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An Overview of Troubleshooting and Maintenance of Pumps in the Oil and Gas Industry

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Abstract

Pumps are critical components in various industrial processes, responsible for the efficient transport of fluids across systems. However, their failure or suboptimal performance can lead to significant operational disruptions, safety hazards, and increased maintenance costs. Pumps find extensive use in our refineries especially in petrochemical process plants, water circulation systems, A/C and heating systems, and many other applications. Keeping these machines running with least troubles and shutdown decreases the downtime of the whole system. Common issues such as cavitation, mechanical seal failures, bearing wear, misalignment, leaks, vibration etc. are discussed. This paper aims to serve as a practical guide for engineers and maintenance professionals seeking to improve pump performance and overall process efficiency in industrial operations.

Keywords: Troubleshooting, Pumps, Maintenance, Cavitation

I. INTRODUCTION

Troubleshooting is a systematic approach to problem-solving that involves diagnosing and addressing equipment breakdowns. A pump troubleshooting is a critical maintenance function that involves identifying symptoms, diagnosing root causes, and implementing corrective actions to restore optimal performance. A systematic approach to troubleshooting not only reduces downtime but also prevents recurring failures and extends the life of pumping equipment. This process often requires a combination of visual inspections, performance data analysis, and condition monitoring tools. As industrial systems become more complex, understanding the common causes of pump malfunctions and adopting effective troubleshooting techniques have become increasingly important for ensuring operational efficiency, safety, and cost-effectiveness. Cavitation is one of the common faults of centrifugal pumps, which will affect the stable operation of the system and reduce the pump head and efficiency. The working environment will also be affected by the vibration and noise made when the pump cavitates.

MANHOURS REPORT						
DAY AND DATE	FROM HRS.	TO HRS.	TOTAL HOURS	NO. OF MEN	TOTAL MAN-HOURS	FORE-MAN SIGN
TOTAL						
NAME OF SUPERVISOR _____						
SIGNATURE: _____						

- **MATERIAL REPORT**
- The under listed materials were utilized.

S/NO.	DESCRIPTION OF SPARE PARTS/ITEM	QTY.	NNPC CODE
1.			
2.			
3.			
4.			
5.			
6.			
7.			

NAME OF FOREMAN _____
SIGNATURE: _____

Figure 2: Schedule and planning form

iii. Daily Work Sheet

The next step after the project-planning schedule is drawn up is to provide the maintenance foreman with a daily order of work sheet as shown in the figure below. It shows what each crew will undertake the following day, the approximate starting time, work description and location.

Format of Daily Work sheet

WARRI REFINING AND PETROCHEMICAL COMPANY, EKPAN-WARRI PREVENTIVE MAINTENANCE PROGRAMME (CONTROL SHEET)				EQUIPMENT (PUMP, COMPRESSOR ETC) ITEM NO. LOCATION: WEEK DUE: WORK REQUEST NO:			
COUPLING TYPE							
S/N	ACTIVITIES	MEN	SECT	EST.	ACTION TAKEN	FORMAN SIGN	
1		2					
2		1					
RADIAL ALIGNMENT BEFORE AXIAL		RADIAL ALIGNMENT BEFORE AXIAL					
SPECIFIC INSTRUCTIONS 1. OBTAIN WORK PERMIT B/F COMMENCEMENT OF WORK 2. ENSURE THAT THE EQUIPMENT IS DE-ENERGIZED AND ALL ASSOCIATED VALVES ARE CLOSED BEFORE WORK IS STARTED							
PLANNING PROGRAMMER NAME: SIGNATURE: DATE:				SUPT-PERFORMING SECT. NAME: SIGNATURE: DATE:		O/C PERFORMING SECT. NAME: SIGNATURE: DATE:	
ALWAYS WEAR THE SAFETY EQUIPMENT AND USE THE RIGHT TOOL							

Figure 3: Daily work Sheet

General Guide of Pumps Troubleshooting

The general guide provides a structured approach to identifying and resolving common pump problems and is intended to furnish maintenance personnel, engineers and operators who need a practical reference for diagnosing and fixing pump-related issues across various applications. This is shown in Table 1.

Table 1: General guide to industrial pumps troubleshooting and maintenance

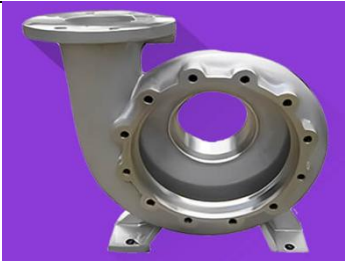
Faults	Identifications	Possible Causes	Remedies
Pump fails to start	No sound or movement; motor does not run	Power failure, blown fuse, open circuit, motor failure	Realign pump and motor, balance impeller, replace bearings, check suction
Pump runs but no flow	Motor operates but discharge line is dry	Pump not primed, air lock, suction blockage, impeller damaged	Check power supply, replace fuse, repair wiring, inspect/replace motor
Low flow rate	Flow less than design capacity	Clogged impeller, worn components, incorrect pump speed	Re-prime pump, vent air, clear suction line, inspect and repair impeller
Excessive vibration	Audible noise or visible shaking	Misalignment, unbalanced impeller, worn bearings, cavitation	Clean impeller, replace worn parts, adjust pump speed
Overheating	Hot motor casing or pump housing	Overloaded pump, poor ventilation, bearing failure	Reduce load, improve ventilation, inspect/replace bearings
Noisy operation	Rattling, grinding or whining sounds	Cavitation, foreign objects, worn bearings, misalignment	Replace seal, tighten fittings, replace gaskets
Leakage at seals or gaskets	Fluid seen dripping or spraying from joints	Worn mechanical seal, loose fittings, damaged gaskets	Inspect and repair wiring, reduce load, check motor amperage
Frequent tripping of circuit	Circuit breaker or fuse trips during start-up or operation	Electrical short, motor overload, improper wiring	Increase suction head, reduce temperature, clean inlet filter
Cavitation	Popping sound, reduced output, vibration	Low suction head, high fluid temperature, clogged inlet	Seal leaks, raise fluid level above pump inlet
Pump loses prime	Pump stops pumping fluid	Air leak in suction line,	Clean suction line, repair/replace foot valve,

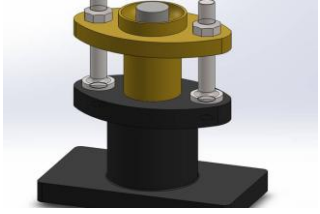
	after starting	insufficient fluid level	check motor rotation direction
Suction problems	Low or no suction pressure	Blocked suction, foot valve failure, wrong direction of rotation	Use wear-resistant materials, control cavitation, match material to fluid.

Troubleshooting of Pump Components

The Table 2 below focuses on diagnosing and resolving problems related to individual pump components. By understanding the function and failure modes of each part, maintenance personnel and operators can conduct more effective inspections, prevent recurring issues and extend the overall lifespan of the pump. Component-level troubleshooting is an essential skill for maintaining pump performance and operational safety.

Table 2: Pump's components troubleshooting

Components	Faults	Identifications	Possible Causes	Remedies
	i. Worn or damaged impeller	Reduced flow/pressure, vibration	Abrasive fluid, cavitation, corrosion	Replace impeller, use proper material, control cavitation
Impeller	ii. Impeller clogging	Reduced flow, noise, vibration	Debris in pumped fluid	Replace volute, use resistant materials
	i. Erosion or corrosion	Material loss, reduced efficiency	Chemical attack, high velocity fluid	Repair/replace volute, control hydraulic conditions

Volute	ii. Cracked volute	Visible cracks, leakage	Hydraulic shock, mechanical stress	Repair/replace volute, control hydraulic conditions
	i. Bent or misaligned shaft	Vibration, misalignment, noise	Improper alignment, overloading	Align pump/motor, balance load.
Shaft	ii. Shaft wear or scoring	Visible wear on shaft	Improper lubrication, seal failure	Polish or replace shaft, improve lubrication
	i. From stuffing box	Fluid leakage around shaft	Worn packing, incorrect installation	Repack or replace packing, adjust gland
Stuffing box	ii. Excessive packing wear	Frequent need for repacking	Friction, poor quality packing	Use correct packing, reduce stuffing box pressure
	i. Seal leakage	Visible fluid leak	Seal face damage, improper installation	Replace seals, check installation
Seals	ii. Seal failure	Frequent breakdowns, overheating	Dry running, improper material	Use correct seals, avoid dry running

			selection	
	i. Bearing noise	Grinding or whining sound	Lack of lubrication, contamination	Lubricate bearings, replace damaged ones
Bearings	ii. Bearing overheating	Hot bearing housing	Overloading, poor ventilation	Improve cooling, reduce load, replace bearings

II. FINDINGS

Impeller Cavitations

Cavitations of the impeller are caused by bubbles, which formed in the low-pressure area of the suction eye and then collapse with great force at the impeller edge. To understand the principle involved, it is important to understand the relationship between the temperature at which a fluid boils (the fluid's boiling point) and pressure. The suction eye of the impeller is a low-pressure area, as it must create suction capable of drawing water into the pump. Pressure increases as the fluid moves away from the suction eye and toward the volute, where the pressure is highest. In a centrifugal pump, therefore, the pressure is lower at the suction eye than it is at the edge of the impeller. The higher pressure at the edge of the impeller was sufficient to collapse the bubbles suddenly; the result being powerful shock waves that pounded against the metal like tiny hammers and created small dents or pits that caused the metal to look like it has been sandblasted. The solution lay in having enough pressure at the suction eye to prevent boiling, or, to use the technical term, in having enough available Net Positive Suction Head (NPSH). The required minimum NPSH was designed into a pump for a specific range of temperatures. As long as the pump handles fluids within its available NPSH, there should be no cavitations problem. A pump may operate for a very short period with cavitations. This situation should not be prolonged. The damage is generally very rapid (depending on the material). It is strongly advised to stop the machine. If the input pressure of the wheel is less than the vapour pressure, partial liquid vaporization occurs which is reflected in the creation of gas bubbles (cavities). These bubbles, which are carried by the liquid, move in the wheel and are therefore subject to increasing pressures. The conditions are therefore such that the bubbles condense and are said to implode.

The following occurred when the pump operated under cavitation conditions for a longer time:

- Pitting marks on the impeller blades and on the internal volute casing wall of the pump.
- Premature bearing failure.
- Shaft breakage and other fatigue failures in the pump.
- Premature mechanical seal failure.

The diagrams below show cavitation phenomenon relating to centrifugal pump blades.



Figure 4: Effect of cavitation on an impeller of a centrifugal pump



Figure 5: Effect of cavitation on the volute of a centrifugal pump

III. OBSERVATIONS

It was observed that the formation of these bubbles increase the volume of fluid present in the low-pressure area, which has the effect of increasing the pressure in certain locations where the gas bubbles violently condensed by imploding. The shock created by the bubbles bursting destroys the walls of the elements in contact with the fluid. A cavitation pump soon becomes worn. When cavitation occurs in a pump, the pump efficiency is reduces. It can also cause sudden surges in flow and pressure at the discharge nozzle. The effects of cavitation are noise and vibration.

The following observations can be possibly made:

- i. A reduction of pressure at the suction nozzle.
- ii. An increase of the temperature of the pumped liquid.
- iii. An increase in the velocity or flow of the fluid.
- iv. Separation and reduction of the flow due to a change in the viscosity of the liquid.
- v. Undesirable flow conditions caused by obstructions or sharp elbows in the suction piping.
- vi. The pump is inadequate for the system.

If your pump is faced by the problem of cavitation, you will have one or more of the following:

- i. Problems with pump packing.
- ii. Problems with mechanical seals.
- iii. Problems with alignment.
- iv. Problems with impellers, casings, and wear bands.
- v. Problems with the bearings.
- vi. Problems with leaks and fugitive emissions.
- vii. Problems with pump efficiency.

And these problems will not go away until you resolve cavitation from its source.

IV. CONCLUSION

A good knowledge of troubleshooting of rotating equipment possessed by operators will drastically reduce machinery problems thereby prolonging the lifespan of the rotating equipment. Regular inspection, proper maintenance and prompt attention to warning signs are key to preventing pump failures and ensuring long-term pump performance. A systematic approach to troubleshooting not only resolves immediate problems but also contributes to improving system efficiency, safety and operational longevity.

CONTRIBUTION TO KNOWLEDGE

This study integrates practical experience with theoretical understanding, offering real-world troubleshooting techniques applicable across various pump types and applications.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship and publication of this article.

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