the piston. This piston has a large surface area exposed to downstream pressure and for this reason is quite sensitive to downstream pressure fluctuations.

When downstream pressure nears the present level, the piston moves upward pulling the poppet towards its seat. The poppet, once it seats, does not allow pressure to continue building downstream.

Figure 2.3 Flow control valve

III. DESIGN AND CALCULATION

3.1 Gripping Cylinder

Force (F_a) required for holding the work piece is 48.1N

Let force at point B be F and is equal to the force applied by the cylinder.

F_a=F

p=49.1/area

Pressure capacity 10 bar and a FOS of 2.5 applied pressure is 4bar and the stroke length is 50mm

Area A=$\frac{49.1}{4*10^5}$

$\frac{\pi * d^2}{4}$ =1.2025*10^{-4}

$d^2 = 1.5310 * 10^{-4}$

d=12.3 mm

Standard cylinder available for gripping is of bore dia 20mm and stroke length is 50mm

3.2 Design of Arm

The arm is considered to be a cantilever beam fixed at one end

Let F be the load =5 kg =49.1N

Since bending is the significant case design is based on bending moment

$$\frac{M}{I} = \frac{\sigma_B}{Y} = \frac{E}{R}$$

M= Moment about fixed point
I = Moment of inertia
σ_B =Bending stress

Y=Element distance from neutral axis
E= Young's modulus
R= Radius of curvature
M= load *distance from fixed end

M= 49.1*500
= 24.05kN-mm

Tensile strength of shaft is σ_t =552 MPa

σ_B =36% of the tension stress for definite design and
FOS =2.5
=.36*552/2.5
=79Mpa

$$I=\frac{b^4}{12}$$

Y=b/2

$$\frac{24050}{I}=\frac{79}{b/2}$$

b=14mm

A counter weight is embedded in order to avoid deflection of the arm .By trial and error, counter weight of 1.5 kg is added and length is increase by 300 mm

Therefore a Standard availability bar of 25mm is selected for the arm

Weight of the bar is =density * volume

W=7700*.025*.025*.800

=3.5 kg

3.2 Design of Shaft

D_s=22.535mm.

3.3 Lifting Cylinder

Standard Cylinder of the bore available is 50mm and stroke length is 150mm.

IV. 3D MODELLING

The modeling of system is done using Creo Parametric 2.0 Software.

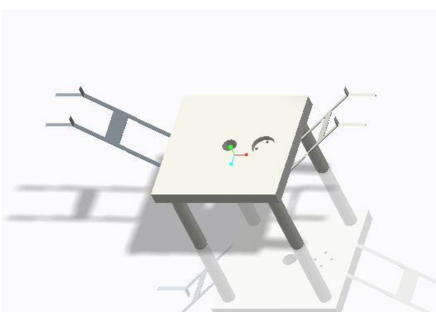

Figure 4.1 3D of frame

Figure 4.2 3D Model of Arm

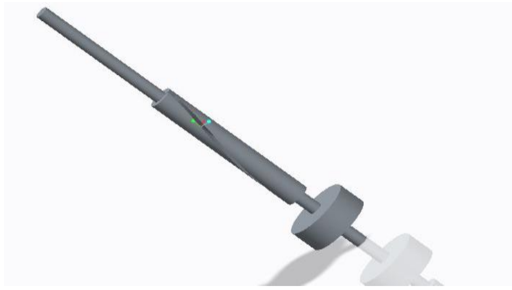

Figure 4.3 3D model of Shaft with Helical Slot

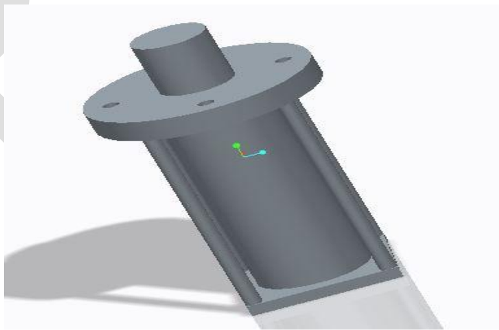

Figure 4.4 3D model of Cylinder

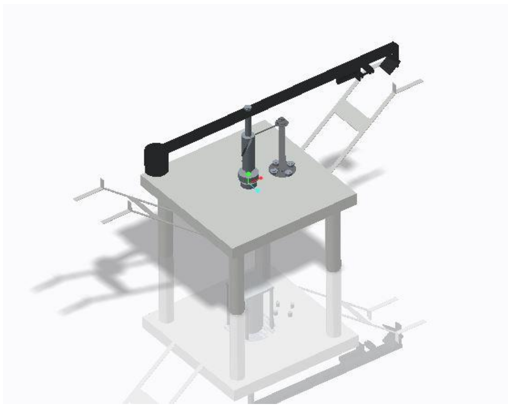

Figure 4.5 Isometric view of Pneumatic Arm

Figure 4.6 Assembled Pneumatic Arm

V. ANANLYSIS

Analysis of our project is done using ANSYS software.

Type of analysis	Linear static analysis
Element division	3-dimensional
Element shape	Tetrahedron

Table 5.1 FE Analysis details

Material	EN-40 Steel
Young's modulus	210GPa
Poisson's ratio	0.3
Yield stress	552 MPa

Table 5.2 Material Properties

Force (N)	49.1
Direction	Y-direction

Table 5.3 Load Cases

5.1 Analysis of Shaft

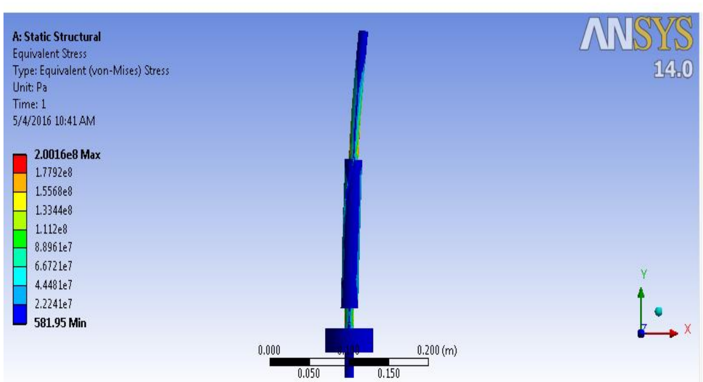

Figure 5.1 Von-Mises Stress acting on Shaft

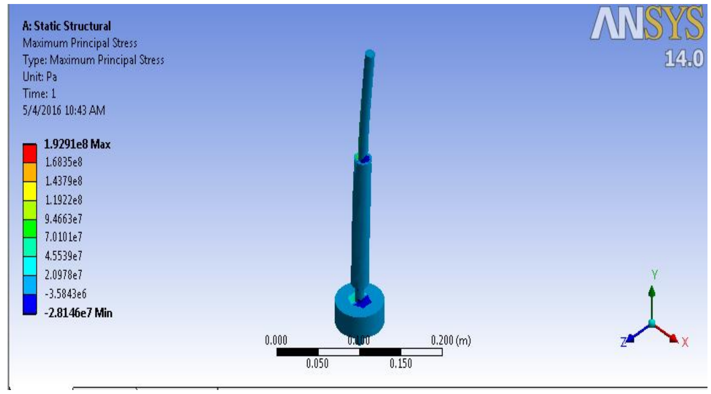

Figure 5.2 Principal Stresses acting on Shaft

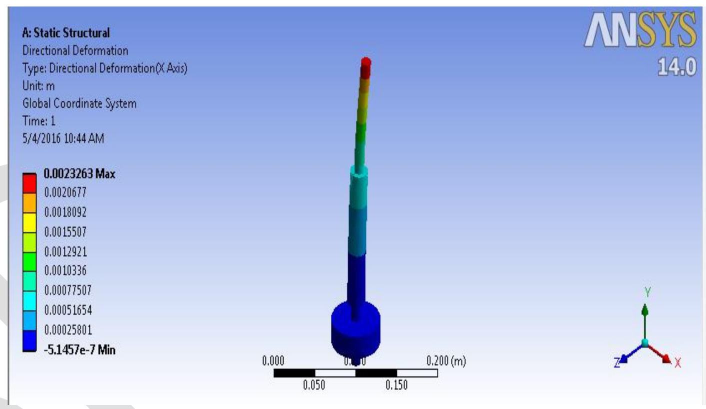

Figure 5.3 Deformation along X axis due to application of load

VI. RESULTS AND DISCUSSION

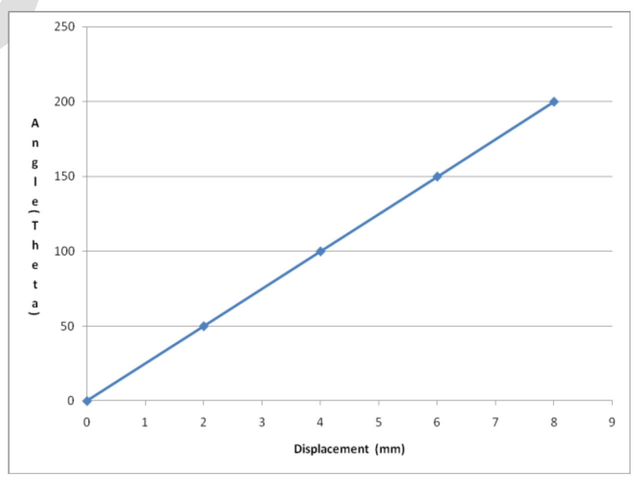

Figure 6.1 Angle V/s Displacement

The pneumatic arm is tested for the displacement and angular rotation due to helical slot. The variation in the angular rotation is due to the increased groove width.

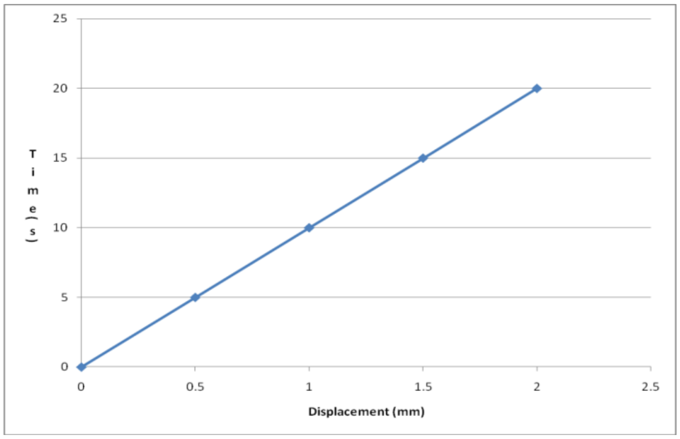

Figure 6.2 Time V/s Displacement for 0 Kg

Time taken for the pick and place of cylindrical objects for different cases are noted by conducting repeatability test for the dead weight or no load condition the time taken by the arm for complete rotation is 2.1 s at a constant pressure of 4 bar.

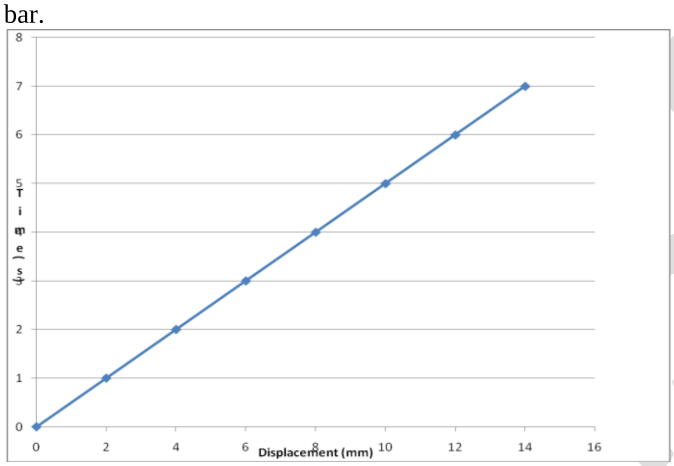

Figure 6.3 Time V/s Displacement for 2Kg

The pneumatic arm is now tested for the pay load of 2 kgs .time taken for one cycle is increased by 4s due to the effect of payload at a constant pressure of 4 bar. The net time taken by the arm for one cycle is 6.2s.

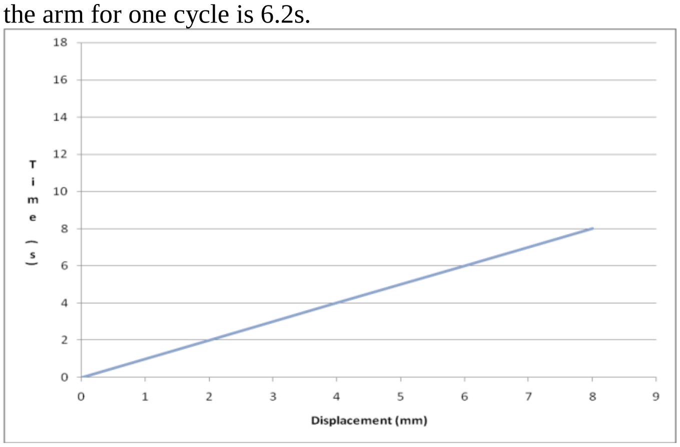

Figure 6.4 Time V/s Displacement for 4Kg

The pneumatic arm is now tested for the pay load of 3 kgs .time taken for one cycle is increased by 4.6s due to the effect of payload at a constant pressure of 4 bar. The time taken for one cycle is 7s.

VII. CONCLUSION

The design and fabrication of pneumatic arm for pick and place is completed with economic and effective considerations. It is controlled by manually operated pilot valves .pneumatic arm movement and rotation is done by pneumatic cylinder using a helical slot mechanism. The gripper is also a pneumatic actuator which holds cylindrical objects. The maximum pay load is 49.1N and total weight of arm is 63.1N.

The results obtained from the theoretical calculations indicate that the pick and place pneumatic arm fabricated can pick a load of 49.1N cylindrical objects with variable dia of 60 to 120 mm, which could pick the object and place in a semi hemispherical work volume.

REFERENCES

[1]. Rakesh.N, Pradeep Kumar.A, Ajay.S International journal of scientific & technology research volume 2, issue 8, august 2013 issn 2277-8616
[2]. Freundt, M., Brecher, C, Wenzel, C, Pyschny, N., 2008, in IFIP International Federation for Information Processing, Volume 260, Micro-Assembly Technologies and Applications, eds. Ratchev, S., Koelemeijer, S., (Boston: Springer), pp. 285-295
[3]. Mohd Aliff, Shujiro Dohta, Tetsuya Akagi, Hui Li 1877-7058 © 2012 Published by Elsevier Ltd. doi: 10.1016/j.proeng.2012.07.153
[4]. Rafigul I. Noorani Math1 Cornput. Modelling, Vol. 14, pp. 450-455, 1990 Printed in Great Britain
[5]. Deb, S. R. (n.d.). Robotic technology and flexible automation.
[6]. Government of India. (n.d.). NPTEL. Retrieved 2013, from http://nptel.iitm.ac.in/
[7]. Groover, M. P., & Weiss, M. (n.d.). Industrial robotics.
[8]. Khurmi, R. S., & Gupta, J. K. (n.d.). Machine design.
[9]. NASA. (n.d.). Robotics alliance project. Retrieved March 13, 2013, from http://robotics.nasa.gov/
[10]. Rajput, R. K. (n.d.). Robotics and industrial automation.