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Stress Analysis on Shaft and Crank of An Auto Ladler System Using Ansys

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Abstract:

Molten aluminum pouring is the key process in casting industries and is traditionally done through manual metal pouring. Most of the automobile components are manufactured using this process. As growth of automobile sector is increasing day by day, Demand for quality casting components is very high. New processes are to be developed in order to increase productivity rate along with quality.

There are some drawbacks in manual pouring systems.

- *There is no Consistent pouring into the DIE.*
- *Working at 750˚c furnaces is hazardous for human beings.*
- *Increased casting capacity will lead to accidents in manual pouring.*

In order to overcome these drawbacks, this project is driven towards automating the hot metal pouring process using an AUTO LADLER SYSTEM. This project is concerned with existing Auto ladle design; doing static analysis on main parts of an auto ladles like CRANK and SHAFT. For crank providing a stiffener for strength and decreasing deformation. For crank the reactant forces and bending moments are initially calculated. Based on these parameters, the maximum shear stresses are calculated. The same values are used then calculated by using ANSYS software. Finally the theoretical and analytical results are compared and verified.

M/S Involute Automation (P) Ltd. is manufacturing the automated pouring system by using PLC, They have standard and patented product called Auto Ladle L-105 model. Although the company is serving many customers, there is more demand for making Auto Ladle which can transfer molten aluminum without spillage.

***Keywords**: Torque, crank design, shaft design, stress analysis.*

INTRODUCTION

Most of the industrial injuries are caused by manual metal pouring leading a quarter of all the industrial injuries caused in the field of industries caused by the improper handling of metal. Various designs have been proposed to avoid and minimize these metal handling accidents. Manual material handling has been known to be one of the prime causes of back injury. The procedure of metal handling has become a topic of interest in the safety boards and counsels for over a long time.

A metal handling process usually involves picking up hot metal using a ladle from a holding furnace and carrying it to a die casting machine and pouring it into a die. The temperatures will usually be at a level of 690^{o}C. It is completely a hazardous for a human being to operate around. Dropping or mishandling of metal can lead to spilling, which causes both human injuries and metal wastage. As the weight carrying capability of a manual operator will be limited, there will be a limited scope for carrying heavy metal quantities for large shot weights. The

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pouring time will vary randomly as human error in time management is a usual problem in any environment

IMPORTANCE OF ALUMINUM POURING PROCESS IN INDUSTRIES

Before the molten metal is converted into a final product, it undergoes a process of cooling and solidification. Before being poured into the castings, the metal has to be raised to a temperature that is usually Called as the pouring temperature. As the distance between the furnace and the die will be significantly high in few cases, the pouring temperature has to taken into consideration along with the heat losses while transfer of molten metal. The metal casts that are used for the casting process will wear out soon as they will be repeatedly exposed to the metals with high temperatures. These casts have to have a property of bearing high temperatures through longer and repeated usage without changing their shapes. This is significant while handling metals with high melting points such as steel.To withstand high temperatures of molten metal sand and ceramic are preferred. Therefore, for the alloys with high temperatures to be cooled down, ceramic and sand are used as the coating layers as they can withstand temperatures as high as 1650-1820c.

The objective of this project is to study the auto ladle design and Corrective remedies in crank and shaft. Strengthen the crank to decrease the deformation as well as for main shaft analysis is carried out on it, to check the max shear stress and factor of safety theoretically and experimentally. Additionally for balancing purpose instead of using dead weight we are suppose to use pneumatic cylinder for better balancing and make design has to be compact. For balancing the crank, there will be a dead weight applied, which in this case is pneumatic counter weight

LITERATURE REVIEW

This section discusses about the literature survey made on different papers to understand the existing auto ladle systems better. This section also helped us in having a god understanding of the control mechanisms used in the auto ladles

LITERATURE SURVEY ON AUTO POURING SYSTEM

The paper "Control of Self-Transfer-Type Automatic Pouring Robot with Cylindrical Ladle" written by Yoshiyuki Noda Ken'ichi Yano Kazuhiko Terashima has helped us in understanding the Design if auto ladle systems with a stable metal carrying capability. In this paper there was a good explanation about how the design of the auto ladle should be made in a way where there won't be any spillage of metal from the ladle cup. The techniques of Fourier transform and the design of hybrid shape approach allowed us to digest the design constraints of a stable auto ladle system

LITERATURE RIVIEW ON METAL POURING

The paper Fabrication of semi-automated molten metal pouring system in casting industries has discussed about. Casting is perhaps the oldest method of manufacturing and invariably the first step in the sequence of manufacturing a product. In this process the raw material is melted, heated to the desired temperature and poured into the mould cavity where it takes the desired shape. After the molten metal solidifies in the mould cavity the product is taken out to get

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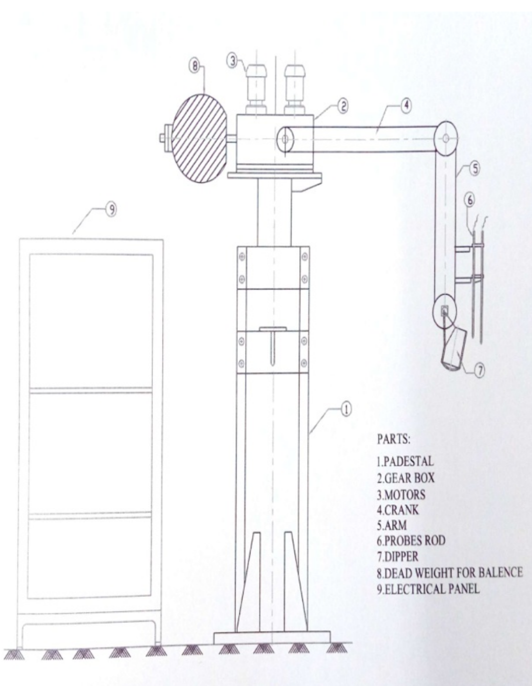
the casting. Casting has various processes like Pre casting Processes, pattern making, core making, molding and mould assembly making, Casting Processes, furnace charging, melting, holding and pouring, and Post casting Processes, shakeout, inspection and dispatch etc

LITERATURE SURVEY OF STRESS ANALYSIS OF A SHAFT USING ANSYS:

The paper "Stress Analysis of a Shaft Using Ansys" written by N. Lenin Rakesh, V. Palanisamy and S. Jeevabharathi has helped us in understanding the analysis part of a shaft by using ansys. In this paper there was a good explanation about how the stresses and deflections are produced in shaft while we applied loads at different point on a shaft. How The reactant forces and bending moments are calculated. Parallel Based on these parameters, how the maximum shear stress calculated. The same values are used then calculated by using ANSYS software. The usage of FEA and ansys for getting results of deformation and equivalent stress produced in shaft.

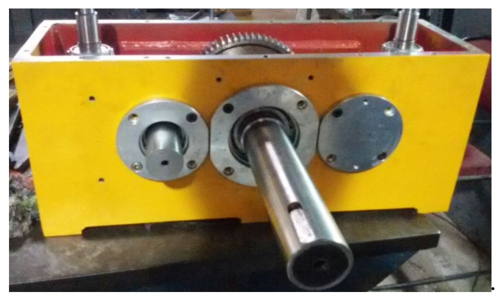
AUTOLADLE PARTS



GEAR BOX

To reduce the speed of a prime mover output shaft and to increase the torque gear boxes are appointed. As the output shaft of a gear box rotates faster than the input shaft there will be a reduced speed which gives a mechanical advantage, increasing torque.

The way that a gearbox puts torque out is dependent on the lifetime of the gearbox..The strength generated from the gear box will decide the power kept out the shaft. The gear ratio which is the speed at which the power of the gear box is keptout will determine the type of gear box used in any system



TIMING BELTS & PULLYS

A **Timing belt** is a non-slipping mechanical drive belt. It is made as a flexible belt with teeth moulded onto its inner surface. It runs over matching toothed pulleys or sprockets.

MOTORS

One of the most common electrical motor used in most applications which is known as induction motor. This motor is

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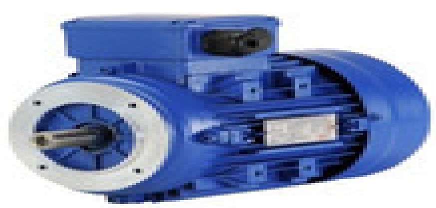
Volume 03 Issue 17
November2016

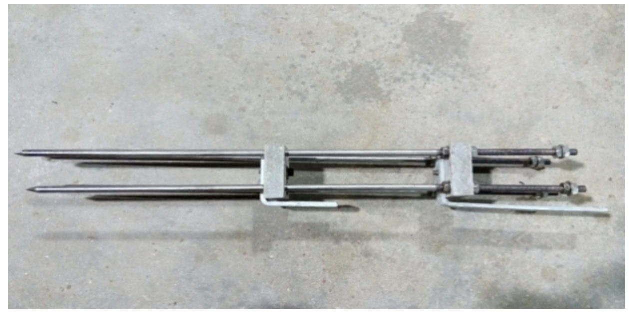
also called as asynchronous motor because it runs at a speed less than its synchronous speed. Here we need to define what is synchronous speed. Synchronous speed is the speed of rotation of the magnetic field in a rotary machine and it depends upon the frequency and number poles of the machine. An induction motor always runs at a speed less than synchronous speed because the rotating magnetic field which is produced in the stator will generate flux in the rotor which will make the rotor to rotate, but due to the lagging of flux current in the rotor with flux current in the stator, the rotor will never reach to its rotating magnetic field speed i.e. the synchronous speed. There are basically two types of induction motor that depend upon the input supply - single phase induction motor and three phase induction motor. Single phase induction motor is not a self starting motor which we will discuss later and three phase induction motors a self-starting



motor.

PROBE RODS

The probes in the auto ladle are very efficient and are compulsorily to be present at the end of the arm. This pair probes act as a metal sensing device which will sense the presence and level of the metal in the furnace. There will be two such sets kept at two different heights which of which the probes situated at a higher level will act as the fail safe sensors. These probes will act as one of the inputs to the PLC helping it in taking a decision on the action to be performed once the cup is full or empty



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INTRODUCTION TO ANSYS

The finite element method represents an extension of the matrix methods for the analysis of framed structures to the analysis of the continuum structures. The basic philosophy of the method is to replace the structure of the continuum having an unlimited or infinite number of unknowns at certain chosen discrete points. The method is extremely powerful as it helps to accurately analyze structures with complex geometrical properties and loading conditions. In the infinite method, a structure or continuum is discredited and idealized by using a mathematical model which is an assembly of subdivisions or discrete elements, known as finite element, are assumed to be interconnected only at the joints called nodes. Simple functions such as polynomials are chosen in terms of unknown displacements at the nodes to approximate the variation of the actual displacements over each finite element. The external loading is also transformed in to equivalent forces applied at the nodes. Next, the behavior of each element independently

ENGINEERING APPLICATIONS OF FEM

The general nature of its theory makes it applicable to a wide variety of boundary value problems in engineering. A boundary value problem is one of which a solution is sought in domain (region) of a body subject to the satisfaction of the prescribed boundary (edge) condition of the dependent variable of their derivatives. Mostly all engineering problems which are illustrated in the table of the finite element method comes under three categories of boundary problems, namely

1, Equilibrium or Transient or time independent problem,

2, Eagan value problem,

3, Transient or propagation programs.

FINITE ELEMENT ANALYSIS

Finite element analysis was first developed for the use of aerospace and nuclear industries where the safety of structure is critical. Today growth in the usage of method is directly attributable to the rapid advances in computer technology. As a result commercial finite element packages exist that are capable of solving the most sophisticated problems, not just in structural analysis, but for wide range of phenomena such as Transient and dynamic temperature distributions, fluid flow and manufacturing processes such as injection molding and metal forming. Finite element analysis is used in new product design, and existing product refinement. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, Finite Element Analysis may be used to help in determining the design modifications to meet the new conditions.

Types of Analysis: There are different types of analysis that are used in industry: Structural, Modal, Harmonic, Transient and Spectrum.

5, PROCESS OF ANALYSIS

STATIC STRUCTURAL ANALYSIS

In this static structural analysis the stress and deformation are charts of the component which before and after modification are generated with applying required boundary conditions. In the static structural analysis initial forces applied and within the specified position.

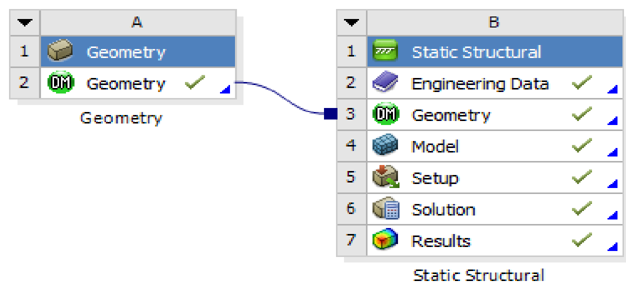
Open ANSYS Workbench 16.0, It opens a project Schematic window with tool box, graphical User Interface with some other important tools.

Use import tool to import the geometry with STP file format.

After importing the geometry file we do the required Analysis.

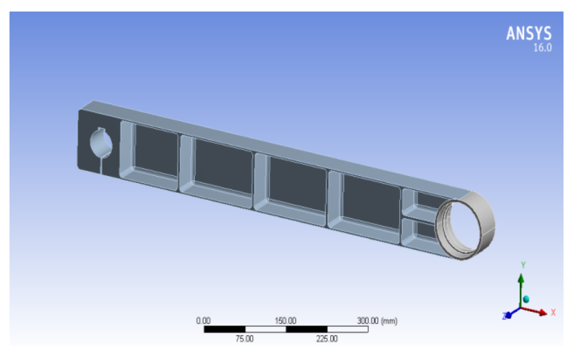
Now on our ac condenser model static structural analysis is done. From the tool box select static structural analysis tab and drop on GUI.

Now link the imported geometry to the static on Model to open analysis window as shown below in the Project Schematicwindow.



ANALYSIS PROCEDURE FOR CRANK MODEL

Geometry: go to outline - select modal- select geometry



FORCE APPLIED AT THE END OF THE CRANK

Go to outline - select model-select static structural- right click- select force support- select position for force are acting. In details outline go to magnitude and select component in

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Volume 03 Issue 17
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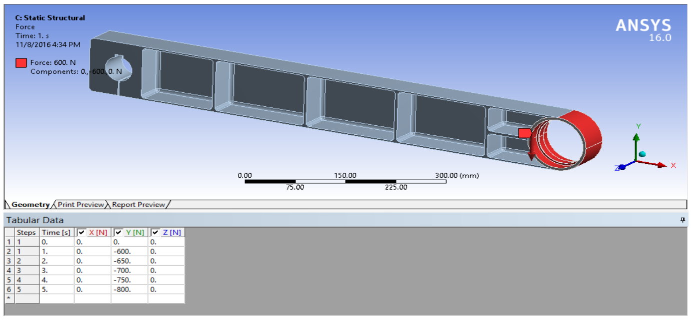
coordinate system in definition.

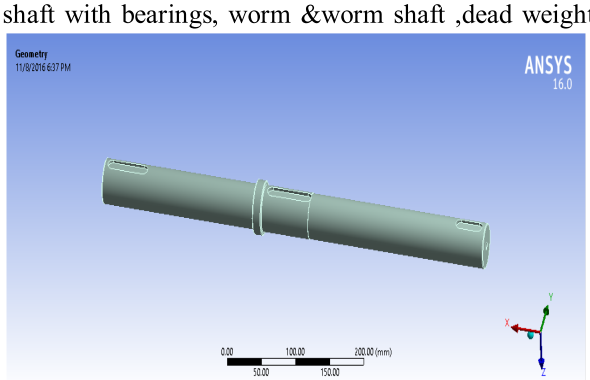


PROCEDURE FOR PROVIDING STIFFNER TO CANK

Go part file in auto ladle and select crank and import creo software for modification. in creo go to part design and select sketch and select reference plane and create a rectangular box with 45*6 mm*mm. and click ok. After that, go shapes and select extrude and select above sketch and specify length 625 mm. after that save the file into step with new name. Then import to ansys further analysis

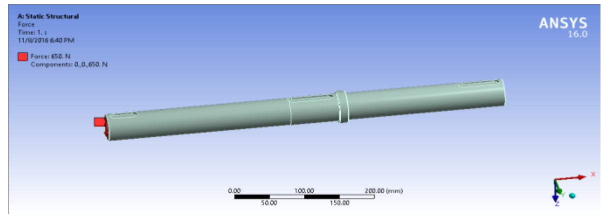
ANALYSIS PROCEDURE FOR FORCES APPLYING ON MAIN SHAFT

Below fig 5.7 shows the geometry of shaft model .we are applying forces at different points on shaft ,forces acting on shaft with bearings, worm &worm shaft ,dead weightandarm

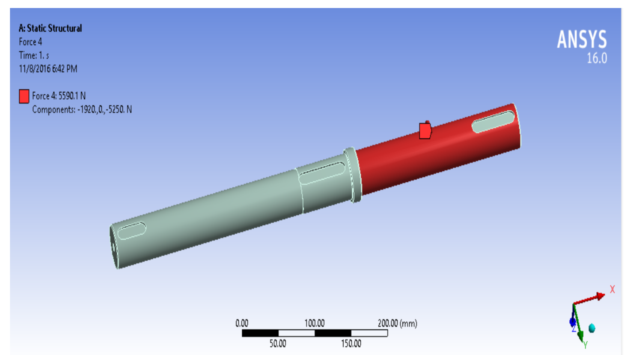


FORCES ACTING ON SHAFT AT DIFFERENT POINTS

At point A the force of 650 N is acting on shaft produced witharm.



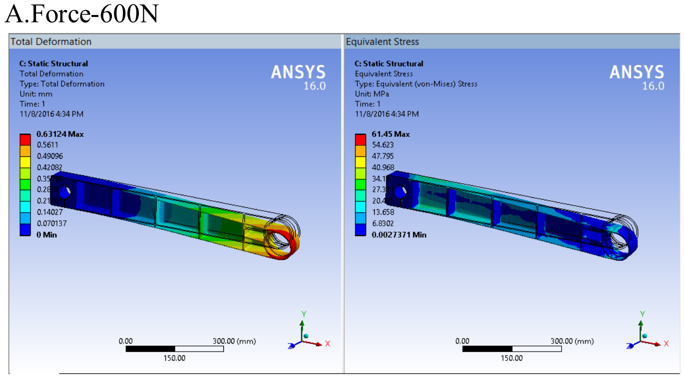
At point B the force of 1920N in-x direction & 5250N in-z direction is acting on shaft produced with bearing. (The resultant force is 5590 N)



RESULTS AND DISCUSSIONS

Results from ansys

A.Force-600N



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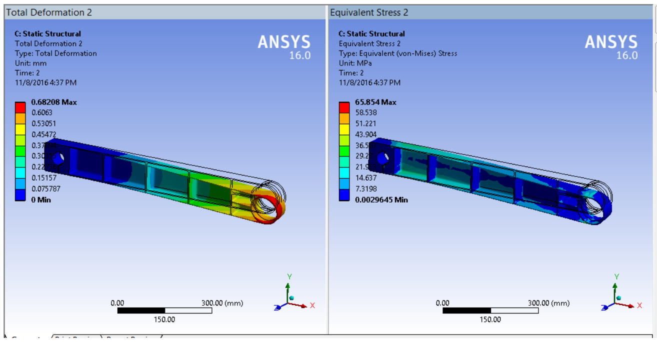
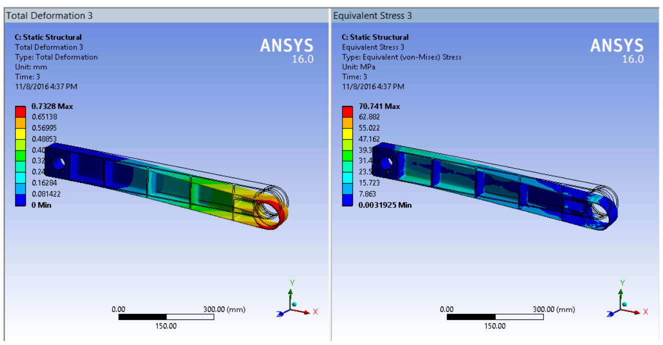
November2016

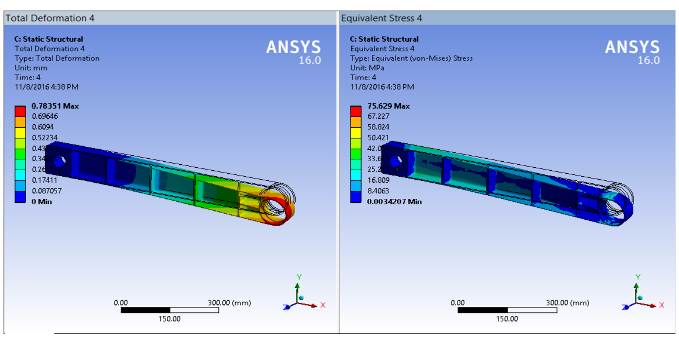
B.Force-650 N



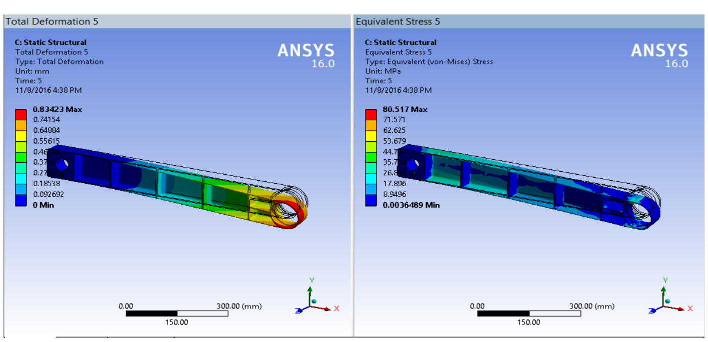
c.Force-700 N



d.Force750-N



E.Force-800N



Results

Consider, varying loads at vertical arm

W= 60kg to 80 kg with rise of 5 kg each time

Table 1 results for total deformation and equivalent stress of crank before modification

Before modification			
S.no	Weight kg	Total deformation mm	Equivalent stress mpa
1	60	0.63124	61.45
2	65	0.68208	65.85
3	70	0.7328	70.74
4	75	0.78351	75.62
5	80	0.83423	80.51

After providing stiffener the deformation and stress values are decreased.

Table 2 results for total deformation and equivalent stress after modification

After modification			
S.no	Weight kg	Total deformation mm	Equivalent stress mpa
1	60	0.52693	55.4
2	65	0.56905	59.42
3	70	0.61108	63.8
4	75	0.65311	68.18
5	80	0.69513	72.56

For safety factor: go to solution and right click and select insert and select fatigue tool. In fatigue tool, right click and select safety

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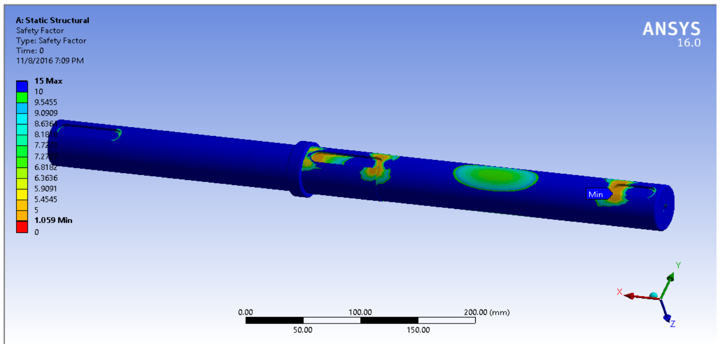
Volume 03 Issue 17
November2016

factor.



As per above (fig6.8) result the safety factor for select material en8 steel, for modal shaft is 1.059 Table 6.3 shows the results of total deformation, equivalent stress and safety factor of main shaft.

S.No	Results	
1	Total deformation	0.016901 mm
2	Equivalent stress	81.4 mpa
3	Safety factor	1.059

CONCLUSION

The project has tested the proposed techniques of implementing a stress analysis and design on the crank and shaft of the existing auto ladle model. There was a problem of stress that existed before the current design is implemented which concerns the amount of stress and deformation of the crank. The project included the design of a stiffener that is attached to the crank for added strength. The stress analysis is made using ANSYS and the mechanical design using AutoCAD. The design is implemented through a new system which is implemented and is tested before it's dispatched to an industrial environment. For crank the deformation also decreased after providing stiffener. The design parameters of the shaft have been taken from standard values and it has been designed to ansys. It was found that the maximum shear stress value found by theoretically is 87.61Mpa and by ansys is 81.4 Mpa. Therefore the stress values are with the permissible limit and the design is safe.

Due to limitations in the practical implementation of the project as it is done in an industry, there was limited number of techniques tried and implemented during the project duration. There can be better techniques suggested over the existing one which may try adifferent approach and can produce better results.

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