SELECTING THE BEST SLURRY PUMP FOR SPECIFIC OPERATING CONDITIONS

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Slurry pumps are extensively applied in various industrial applications. Thus, the main task to improve them is to increase their efficiency and operational life. HMS Group as one of the major pump manufacturers in Russia and CIS region pays a special attention to those issues. Historically Bobruisk Machine Building Plant (BMBP) has specialized in slurry pumps at HMS Group. They started their manufacturing in the 50s of the last century. However, in 70s it became clear that a new range of pumps is required ad in the 80s such pumps were developed by VNIIHydromash. Pump labeling that had been adopted included only capacity and head values whereas liquid features such as slurry features, grain size distribution, microhardness were not taken into account. Nowadays that way of labeling often leads to the wrong pump selection for specific operating condition and shortens its operational life.

The task of optimal pump selection (particularly for handling liquids) with solids is relevant and requires special attention of both manufacturers and customers. The following steps should be taken to select the best (optimal) slurry pump:

- Hydraulic features evaluation of slurry pipelines;
- Actual slurry features determination (density, solids content by volume, viscosity, etc);
- Solids parameters determination, such as grain size distribution, water saturation ratio, class of abrasiveness, density in a natural state and in bulk, Shore hardness for minerals, etc.
- LCC calculation.

At present unfortunately there is no generally accepted calculation methodology for hydro transportation that is known to us. Although, there

is a number of empirically calculated methods that have been developed over the years in the mining industry. Engineering companies apply various techniques in facilities engineering for mining and other industries that can often lead to large deviations in final hydro transportation features. This in turn often causes different pump selection for each specific application and as a result would lead to pump operation in various modes and with different rates of reliability. In order to achieve desired efficiency and the lowest power consumption of hydro transporting pump operation modes should match the slurry parameters throughout the whole range of projected solids content and head losses in the pipeline. In case of a significant increase in volume concentration pump capacity and head can dramatically drop down whereas power consumption as well as bearings and motor temperatures would sharply increase and that would finally lead to the emergency pump shutdown (Fig. 1) [ANSI, Inc., 2011].

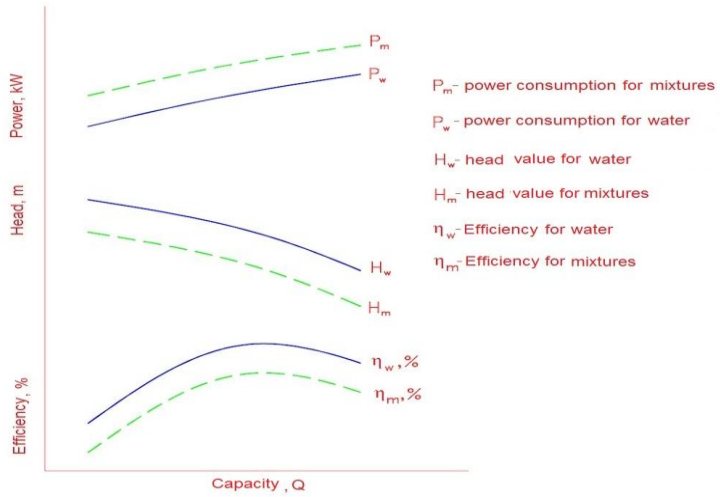

Fig. 1 Characteristic curves of slurry pump for pumping water and slurries

Therefore, all possible variations of volume concentration in the operated or projected hydro transport must be taken into account to select the best pump capable for providing stable operation in the specified range

of the volume concentration (Fig. 2) [European Association of Pump Manufacturers, 2001].

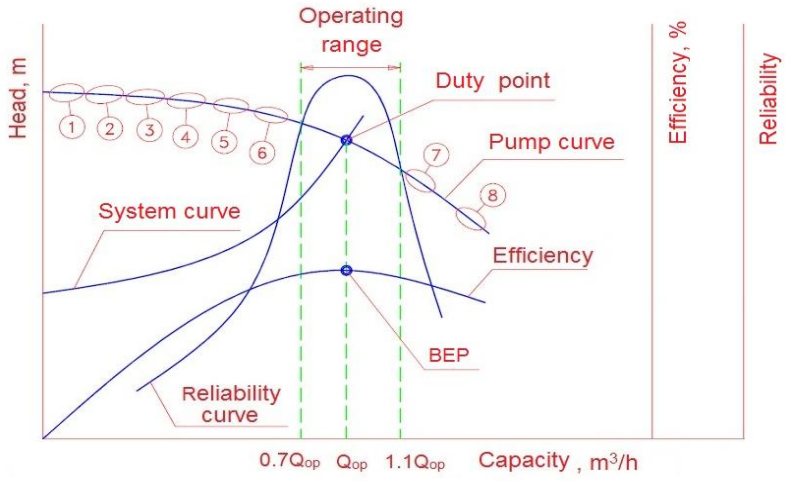

Fig. 2 Reliability curve of the centrifugal pump in all operating region

Figure 2 shows the superposition of reliability curve and pump feature that operates in a certain system. 1-8 zones on the pump feature are related to the typical problems that occur when pump operates in a certain zone: Zone 1 => bearing temperature increase; Zone 2 => low cavitation; Zone 3 and 7 => shorter operational life of bearings and seals; Zone 5 => recirculation at the input; Zone 6 => recirculation at the output; Zone 8 => cavitation. After having analyzed the available data on the application of slurry pumps for hydro transport system in Russia it has been acknowledged that more than half of them operate in zones 4, 5, 6, 7 and 8, which significantly reduces their operational life, especially in case of handling abrasive slurries.

In centrifugal pumps recirculation occurs in various parts: in impeller (Fig. 3) or volute. In a well-designed pump recirculation appears only in the underload mode when pump operates out of the operating regime [European Association of Pump Manufacturers, 2001]. Recirculation has a

strong impact on the pump performance (main parameters, pressure fluctuations in pump and system, vibrations and noise level).

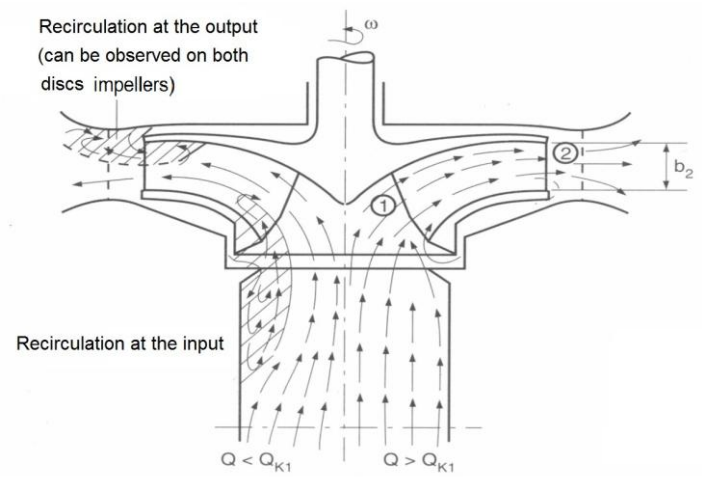

Fig. 3 The flow structure in the meridional section of radial flow impeller:
- in operation regime (right-hand of figure);
- out of the operating regime (under load mode) (left-hand of figure)

Recirculation that occurs in impeller and volute may lead to substantial abrasive wear (Fig. 4).

Fig. 4 Abrasive wear of impellers in slurry pumps

Current methods of selecting and controlling slurry pumps are mainly employed to provide the required capacity at which the maximum pump efficiency is achieved. Herewith the solids content variation and their specifics are not taken into consideration. In this case slurry pump in the hydro transport system operates with variable capacity and head, which are primarily affected by the grain size distribution and water saturation of handled slurries. In order to provide the nominal pump parameters it is necessary to develop methods of selection and control of slurry pumps taking into account process specifics and solids features. Besides that, in determination of pump mode operation design features and material specification must be taken into account based on the slurry properties. Selecting the optimal slurry pump will provide the required slurry flow rate in the hydro system that will be higher than sedimentation rate and will not allow static bed formation at the pipeline bottom from solids that fall out from the stream. And at the same time, the slurry flow rate should not be too high that can lead to a reduced operational life of the hydro system.

R&D department of HMS Group began developing software for calculations of hydro transport features based on the specified conditions. This software is assumed to be applied extensively for various types and classes of slurries and would provide the optimal pump selection with design features and material specification most suitable for specific operating conditions and predict the approximate operational life. Methods and techniques of the following leading hydraulic transport engineering centers have been analyzed during the software development by the leading institutes, such as:

- National Mineral Resources University, St Petersburg, Russia;
- Mekhanobr Engineering, St Petersburg, Russia;
- ANSI/HI 12.1-12.6-2011 standard for Rotodynamic (Centrifugal) Slurry Pumps;
- ASTM G75-01 Standard Test Method for Determination of Slurry Abrasivity (Miller Number) and Slurry Abrasion Response of Materials (SAR Number)

Another focus of our work is the modernization slurry pumps of BMBP. One of the results of this work is the modernization the impellers. The first upgraded pump impeller was for pump GrAT 1800/67. After the available materials had been analyzed, it was agreed to change geometry and amount of outer vanes on shroud and hub discs.

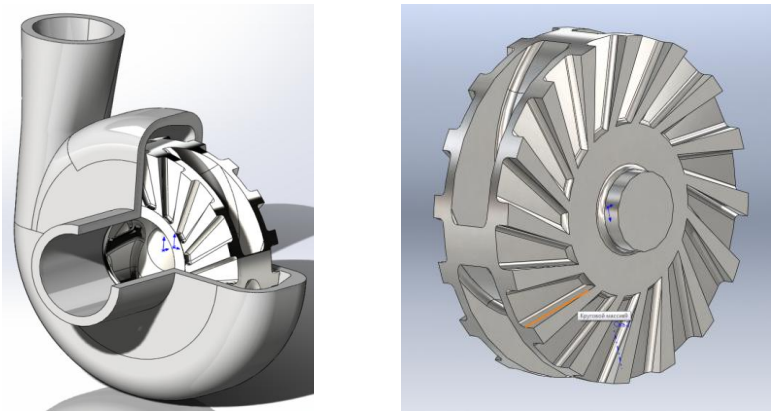

Fig. 5 Standard impeller of GrAT 1800/67 pump

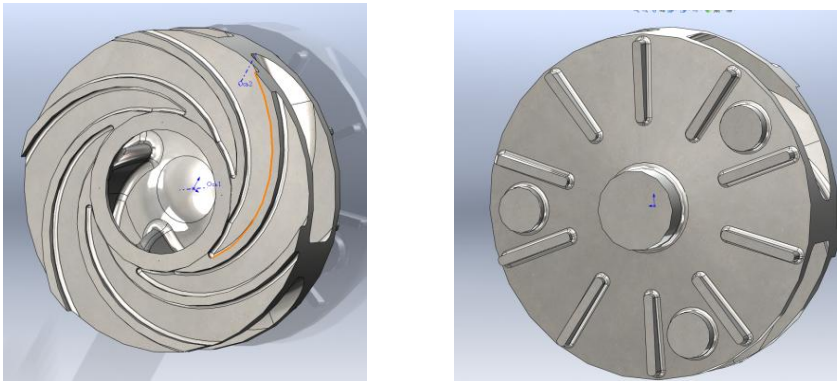

Fig. 6 Upgraded impeller of GrAT 1800/67 pump

The outcome:

1. Upgraded impeller is easier to manufacture and has places for balancing. Weight was reduced by 72 kg.
2. Pump efficiency increased by 2,5% due to the optimal amount of outer vanes on shroud and hub discs.
3. Axial load on rotor in the preferred operating region remained unchanged.
4. Estimated wear in pump regarding the preferred operating region was reduced less by 20-30% (fig. 7, 8).

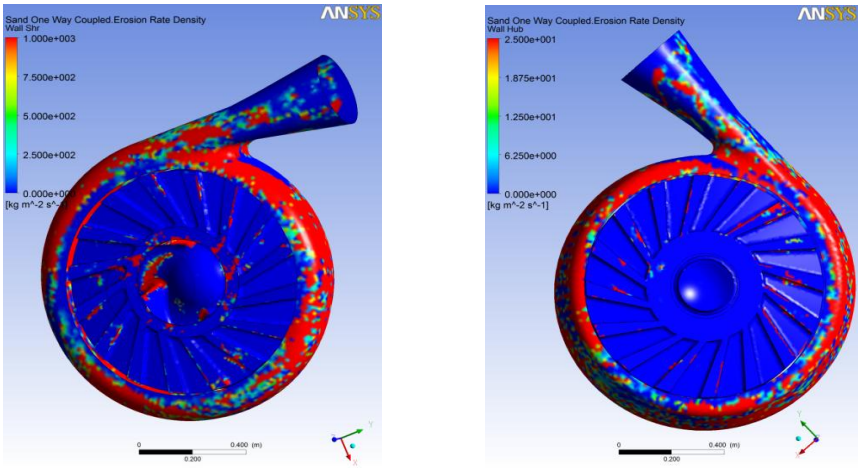

Fig. 7 Flow part simulation of GrAT 1800/67 pump with a standard impeller in ANSYS CFX

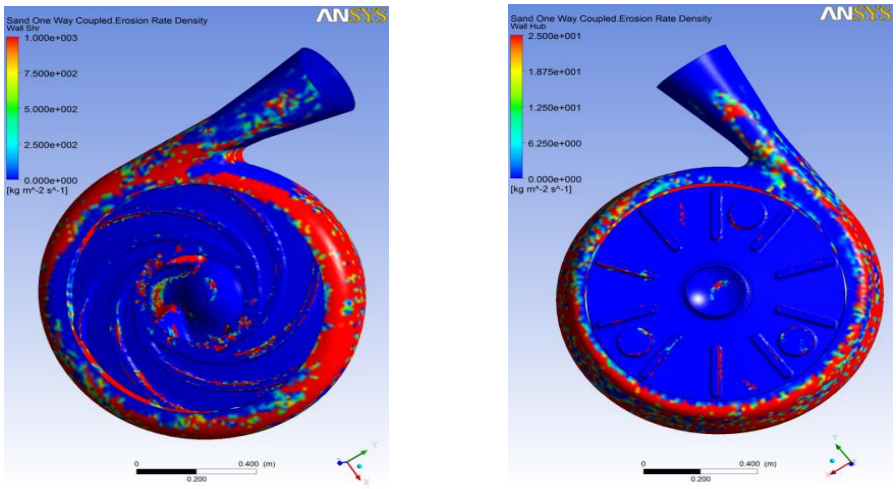

Fig. 8 Part simulation of GrAT 1800/67 pump with upgraded impeller in ANSYS CFX

At the moment GrAT 1800/67 pump with upgraded impeller is undergoing a full-scale testing. After the completion upgraded impellers will be installed in the operating pumps at one of the copper mines for trial operation for getting the feedback on operation and operational life.

It also is worth noting that the modernization program of production facilities has been launched at BMBP with the main purpose to improve quality of manufactured pumps. Along with design optimization of slurry pumps we also continue developing the slurry pump selection program for specific conditions and carry out the following:

✓ Analyzing the current methods and techniques of slurry transportation engineering and operating conditions of major mining companies with data gathering for our database;

✓ Upgrading the current slurry pump range of BMBP to bring their quality level to international standards.

CONCLUSION

1. Extensive practice of slurry pump operation has showed that their operational life and performance are progressively depending on:

- ✓ The mode of operation
- ✓ Slurry features
- ✓ Material specification

2. Development and implementation of equipment selection methods and programs for specific operating conditions, as well as ongoing training of maintenance personnel should play a leading role among actions and activities of heavy-duty equipment manufacturer, i.e. – for slurry handling.

3. It should be noted that there are no generally accepted methods and programs for slurry pump selection for specific operating conditions and criteria evaluation for their engineering. ANSI/HI 12.1-12.6-2011 suggestions and recommendations are fairly general for slurry pump selection but do not contain the criteria for flow part designing.

4. Due to the large number of various operating and design features slurry pump selection program should have sufficient database on the operating conditions, modes of operation according to extraction, processing and enrichment processes; as well as all pump parameters and reliability indexes for selecting the appropriate pump for the specific operating conditions.

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