King Fahd University of Petroleum & Minerals

College of Engineering

Electrical Engineering Department

EE 399 – Summer Training

Semester 2009-2010 (093)

Company Name : ITT SAUDI COMPANY

Training report

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Submitted To

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Introduction

King Fahd University of Petroleum & Minerals gives students opportunity to spend 8 weeks on the industrial training .The goal of the program is to get experience and familiar with industrial life and to be ready for future jobs.

I started my training program at ITT Saudi Company from 03/07/2010 until 28/08/2010. The focus of my training program was on how to select suitable motor for specific pump and observe the torque sensor .

During my training ,I spent almost in three departments which are Engineering Area ,Quality Assurance and Operation or Test Stand .

This report is discussed the following topics :

- Company Background .
- Safety Course .
- Introduction to pumps .
- Affinity Laws .
- Speed Control .
- Variable Frequency Drives .

ITT Background :

ITT is work in three main fields :

● *Fluid Technology*

ITT is a global water leader and the world's largest supplier of pumps and systems to transport, treat and control water and other fluids.

● *Defense & Information Solutions*

ITT is a leading defense and aerospace company providing advanced technologies, systems, and operational services for military and civil customers.

● *Motion & Flow Control*

ITT is a leading provider of mission-critical products for the aerospace, industrial, transportation, medical and consumer markets.

- ✓ Gould's Pump company is a part of the first field ,Fluid Technology, and partner of ITT family .

❖ ITT Saudi Company:

ITT Saudi Company is a manufacture and service facility , serving various industries fields ,such as oil and gas, petrochemical, chemical, power, mining and minerals ,water treatment ,and steel. The capabilities of the company is due engineering fields aiming to meet their customers requirements, to manufacture pumps (horizontals and verticals) to provide several services for other companies

,such as plant performance services, energy conservation, troubleshooting, start-up services, upgrading ,and reliability improvements.

Our company is interested in centrifugal pumps only .

⇨ Company Scope:

- Manufacture and supply of pumps and systems in full compliance .
- Vertical Turbine Pumps for API, Oil & Gas, Mining and Power sectors engineered to order
- Test facility – designed for up to 2000HP
- Fully equipped for fabrication, assembly, machining, welding, balancing, packaging and painting
- Variable Speed Drive for any speed requirements testing
- Low Voltage & Medium Voltage Power capability
- Horizontal & Vertical Turbine Pumps testing up to 21,000GPM
- Customized components stocking programs

⇨ PRO Services :

- PRO Service Center provides an extensive range of integrated service solutions for industry including preventive maintenance monitoring, contract maintenance, emergency field service, engineered upgrades, inventory management, overhauls & repairs for pumps and other rotating equipment.
- Our expert technicians repair ALL brands of pumps and rotating equipment in our service center or at your location .
- Engineering support from the world's leader in pumping technology

- Services to improve cost of ownership:- Repair and Upgrade Equipment .
- Re-Engineering & Engineered Parts Replication:- API Power end and Seal chamber Upgrades .

⇨ Capabilities :

● Engineering

Meeting strict customer requirements and latest API standards

● Manufacturing

Horizontal and Vertical Engineered Pumps

● Services

Plant Performance Services (PPS),
Energy conservation,
troubleshooting,
start-up service,
upgrades,
and reliability improvements

● Testing

horizontal and vertical pumps up to 1000 HP

● Training

Hands-on classroom
activities including hydraulic theory,
installation, maintenance and operation of pumps

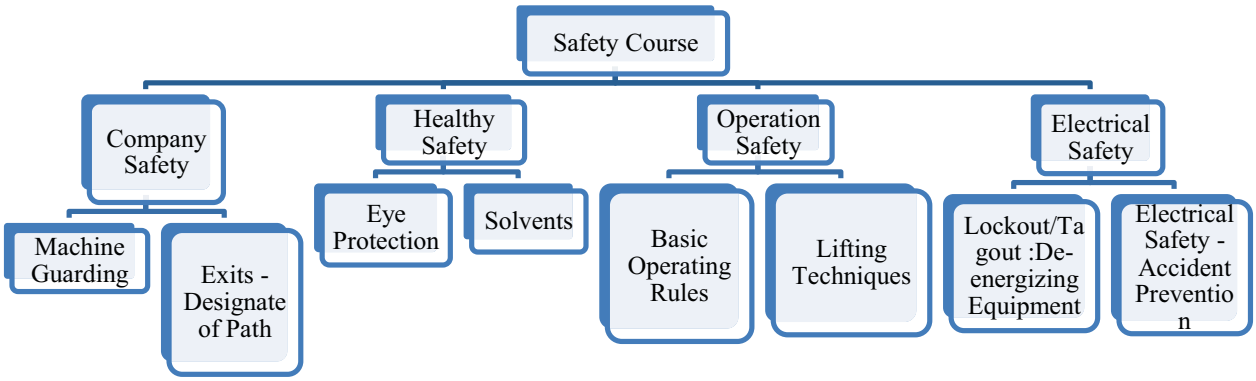
⇨ Company Department :

1. Finance .
2. Contracts .
3. Engineering .
4. Quality Assurance .
5. Operations .
6. Service & Aftermarket .
7. Human Resources .

Safety Course :

In the first week of training ,we took a course about safety issues . The course discussed the importance of safety , how to work safely, and what are the equipments that protect us from hazard ? .

I can summarize the course topics by the following chart .



Introduction to pumps :

The definition of pump is a mechanical device that rotates to move fluid from one place to another place . Pumps transfer fluid from low pressure areas to higher pressure areas, low elevations to higher elevations, and from local locations to distant locations.

The design of pump depends on several parameters ,such as :

1. What type of liquid is used ?
2. What is the flow rate required ?
3. How far the liquid is moved ?
4. Under What environmental conditions the movement is taking place ?.

There are several factors to select proper pump that fit your needs ,like :

- Flow rate or Capacity range of the liquid .
- Total or pressure against which it must operate .
- NPSHR: Net Positive Suction Head Required .
- Pumps speed .
- Characteristics of fluid .
- Construction.

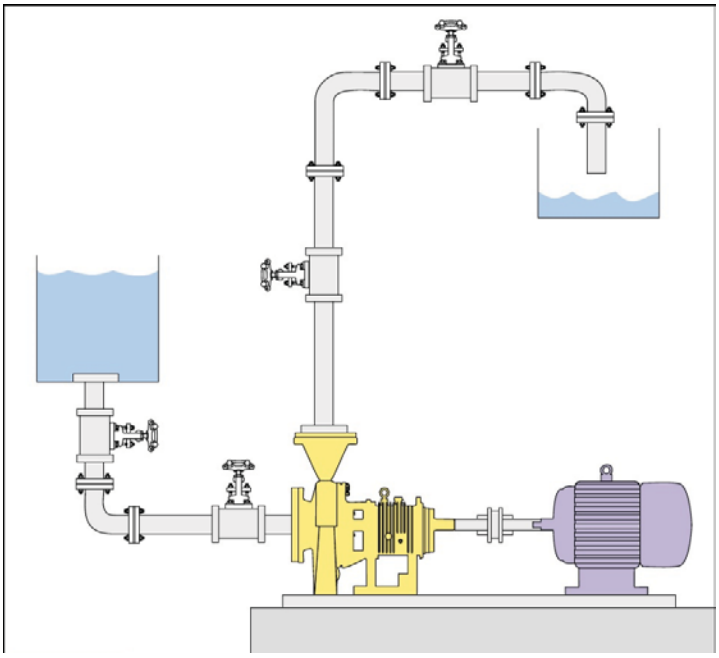


Figure 1 : A typical pumping system

As sated earlier , ITT Saudi Company is interested only in one type of pumps which is centrifugal pumps .

Centrifugal pump has two main components:

1. A rotating component consisted of an impeller and a shaft

2. A stationary component comprised of a casing, casing cover, and bearings.

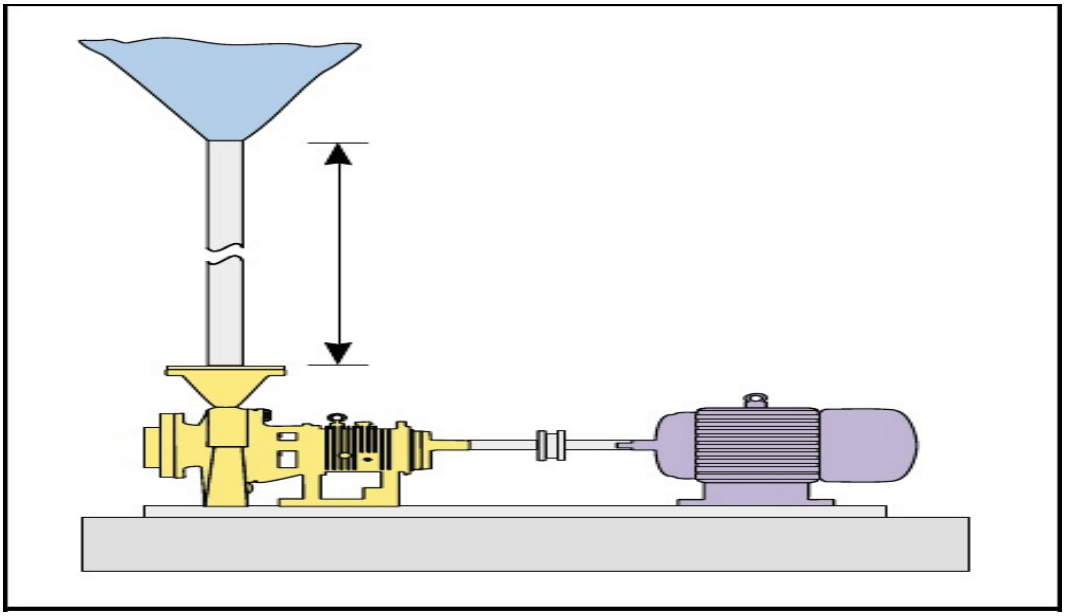


Figure 2 : Centrifugal pump

Affinity Laws

Affinity Laws are a group of rule that govern the pumps .Theses laws are to predict the pumps operation and performance ,especially when the pumps are exported to a country with different electricity. Because the running speed differs with the supply frequency .

The affinity laws become more important in industrial pumps regarding with increasing of using Variable Frequency Drive (VFD) .

The affinity laws express the mathematical relationship between the several variables involved in pump performance. They apply to all types of centrifugal and axial flow pumps. They are as follows :

1. $\frac{N_R}{N_M} = \frac{Q_R}{Q_M}$
2. $\left(\frac{N_R}{N_M}\right)^2 = \frac{H_R}{H_M}$
3. $\left(\frac{N_R}{N_M}\right)^3 = \frac{BHP_R}{BHP_M}$

Where

N_R : Rated Speed (rpm) . N_M : Measured Speed (rpm) .

Q_R : Rated Flow or Capacity (gallon per minute / gpm) .

Q_M : Measured Flow or Capacity (gpm) .

H_R : Rated Head (feet / ft) . H_R : Measured Head (feet / ft) .

BHP_R : Brake Horsepower (hp) .

These affinity laws listed above are used to determine the new performance .

For example, If a motor operated at BHP_R = 20 hp and speed N_R = 1750 rpm to provide Q_R = 300 gpm with head H_R =160 ft .What would be the performance when N_M =2000 rpm ?

Firstly, we find the capacity when the new speed N_M = 2000 rpm

$$\frac{1750}{2000} = \frac{300}{Q_M} \Rightarrow Q_M = 342.86\ gpm$$

Secondly, we find the head or pressure at N_M = 2000 rpm

$$\left(\frac{1750}{2000}\right)^2 = \frac{160}{H_M} \Rightarrow H_M = 209\ ft$$

Thirdly, we find the Brake horsepower at N_M = 2000 rpm

$$\left(\frac{1750}{2000}\right)^3 = \frac{20}{BHP_M} \Rightarrow BHP_M = 29.85\ hp$$

How to choose suitable motor for specific pump ?

Now based on the value of Affinity laws ,Engineer can select the motor that can feed the pump and system .

Figure 3 : AC motor with 400 hp,480 V,3570 rpm

Figure 4 : Vertical motor with 100 hp,480 V,3565 rpm

Speed Control

The speed of AC Induction Motor depends on two factors :

1. The number of poles .
2. The supply frequency .

Example : The speed of 4-pole induction motor operating at 60 Hz =

$$N_s = \frac{120\,f}{p} = \frac{120 \times 60}{4} = 1800\ rpm$$

The motor speed is inversely proportional to the number of poles .Synchronous speed can be controlled by changing number of poles .Changing the number of poles has to be incorporated at the manufacturing stage and it is called “pole changing motor” or “multi-speed motor” .

Although ,this method is simple but expensive .

The other alternative way is to vary the supply frequency .

The main advantage is speed control and breaking operation are possible from zero speed to maximum speed .

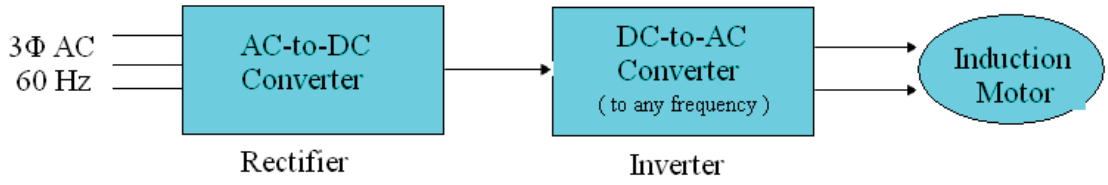


Figure 5 : speed control of induction motor

Variable Frequency Drive (VFD)

⇨ Definition :

VFD is a piece of equipment that regulates the speed and torque of an electric motor .

⇨ Why do we need to use VFD ?

There are millions of motor in use in industry around the world. They operate fans, pumps, compressors, conveyors,…etc.

According to ABB, more than 65% of industrial electrical energy is consumed by motors .

The motors can be controlled by a valve that regulates the flow of fuel or a vane that controls airflow while the motor speed remains unchanged .Also, switching On or Off the motor is not efficient from energy point of view .

⇨ How VFD works ?

Induction motors are the workhorse of industry .They rotate near synchronous speed (120f/p) . So it is efficient to change the motor speed by changing the frequency of the supply .

VFDs convert the fixed-frequency supply voltage to a continuous variable frequency to adjust the motor speed .

The conversion process incorporates into two main stages :

1. Rectifier stage : convert from AC-to-DC .
2. Inverter stage : convert from DC-to-AC with any frequency required .

⇨ What are the benefits of VFD ?

1. To improve the efficiency of motor-driver equipment by matching speed to changing load requirements .
2. To allow accurate and continuous process control over a wide range of speed.
3. Low maintenance costs, since lower operating speed .

Figure 6 : VFD for motor with 100 hp , 480 V

Figure 7 : VFD for motor with 1000 hp , 4160 V

Torque sensor :

There is an important device in any rotating system ,which is torque sensor .It is defined as a device which measures the torque on a rotating system such as a gearbox or shaft. Torque sensors convert a mechanical input into an electrical output signal, showing a component performance which can be monitored using a data logger or data acquisition system in the control room .

In our company , torque sensor is place between motor and pump .sometimes ,you can monitor the problems and avoiding dangerous cases in the system by watching the speed and torque of the motor .For example , cavitation in the pumps which may damage your impeller and casing .

The figure below is showing one type of torque sensor

Figure 8 : torque sensor

Conclusion :

I feel that I have satisfied the objectives of the training program .

The training has enhanced my skills related:

(a) Team work.

(b) Planning.

(c) Technical Reporting.

(d) Oral presentation

References

1. Company website " *www.itt.com*"
2. "Electric Machines" 2nd Edition , *By Mulukutla Sarma*
3. "What is a variable speed drive ? " article from ABB Company ,*www.abb.com*, .
4. "Variable Frequency Drives " Article from Natural Resources Canada,*www.nrcan-rncan.gc.ca*, .