CASE STUDIES – CS1

Segment – Pumping System \ Materials of construction\ Retrofit for energy optimization

Topic / case – Retrofit & upgrade of raw water pumps

Installed in the 1920's for water supply to city of Kolkata

Introduction to the case – Municipal Corporation of Kolkata wants an energy efficient impeller for their existing raw water pumps. These pumps were supplied by Mather + Platt Ltd , Manchester in the 1920's.They are bottom suction split case pumps and have given good services to the corporation. Replacement impellers were procured from local contractors – they were of poor hydraulic design leading to decline in efficiency and progressively reduced life of impellers. Pumps works on suction lift and there is evidence of cavitation damage at the impeller inlet edges. Pumps handle raw water and the shaft sleeves show excessive wear. Retrofit assignment considers building an energy efficient and cavitation resistant impeller along with other internals to ensure a minimum uninterrupted working life of five years.

Questions for discussions:

1. Finding the right replacement of impeller for old water supply pumps - should this be the task of a specialist pump company?
2. What are the steps in building an optimum impeller for an existing pumping installation?
3. How do we select materials for impellers subject to potential cavitation erosion?
4. Which materials should be considered to prevent excessive sleeve wear in raw water applications?

Rotating Element for Raw Water Pump – Technical Specifications

A. Introduction

Indira Gandhi Water Treatment Plant (IGWTP) at Manirampur, Barrackpore, has two raw water pumps supplied by Mather & Platt Ltd, Manchester, UK in the 1920s. The pump casings are in good working order and it is intended to replace rotating element of one of the existing pumps with an energy efficient new design. The new rotating element should ensure at least four years of uninterrupted working life.

B. Existing Pump

Following is the brief description of the existing pump unit:
Make: Mather & Platt, Manchester, UK
Type: Axially split case
Delivery / Suction Branch Sizes: 33"/36"
Casing Design: Single volute, bottom suction, side discharge.
Rated Capacity: 1.75 mgH – 7947 m^3/hr
Rated head: 54 ft - 16.5 m
Rotational Speed: 370 rpm
Driver: 485 KW (650 HP), 14 pole, 50 Hz, 6 KV slipping motor
Suction lift: 3.0 m (max), 1.0 m (average)

C. Scope of Work:

Offers are invited from pump manufacturers and pump service providers who can demonstrate successful experience in designing and manufacturing split case pump impellers for pump sizes of 400 mm discharge and above for the following scope of work:

1. Measurement of internal dimensions of the existing pump and rotating element at site in order to clearly establish the site constraints for optimizing the design of rotating element.
2. Design of impeller, shaft and other rotating components as per the list of components included in this document.
3. Preparation of final data sheet and of machining drawings for components of the rotating element. Submission of these documents to IGWTP for approval.
4. Manufacture of components based on approved drawings
5. Submission of all quality assurance documents as per the list included in this document.
6. Installation of the rotating element at site. Conducting trial run of the pump with the new rotating element in association with IGWTP engineers.
7. Demonstrating to IGWTP that performance guarantee has been met.

D. Components and Their Material Specifications

Sr. No	Component	Material Specifications
1	Impeller	Nickel Al. Bronze BS1400 AB2
2	Case Wear Rings	Bronze BS1400 LB2
3	Shaft	AISI – 410
4	Sleeves and sleeve nuts	Nickel Al. Bronze BS1400 AB2
5	Stuffing box bushes	Bronze BS1400 LB2
6	Glands	Bronze BS1400 LG2
7	Lantern ring	Bronze BS1400 LG2
8	Water deflector	Neoprene Rubber
9	Bush bearings	Bronze White Metal Lined
10	Gland packing	PTFE

Note: Bidders should note that the above list is indicative only and any additional components / consumables needed to successfully carry out the replacement of the existing rotating element will be in the scope of supply of the successful bidder.

E. Quality Assurance Documents

The following quality assurance documents are required to be submitted by the successful bidder:

Component	QA Documents
Impeller	Dynamic balancing report as per ISO 1940 G 6.3 Chemical test report, dimensional report
Shaft	Ultrasonic test report, chemical and physical test report, dimensional report
Wear Rings	Hardness, chemical test and dimensional reports
Shaft sleeves	Chemical test and hardness reports

F. Data Sheets

The attached preliminary data sheets should be completed by all bidders. The data sheet contains key information relating to dimensions of the component and their design features. Preliminary data sheet will be considered indicative only and will be used to evaluate bidders understanding of the design task and the design approach proposed by them. The successful bidder will submit a final data sheet for approval when all of the design elements have been finalised. Bidders should note that key hydraulic design data – rated capacity, head, efficiency and NPSHR shall not be changed and retained as per the preliminary data sheet.

G. Meeting Performance Guarantee

Fulfilment of performance guarantee will be ensured by taking suction and delivery pressure gauge readings and power consumption at the motor terminals for pre-defined number of flow conditions before and after the installation of new rotating element. The method of fulfilment of performance guarantee will be discussed in detail with the shortlisted vendors during pre-award discussions to arrive at mutually agreed procedure.

IGWTP – Replacement of Rotating Element of Raw Water

Pump Data Sheet

Guaranteed Performance	Bidder's Confirmation
Rated Capacity (M^3/Hr.)	**7947**
Rated Head (M)	**16.5**
Pump Speed (Rpm)	**370**
Driver Rating (kW)	**485**
Pump Efficiency (%)	
Pump NPSHr (M)	
Power Absorbed (kW)	
Margin Available over Driver Rating (%)	
Impeller Design Data	**Bidder's Confirmation**
Design Flow (M^3/Hr.)	
Design Head (M)	
Efficiency at Design Point (%)	
NPSHr at Design Point (M)	
Pump Specific Speed (US Units)	
Suction Specific Speed (US Units)	
Max. Impeller Diameter (mm)	
Rated Imepller Diameter (mm)	
Impeller Width at Outlet (mm)	
Eye Diameter (mm)	
Eye Area per Eye (cm^2)	
No of Vanes	
Impeller Vane Angle at Outlet (^{o})	
Impeller Neck Diameter (mm)	
Shut-off Head (M)	
Shut-off Power (kW)	
Maximum Power (kW)	
Shaft Design Data	**Bidder's Confirmation**
Shaft Diameter at Impeller (mm)	
Shaft Diameter under Sleeves (mm)	
Shaft Diameter under Bearings (mm)	
Shaft Diameter at Coupling (mm)	
Shaft Stress @ Maximum Power (kPa)	
Wear Ring Design Data	**Bidder's Confirmation**
Wear Ring ID (mm)	
Wear Ring OD (mm)	
Minimum Diametral Clearance (mm)	
Maximum Diametral Clearance (mm)	
Width of Wear Ring (mm)	

PUMPSENSE FLUID ENGINEERING PVT. LTD

To,
Indira Gandhi Water Treatment Plant (IGWTP)
Barrackpore, Kolkata - 700120
Q1144
20.07.10 **HS/IGWTP/1144**

Kind Attention : Mr. D.K. Mahajan (Executive Engineer)

SERVICE : REPLACEMENT OF ROTATING ELEMENTS OF 33"/36" LONOVANE

	PARAMETERS	UNIT	ITEM1
DUTY SPECIFIED	Rated Capacity	m^3/hr.	7947
	Rated Head	m	16.5
	Speed	rpm	370
	Type of Pump		Axially Split Case Single Stage
	Liquid		Raw Water
	Specific Gravity		1
	Temperature	°C	32
	Suction Lift	m	1 to 3 (As Per Tidal Condition)
	Driver		Electric Motor

DETAILS OF EXISTING PUMP	Make		Mather & Platt, Manchester, UK
	No of Pumps		1
	Stages		One
	Model No.		33"/36" Lonovane
	Discharge	mm	850
	Discharge Flange Rating		—
	Suction	mm	900
	Suction Flange Rating		—
	Type of Casing		Single Volute, Bottom Suction & Side Discharge
	Type of Impeller		Shrouded Double Entry

DETAILS OF NEW IMPELLER	Type of Impeller		Shrouded Double Entry
	Impeller Diameter Max.	mm	1135
	Impeller Diameter Rated	mm	1135
	Impeller Diameter Min.	mm	960
	Impeller Width	mm	185
	No. of Vanes		6

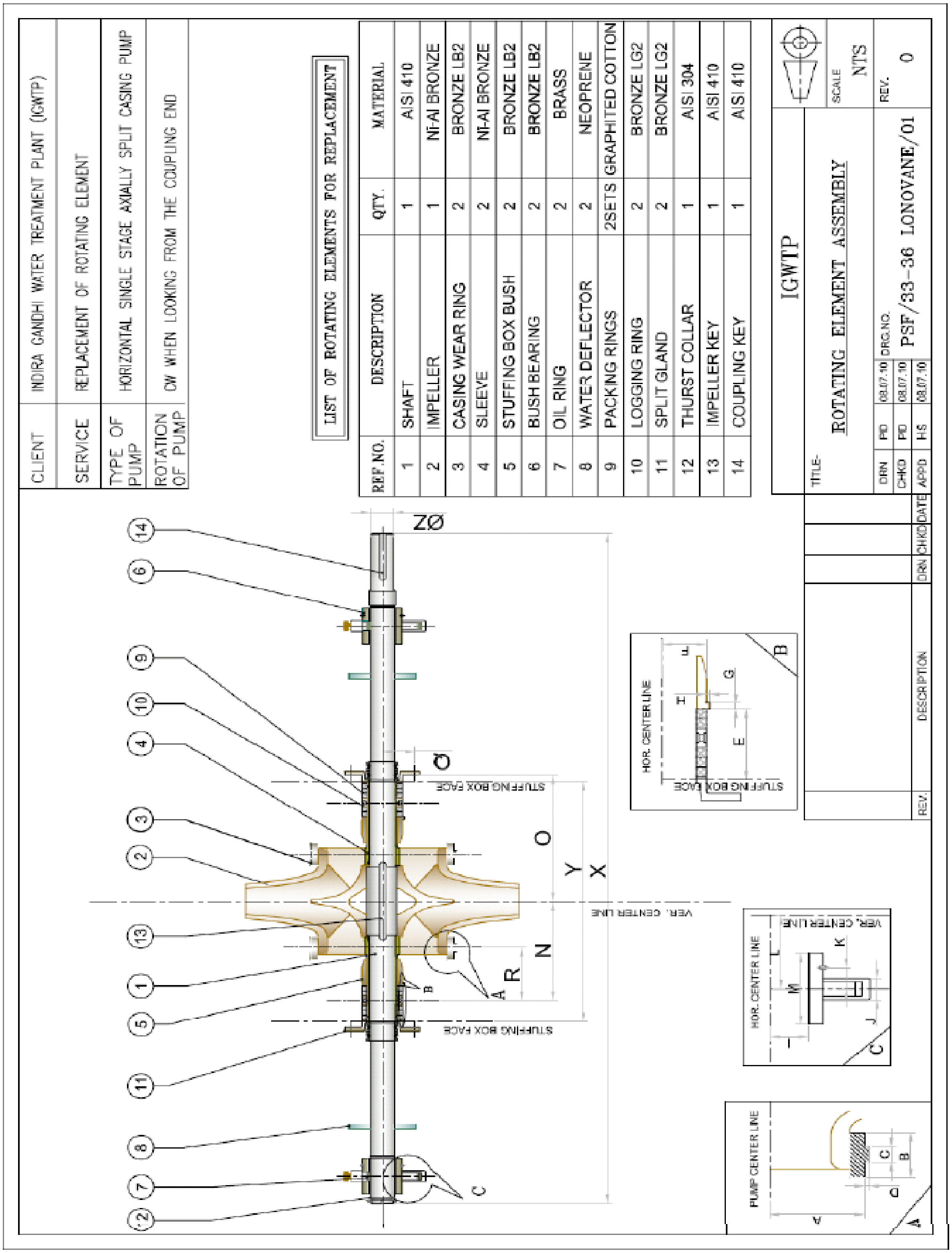
Note : Impeller Data Provided Based Only on Hydraulic Calculation, will be Checked Against Existing Casing for Conformance

PERFORMANCE DETAILS AT RATED CAPACITY WITH NEW IMPELLER	Efficiency	%	88
	Speed	rpm	370
	NPSHr	m	4
	Power absorbed	kW	406.0
	Driver Power	kW	485
	Power Supply Driver Details		16 Pole, 50 Hz, 6 KV Slipping Motor

MECHANICAL DATA	Shaft Span	mm	To be confirmed after survey
	Shaft Dia. at Coupling	mm	To be confirmed after survey
	N.D.E Bearings	mm	Thrust Bearing + Bush Bearing
	D.E Bearings	mm	Bush Bearing

	PARAMETERS	Qty	ITEM1
COMPONENTS FOR REPLACEMENT & MATERIAL OF CONSTRUCTION	Impeller	1	Nickel Al. Bronze BS1400 AB2
	Case Wear Rings	2	Bronze BS1400 LB2
	Shaft	1	AISI – 410
	Sleeves	2	Nickel Al. Bronze BS1400 AB2
	Sleeve Nuts	4	Nickel Al. Bronze BS1400 AB2
	Stuffing box bushes	2	Bronze BS1400 LB2
	Glands	2	Bronze BS1400 LG2
	Lantern ring	2	Bronze BS1400 LG2
	Water deflector	2	Neoprene Rubber – BS1400 LG2
	Bush Bearings with Oil Ring	2	Bronze White Metal Lined
	Packing Rings	2 Sets	Soft Graphited Cotton

Rotor Assembly



REF.NO.	DESCRIPTION	QTY.	MATERIAL
1	SHAFT	1	AISI 410
2	IMPELLER	1	Ni-Al BRONZE
3	CASING WEAR RING	2	BRONZE LB2
4	SLEEVE	2	Ni-Al BRONZE
5	STUFFING BOX BUSH	2	BRONZE LB2
6	BUSH BEARING	2	BRONZE LB2
7	OIL RING	2	BRASS
8	WATER DEFLECTOR	2	NEOPRENE
9	PACKING RINGS	2SETS	GRAPHITED COTTON
10	LOGGING RING	2	BRONZE LG2
11	SPLIT GLAND	2	BRONZE LG2
12	THURST COLLAR	1	AISI 304
13	IMPELLER KEY	1	AISI 410
14	COUPLING KEY	1	AISI 410

Notes on Material Specification

Materials of construction of the various components of the pump rotating element have been suggested based on the following:

a) Our observation of the old impeller, shaft and shaft sleeves
b) Liquid handled by the pump – raw river water
c) Variations of the water level in the suction pump

The guiding principle in the selection of materials has been to ensure an uninterrupted service life of four years for these rotating elements without any need for repairs or replacement.

The following general features were considered:

- Corrosion
- Erosion
- Level variation in the pump suction sump
- Cavitation resistance
- Strength
- Wear resistance
- Gelling properties and compatibility
- Ease of manufacture
- Cost

The reasons for selection of materials for individual components are as follows:

1. **Impeller – Nickel Al. Bronze (BS1400 AB2)**

   AB2 aluminum bronze has a very high strength, good wear and corrosion resistance and also has a high resistance to oxidation.

   All large pumps on suction lift tend to cavitate, the extent of cavitation erosion depends on the point of operation of the pump (for example, at part flow the damage gets accelerated) and also on the material chosen for the impeller. Nickel Al Bronze AB2 offers very high resistance to cavitation erosion and this will be seen from the relative cavitation erosion rating chart enclosed.

   Following is a comparison of chemical and physical properties of Ni-Al Bronze, Gunmetal (LG2 Bronze) and cast iron FG 260.

Chemical Composition & Mechanical Properties	Nickel Al Bronze – AB2	Gunmetal LG2	CI FG260
Copper	79%	85%	
Tin	0.10%	5%	
Zinc	0.50%	5%	
Lead	0.05%	5%	
Nickel	4.0-5.0%	5%	
Aluminium	8.5-9.5%	5%	
Manganese	0.8-1.5%	5%	
Iron	3.5-4.5%	5%	
Tensile strength	595-655 MPa	270-340 MPa	260 MPa
% Elongation	18-25%	13-25%	
Hardness HB	150-170	75-90	
0.2% Proof-stress	240-260 MPa		

The following are, therefore, the major reasons for suggesting Nickel Al Bronze as impeller material:

- High resistance to cavitation erosion
- High corrosion and abrasion wear resistance
- Relatively easy to cast and machine
- Yields smooth surface and hence ensures good efficiency
- Does not rust

2. <u>Case Wear Rings and Stuffing Box Bushes – Leaded Bearing Bronze BS1400 LB2</u>

These components have a very close clearance with impeller and shaft sleeves respectively – only a few thousandths of an inch. The liquid between the two components is raw water. The lubricating properties of the liquid are poor and contribute little to the avoidance of seizure or galling. To the greatest possible extent, therefore, the materials chosen for these areas should be mutually compatible. This means that they should be capable of rubbing together at high peripheral speed without welding or breaking up. In addition to possessing this mutual compatibility under rubbing conditions, the material chosen must also be able to withstand the erosive/corrosive environment of the fluid.

In leaded tin bronze LB2, the lead content renders the metal almost immune to seizure as it acts as a lubricant under severe condition of rubbing, while the hard tin rich constituent provides a good wearing surface under normal wearing conditions.

In summary, therefore, LB2 has been chosen as a wear ring and stuffing box bush material on following considerations:

a) Galling characteristics (compatibility with AB2)
b) Corrosion resistance
c) Abrasive wear resistance
d) Easily cast and machined

Properties of BS1400LB2

Chemical Composition	
Copper	Remainder
Tin	9.2-11%
Lead	9-10.5%
Zinc	1.0%
Nickel	2.0%
Mechanical Properties	
Tensile strength	190-270 MPa
Elongation (%)	5-15%
0.2% Proof stress	80-130 MPa
Hardness (HB)	65-85

3. **Shaft Sleeves and Sleeve Nuts – Nickel Al Bronze BS1400 AB2**

Shaft sleeves are used to protect the pump shaft from abrasion and wear particularly under gland packing at the pump stuffing boxes. Our observations of some of the pumps at IGWTP suggest severe scoring of shaft-sleeves at the stuffing boxes.

We have recommended AB2 as sleeve material for the following reasons:

a) High mechanical strength, as already explained under impeller material
b) High hardness to resist abrasion wear at the packing
c) AB2 can be ground finished with high precision and this will keep mechanical losses due to friction at the pump stuffing boxes low

4. **Pump Shaft – AISI 410**
5. The criteria for selection of shaft material are:

a) Permissible shear stress at the coupling end of the shaft
b) Endurance limit
c) Corrosion resistance
d) Notch sensitivity

AISI 410 is a martensitic grade stainless steel and offers excellent performance on the above criteria.

Cavitation Resistance of Materials

General Ranking of Cavitation Erosion resistance of Common Cast Metals When Pumping Clear Water at Ambient Temparature