

Mechanical vacuum pump system for steel degassing

Vacuum Degassing (VD) and Vacuum Oxygen Decarburisation (VOD) are often used in the production of speciality steel alloys. They are used to reduce the levels of hydrogen, carbon and other impurities during the secondary steel making process.

Historically large multi-stage steam ejector systems, backed with liquid ring pumps, have been used. However, these are energy inefficient, rely on high steam quality for consistent performance, and cause foreline dust deposits that develop into “cakes” making cleaning difficult.

Steel degassing in tanks or in the ladle involves two basic processes: Vacuum Degassing (VD) and Vacuum Oxygen Decarburising (VOD). For these processes two types of vacuum pump system have been operated over the past 25 years.



1. The steam ejector system uses multi-stage high pressure steam ejectors usually supported by water sealed Liquid Ring pumps.
2. The alternative mechanical system uses multi-stage mechanical boosters supported by completely dry primary vacuum pumps.

The completely dry pump system has proven to be the most effective. The cost saving is significant, as shown over the page. There are also metallurgical benefits from the elimination of back-streaming of water vapour. Combined with the better ultimate vacuum, this leads to reduced residual hydrogen in the metal. Faster evacuation and more flexible operational characteristics allow for closer chemistry control. This leads to more consistent formulation and opportunities for new steel qualities.

All maintenance costs are reduced, including cost for cleaning the pumps and pipework. The waste disposal costs for the dry dust are also reduced, or the dust can be recycled reducing costs further and limiting the impact on the environment.

Why mechanical pumps?

- Cost saving
 - Energy costs reduced by over 90%
- Reduced maintenance
 - Elimination of fore line deposits
- Reduced effluent costs
 - Easier disposal or recycling of dry waste
- Reduced cycle times
 - Vacuum on demand
- Consistent processing
 - Reliable and dependable vacuum level
- Better steel quality
 - Lower hydrogen levels achieved in VD
- Improved stainless quality
 - Better VOD control
- New steel qualities
 - Easier control of chemistry

Operating cost comparison:

Dry mechanical vacuum pumps vs. steam ejectors

Melt mass (tonnes) = 60

Boiler size (kg/h) = 10000

Production tonnage = 300.000

Process = VD

Cycle time in vacuum (mins) = 25

Cost criterion	Condition	Specific cost	Steam ejectors	Dry running pumps including filter operating costs
Consumption				
- steam	12 bar, 194°C	20,00 €/t	69,4 kg/t	1,3888889 €/t
- contact water	3 bar, 32°C	0,04 €/m ³	4,5 m ³ /t	0,1805556 €/t
- non-contact water	4 bar, 32°C	0,03 €/m ³		0,0875000 m ³ /t 0,0026250 €/t
- compressed air	5 bar	0,02 €/m ³		0,0002500 m ³ /t 0,0000050 €/t
- nitrogen	5 bar	0,10 €/m ³		0,0550000 m ³ /t 0,0055000 €/t
- gear box oil		3,00 €/liter		0,0004400 liter/t 0,0013200 €/t
- power (pumps+auxiliaries)		0,05 €/kWh	0,69 kWh/t	0,0347222 €/t 0,3750000 kWh/t 0,0187500 €/t
Subtotal consumption				1,6041667 €/t 0,0282000 €/t
Maintenance				
	€ per hour	man hours		
- pump service	35,00	4	140,00 €/pump	5000 tappings 0,0014000 €/t 5000 tappings 0,0042000 €/t
- pump cleaning	35,00	40	1400,00 €/job	200 tappings 0,1166667 €/t
- heat exchanger cleaning	35,00	12	420,00 €/job	5000 tappings 0,0000003 €/t
- filter bag changing	35,00	8	280,00 €/job	2083 hours 0,0000011 €/t
- dust disposal			0,00 €/t	0,00 kg/t 0,0000000 €/t 0,20 kg/t 0,0000000 €/t
- contact water disposal			1,00 €/m ³	0,45 m ³ /t 0,4513889 €/t
Subtotal maintenance				0,5694556 €/t 0,0042014 €/t
Spares				
	€ each	number		
- filter bags	15,00	216	3240,00 €/change	0,0000033 sets/ton 0,0000000 €/t
- seals and bearings	2000,00	per installed pump		3 pumps 0,0100000 €/t 9 pumps 0,0300000 €/t
Subtotal spares				0,0100000 €/t 0,0300000 €/t
TOTAL				2,1836222 €/t 0,0624014 €/t
Difference				0,0000000 €/t 2,1212209 €/t
Annual saving				Saving 636 k€

Operating costs	Steam ejectors	Dry running pumps including filter
	€/ton	€/ton
Energy and fluids	1,6041667	0,0282000
Maintenance	0,5694556	0,0042014
Spares	0,0100000	0,0300000
TOTAL	2,1836222	0,0624014
Saving	0%	97%

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