Centrifugal Pump Efficiency Improvement

Alternate Methods and Design Methodology

Abhay Keny

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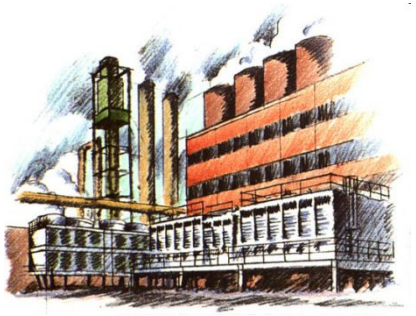
Introduction

Wide Usage

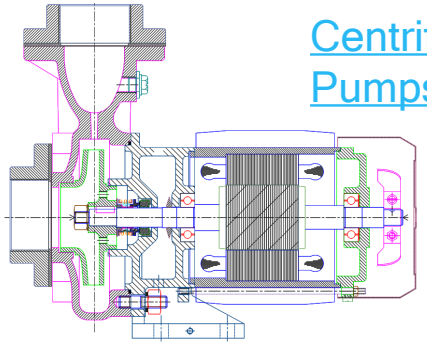
Industrial



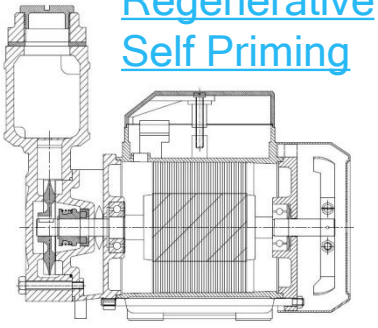
Agricultural

Domestic

Varied Designs



Centrifugal Pumpsets



Regenerative Self Priming

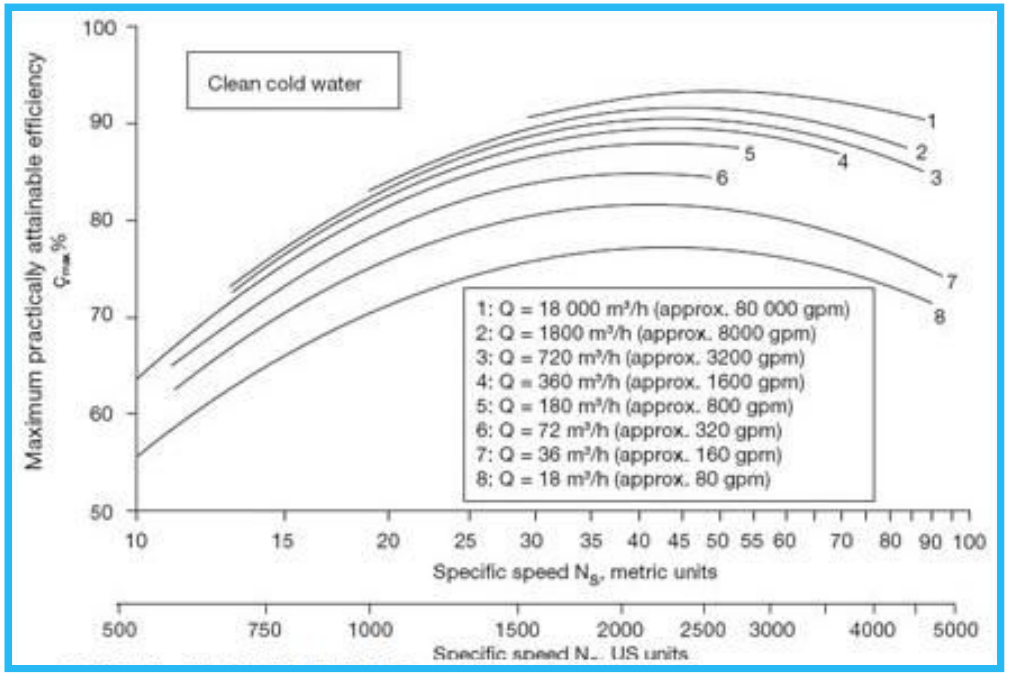
Multistage Monoset

Submersible

Growing Usage demands Optimal Designs with Efficient Operation

Pump Efficiency

Efficiency with Specific Speed



$$N_s = \frac{n\sqrt{Q}}{(gH)^{3/4}}$$

- N_s : Specific speed (unit less)
- n : Pump rotational speed (rpm)
- Q : Flowrate (m^3/s)
- H : total head per stage (m)
- g : acceleration due to gravity (m/s^2)

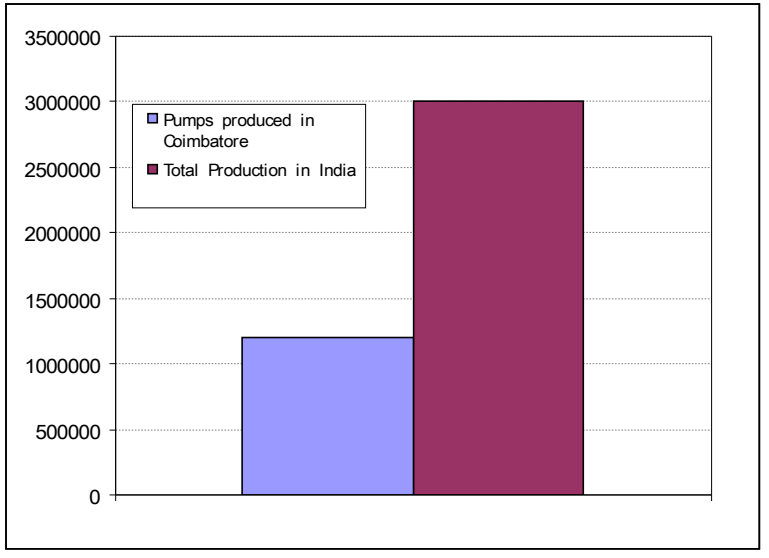
Specific Speed provides Efficiency Entitlement

Regenerative Pumps

Characteristics

- Specific Speed = 5-7
- Flow Rates 2.5
- Pump Efficiency ~ 25-35%
- Overall Efficiency ~ 15-22%

Production in India



- The amount of Energy required to energies and run these pumps is ~50000 MWH per annum assuming they run for just 300days in a year with 1 hour of operation.
- Clearances are observed to almost double after a working of 500 hours making causing inefficient operation

Case Study

Location: Goa

Objective: Study performance deterioration with Time

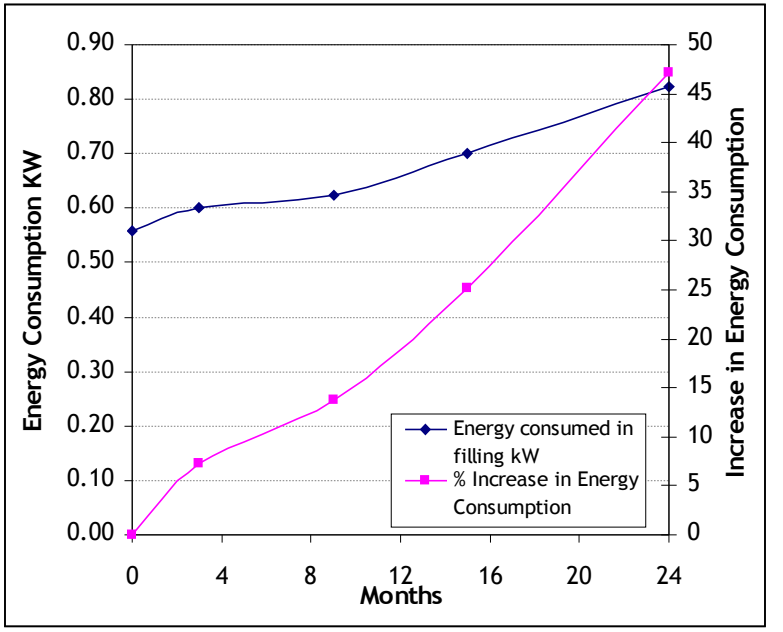
Time : 2 Years

Pump Type : 0.5Hp Self Priming Regenerative

Application : Pumping well water to overhead tank

Field Data

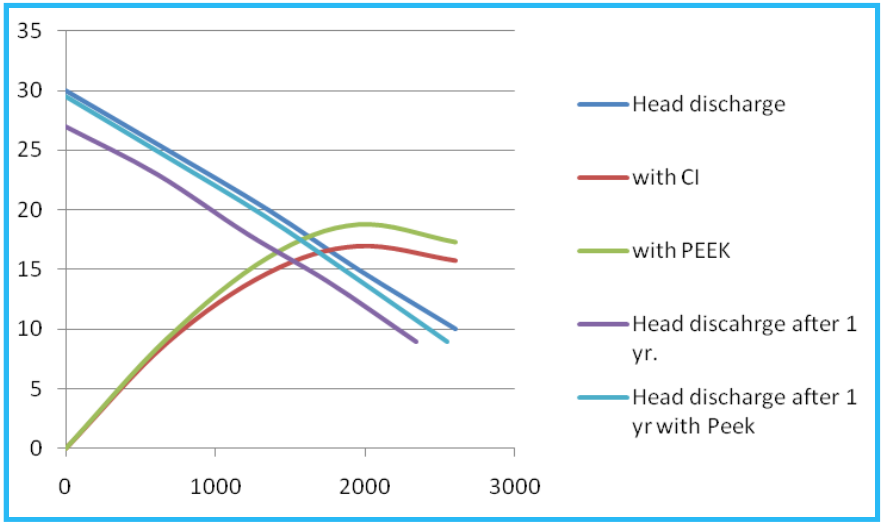
Date	Static suction Head (m)	Static Delivery Head (m)	Time for 2000 liters hrs	Power Input watts	Energy consumed in filling kW	Yearly consumption kWh	% Increase
15-06-2006	4	10	1.2	470	0.56	168	0.0
15-09-2006	3.5	10	1.3	450	0.60	180	7.2
15-03-2007	5.2	10	1.4	430	0.62	187	4.1
15-10-2007	3.7	10	1.7	420	0.70	210	13.7
15-06-2008	3.8	10	2.0	420	0.82	247	22.1



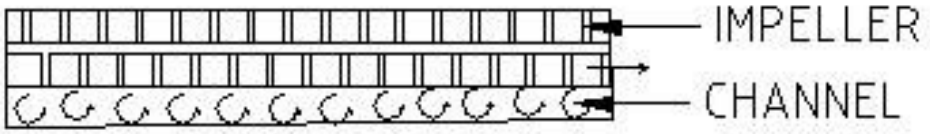
Increased clearances due to corrosion of cast iron components identified for performance degradation

Materials for Efficient Pumps

Improvement in Efficiency with PEEK



Tapered Channel Design



- Use of PEEK (Poly-Ether-Ether- Ketone) with carbon fibers
  - Provides excellent wear and corrosion resistance
  - Flexibility and Ease of Channel Design for improving suction Lift

Efficiency Improvement by 1.5 by use of Thermoplastics

Multistage Centrifugal Pumps

Characteristics

- Specific Speed > 15
- Efficiency ~ 45%
- High Head and Low Discharge

Comparison with Other Pump Types

Rated Power	Model	No of stages	Head m	Q lpm	P1 W	Effy %	Weight
0.5	Centrifugal	2	20	37	570	25.2	10.9
0.5	Regenerative	1	20	27	470	18.8	8.5
1	Centrifugal	4	24	80	960	34.7	14
1	Regenerative	2	24	65	980	22	11

High Manufacturing Cost Limits Multistage Centrifugal Pump Production in India

Trends in Multi stage Pumps Design

Use of Engineering Plastics

- PPO Poly phenolic oxide (Noryl)
- Delrin … better wear resistance and lower frictional resistance.
- Engineering Plastics…good efficiencies.

Stainless Steel for Multistage Pumps

- Easy to fabricate
- Consistency in dimensions
- No machining
- Consistent performance due to control of dimensions.

- High Development Cost

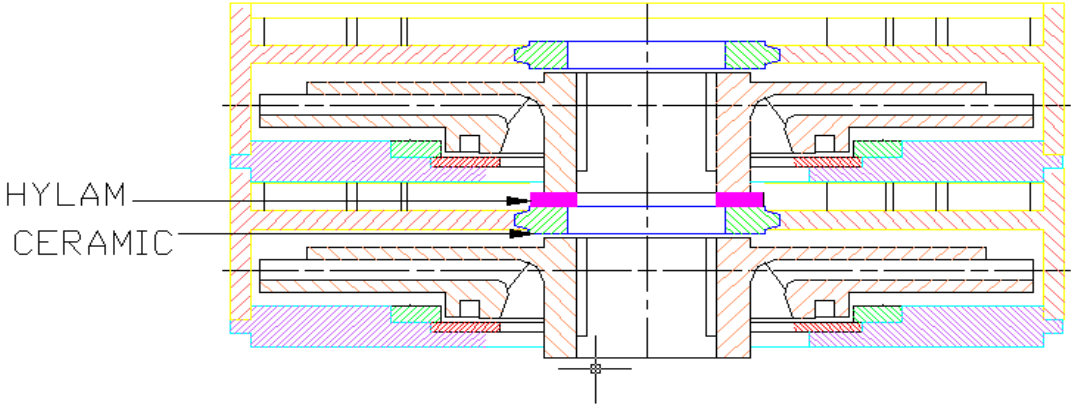
Use of Engineering Plastics

- Self Priming design with recirculation of flow in initial stage of priming with auto closing of recirculation of flow when pump develops pressure

Trends in Multi stage Pumps Design

Uuse of ceramics

- Reduces leakage
- Increases Efficiency
- Improves thrust Bearing Life



A Typical Impeller and Diffusor Assembly

Fig 14

Case Study

Objective: Study performance with Time

Time : 2 Years

Pump Type : Stainless Steel Multistage Pump

Field Data

Date	Static suction Head (m)	Static Delivery Head (m)	Time for 2000 liters hrs	Power Input watts	Energy consumed in filling	Yearly consumption	% Increase
20-06-2006	4	10	0.901	470	0.423	127.0	0.0
16-09-2006	3.5	10	0.855	450	0.385	115.4	-6.9
15-03-2007	5.2	10	0.855	430	0.368	110.3	-3.1
16-10-2007	3.7	10	0.913	420	0.384	115.1	2.9
16-06-2008	3.8	10	0.889	420	0.373	112.0	-1.8

Impressive Performance of Multistage Centrifugal Pump was Observed

Impeller Neck Rings

Functions and Advantages

- Help control Impeller neck clearance
- Reduction in recirculation losses

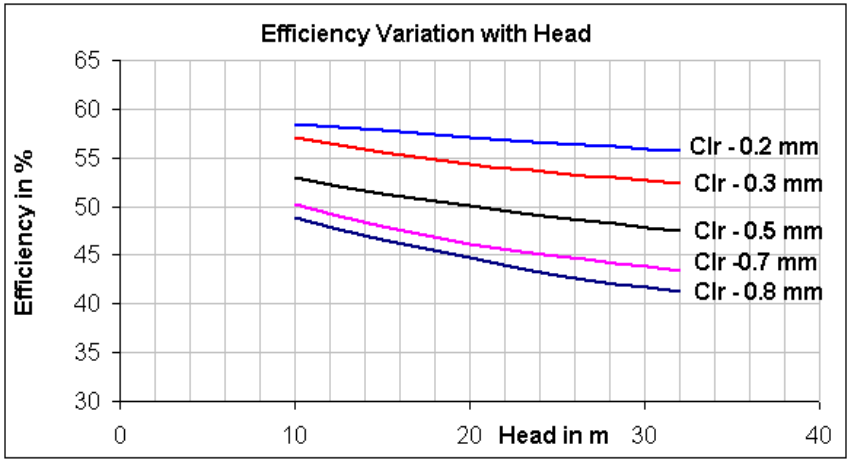
Issues

- Economics of production in sub 20Hp pumps
- Lower clearances causing jamming due to material thermal expansion mismatch

Possible Solutions

- Use of Polymer wear rings
  - Reduction in Noise and NPSH requirements
  - Low Friction and dimensional Stability
  - Eg. Noryl, Delrin, Vespel , Zytel etc..

Effect of Clearances on Efficiency



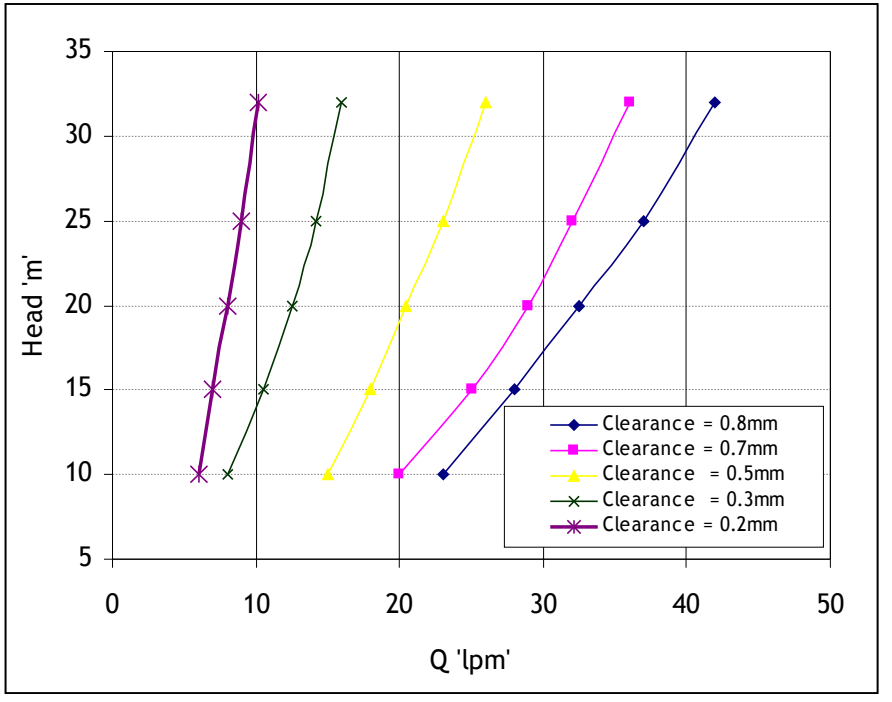
Duty Point at 80lpm

Maintaining close Clearances Important for Efficient Operation

Effect of Clean ace on Leakage

Effect of Clearances on Leakage Past Wear Ring

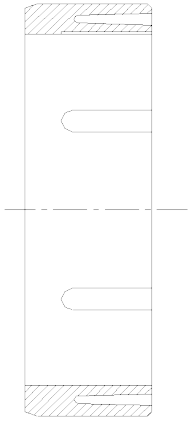
Head (m)		DIAMETRICAL CLEARANCES IN MM				
		0.8	0.7	0.5	0.3	0.2
32	Leakage past (lpm)	42	36	26	16	10.2
25		37	32	23	14.2	9
20		32.5	29	20.5	12.5	8
15		28	25	18	10.5	7
10		23	20	15	8	6



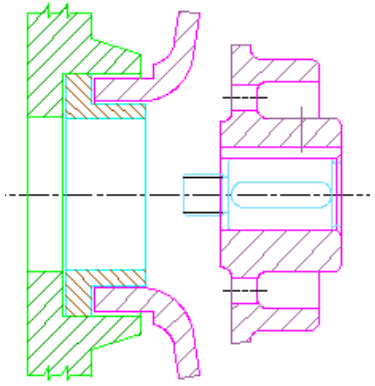
leakage path length of 12 mm and for a neck diameter of impeller of 30 mm

Increased Clearances Greatly Increase Leakage at High Head

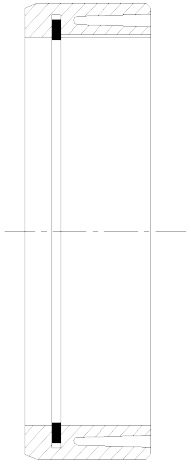
Wearing Ring Design



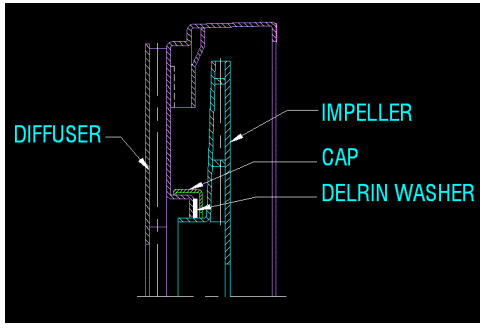
•Design with annular space making the lip of the ring to contract as delivery head increases there by decreasing the neck ring clearance and thus reducing the leakage.
•Grooves in axial direction can be cut on the ring to form sectors and allowing for boundary layer lubrication and damping effect to occur.



•Molded ring used in the eye of impeller.
•Provides double path and low leakage but is unsuitable for pumps handling turbid water due to sediments settling in the neck causing the pump jam



•Design with elastomeric ring with low abrasive properties included in the groove.
•Helps reduce leakage to nearly zero but cannot be used with Impellers molded with Engineering Plastic as it forms a groove on the neck ring.
•Good for multi staged impeller like submersible pump using either stainless steel or brass impeller.



•flat ring held still by canopy as retainer.
• helpful where axial length are constraints., such as multistage pumps.
•Can reduce neck length to 2.5-3 mm
•Controls leakages past rings to nearly 1-2 % of full flow

Conclusion

- Use of corrosion resistant material to prevent corrosion
- Use of material with high life for the pump
- Efficient design aiming lower clearances and leakages

Efficient Pump Operations will help towards a green future

Questions???

THANK YOU