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BASE FRAME OPTIMIZATION OF MULTISTAGE PUMP AND SHAFT DEFLECTION ANALYSIS AS PER API STANDARDS

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ABSTRACT

Base Frame are the traditional and most common means for reducing weight of pump. Over past many years, changes had to be made to pumps and parts of pumps to improve performance. Base Frame, Shaft, bearing are the key components of any single stage or multistage pump. Therefore to obtain better performance of multistage pump, different theoretical cases have been studied by changing length of I-section, by changing size of supporting channel etc. Then these cases have been analyzed for the stresses coming on the components of base frame, shaft etc. of pump by using design formulae / data book and CAD /CAE software's like HYPERWORKS /ANSYS .The vibrations can be controlled and also life of pump can be increased by base frame optimization and shaft deflection analysis.

KEYWORDS: Base Frame, Centrifugal Pump, I-channel, Shaft deflection, API Standards.

INTRODUCTION

Pumps are widely used in various industries like petrochemical, textile, natural gas, chemical based on application. So, it is very much essential for the manufacturers to produce parts of pump assembly having highest possible reliability. Over past many years, changes had to be made to pumps and pump assembly to improve performance. In these industries, base Frame are the traditional and most common means for reducing weight of pump assembly. Hence, optimization of base frame of pump has become the area of interest. However, for petrochemical industry compliance of API 610 standard is mandatory.

When pump is running, the unbalanced forces are induced at inlet and exhaust of the pump. It will results in increasing vibrations and reducing life of pump, shaft, bearing etc. Thus above problem can be solved by optimization of base frame and shaft deflection analysis as per API standards. So, the size and weight reduction can be done with respect to the unbalanced forces induced.

OPTIMIZATION

Optimization is finding an alternative with highest achievable performance or the most cost effective under the given constraints, by maximizing desired factors and minimizing undesired ones. In comparison, maximization means trying to attain the highest or maximum result or outcome without regard to cost or expense. The term optimal structure is very vague.

In this dissertation work, going to do optimization of existing base frame i.e. weight reduction is done. The Factor of safety of existing base frame is very high and cost is as high.

If we calculate the factor of safety (FOS) for existing base frame becomes,

$$\text{FOS} = \frac{\text{Yield limit}}{Max.\ Stress} = \frac{230}{30}$$
$$= 7.6$$

Hence, the FOS of existing base frame is 7.6 which is too high as compared to the base frames available in the market now days.In 1960, while preparing this base frame they are not used FEA technique for designing hence now we optimize this base frame so as to get FOS as per the market value.Typical FOS used in product design is between 2 to 2.5 for common applications.

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After modification in base frame we get this FOS near about market value and also cost of modified base frame becomes decreases by reducing the weight of base frame.

DESIGN PARAMETERS OF EXISTING BASE FRAME

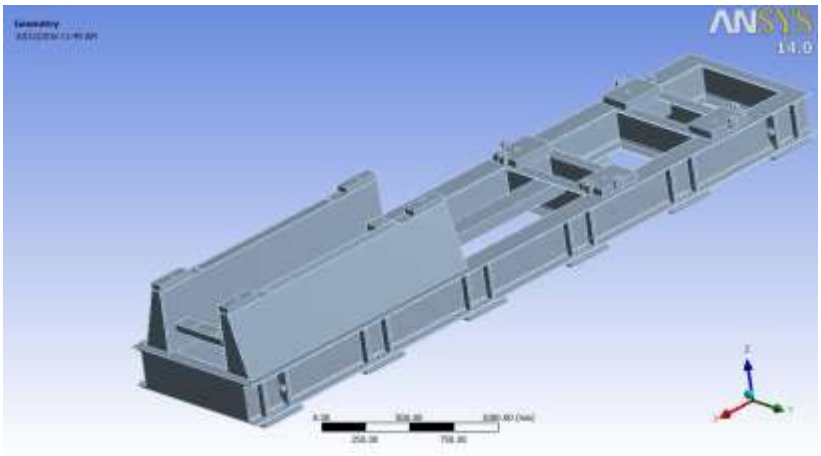
Parts of Base Frame

1. Channels ISMC – These C-section beams are used for in various parts. Channels mainly used to build the frame structure of base frame. 4 C-section Channels provide the main base structure of frame and gives it required stability. Two C-section channels are welded together to form an I-section. This structure is joined by means of welding small sized C-section channels at certain length. Those forms bulk heads in the main structure.
2. Steel sheets – Sheets are used to form resting section where pump is mounted. Sheets are joined together by means of welding. A hollow section is built up to mount pump on it. The hollow structure has been filled with grout. Grouting provides necessary strength and rigidity to it.
3. Pump plate – Pump is mounted on pump plates and bolted to channels to maintain its alignment. Four legs of pump are bolted to pump plate by means of standard but and bolts. Pump mass acts equally on all four pump plates.
4. Motor plate – Motor is mounted on motor plate and bolted to channels to maintain its alignment. Four legs of motor are bolted to motor plates. Motor mass acts equally on all four motor plates.
5. Bottom plate – It is the form of shimming. It is at the bottom of the base frame and is bolted to the floor. According to design criteria's, bottom plates are places at a point where forces and vibrations are transferred from frame to shop floor. As bottom plates are bolted to the base, it gives firmness to the base frame.
6. Jacking plates – Jacking plates are provided at all corners of base frame. These are specially used in lifting of base frame i.e. shifting of base frame from one place to another. While lifting the base frame all jacking plates must be used, this precaution must be followed to avoid twisting of base frame.
7. Strengthening ribs – Two different types of strengthening ribs are provided. The main function of these ribs is to provide support at the outer flange of the main C-sections of base frame. Strengthening ribs helps to improve the strength and rigidity of C-sections.

These all parts of base frame are considered while reducing weight of the base frame.
By using Maculay's method we find out the deformation of existing base frame and also modified base frame.

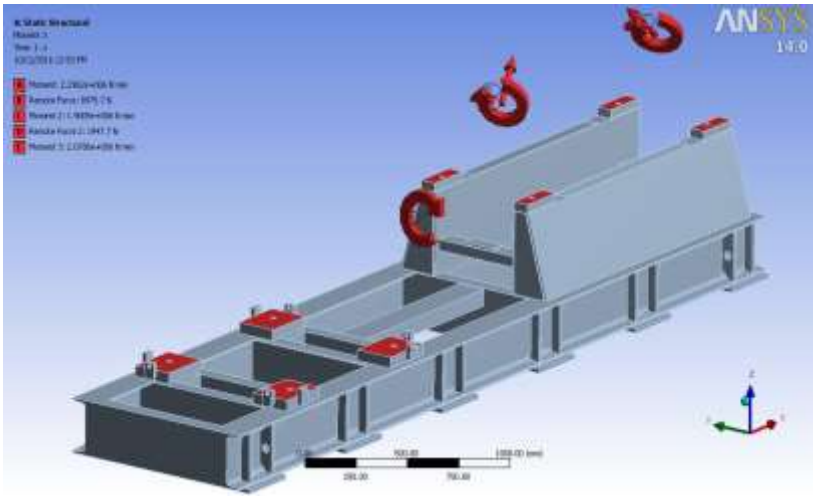
ANALYSIS OF BASE FRAME BY USING FINITE ELEMENT METHOD

In this work finite element analysis was carried out using FEA software ANSYS. The solid model of base frame was imported into ANSYS 14 for meshing and analysis.

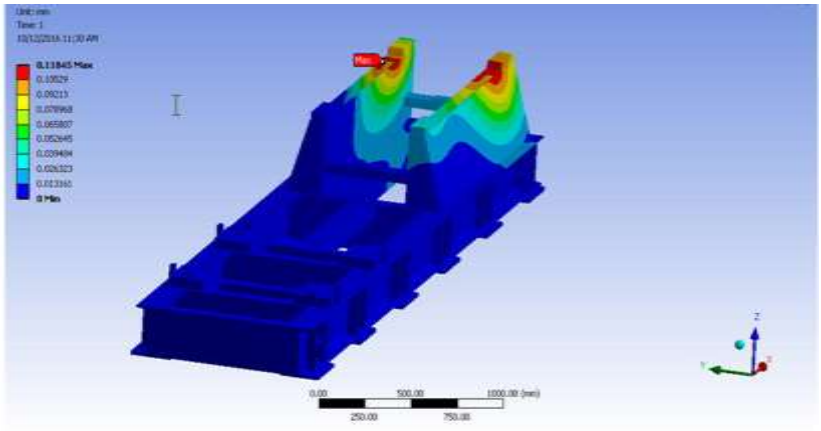


Solid model of base frame was imported into ANSYS 14

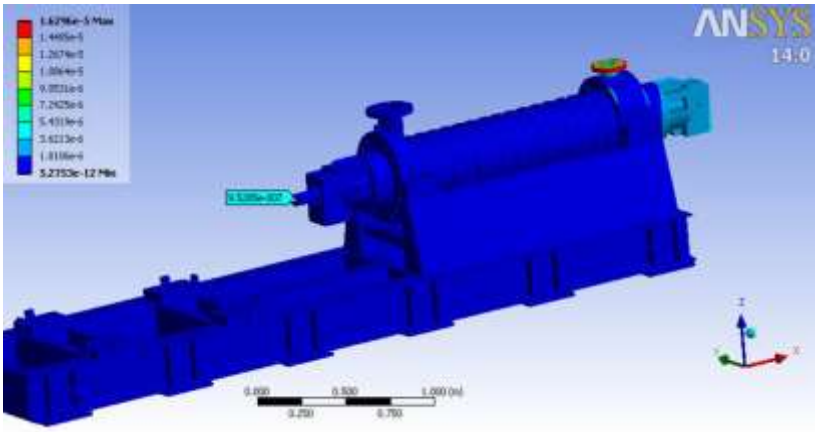
Solid 168 element is used for meshing. Geometry is meshed by keeping relevance center as medium. Element size has been set to 6.
The direction of forces and moments acting on pump nozzles. API610 is referred for this.



Resultant Moments & Forces from Motor and pump



Total deformation of old base frame



Deflection at shaft end due to M_Z

The base frame can be modified such as,
1) Rectangular Pocket of 215 * 1140 mm 2) "H" Channel replaced by "C" channel
After this meshing can be done and the same forces and moments are applied for modified base frame.

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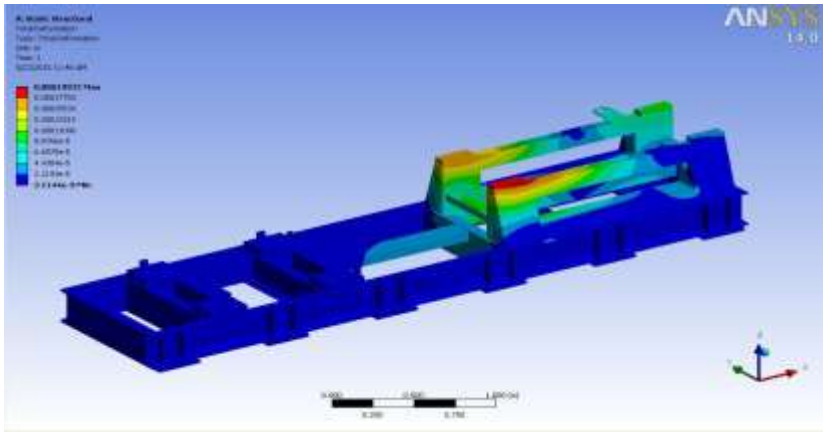
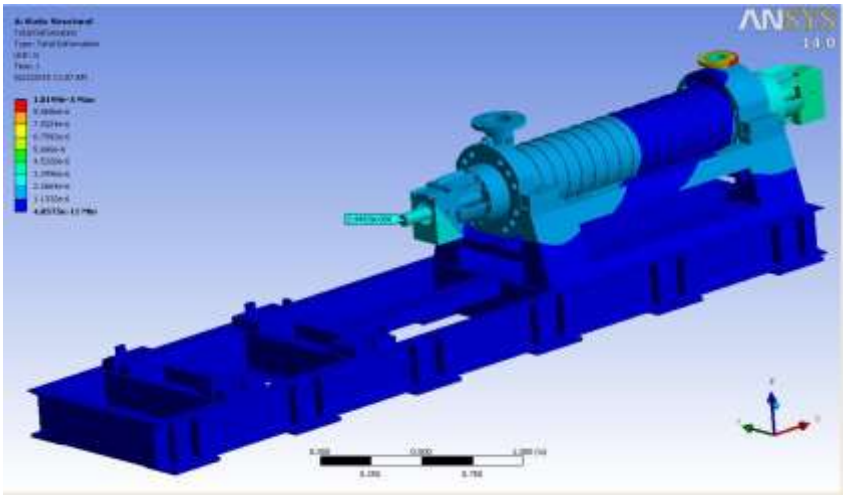


Total deformation of modified base frame



Deflection at shaft end due to M_Z

RESULTS AND DISCUSSION

Mass of both base frames is obtained by using ANSYS14.0. It is mentioned below.

1. Mass of old base frame – 1300 kg
2. Mass of new base frame – 900 kg

The mass of new base frame is 225.6 kg less as compared to old base frame.

By using strain gauges we found the deformation of existing and modified base frame experimentally. The values obtained experimentaly, theoreticaly and by using ansys software are near about same. The shaft deflection of existing base frame is 9µ and the shaft deflection of modified base frame is 11µ and API allows upto 50 µ shaft deflection.

CONCLUSION

After modification in base frame we get the FOS near about market value and also cost of modified base frame becomes decreases by reducing the weight of base frame. Shaft deflection of existing base frame and modified base frame are within API standards.

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