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Design and Analysis of Concrete Pipe Suspender Jaw System using FEA

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ABSTRACT

Design and analysis of concrete pipe suspender jaw system is an important issue in view of proper handling and placement of the concrete pipes. In the present work, a unique jaw system to hold the suspended concrete pipes is designed and tested for stresses occurred for different weights of pipe. The jaws suggested are simple in structure and light in weight. The concrete pipe can be kept by turning the hanging force into clamping force. The holding mechanism is self-adjusting in the defined range of the ring thickness. The suggested concrete pipe suspender system comprises of three jaws which are coupled by chain mechanism to the crane hook. The jaws are designed in such a way that the pull in the chain mechanism gets converted into clamping force. Stresses developed in jaws were determined by using ANSYS.

***Keywords*— Clamping jaws, concrete pipe, FEA, griper jaw.**

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I. INTRODUCTION

Presently the concrete pipes are handled manually by use of crow bar and human Labour, which is time consuming, damages the pipes while transportation, unsafe work practice hence there is a need of concrete pipe suspender for fast and safe handling of concrete pipes and concrete rings. It is important to keep the pipes and rings properly by lifting the concrete pipes and concrete rings. If the tool is prepared incorrectly, it may cause partial or total damage of the pipes or rings. Labour safety conditions highlight the use of concrete pipe suspender, concrete pipe holder, fount pipe holder and fount pipe suspender that have proper capacity.

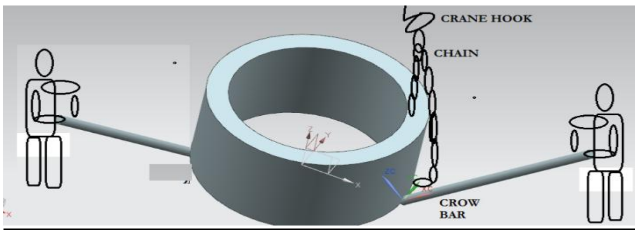

Fig.1 Present Techniques or Methods of Lifting Concrete Pipes

The type of gripper jaws which is used generally has a major role in determining the force which is required in the functioning of a gripper. Friction grip rely totally on the force of the gripper to hold the part, the “squeeze” of the gripper does all of the work. The gripper jaws are generally of 2 types or are found in two styles, namely friction grip and encompassing grip.

The friction force depends on two factors,

1) The materials that are in contact:
Rougher surfaces have higher coefficient of frictions but to slide apart. This makes sense in terms of a

model in which friction is described as arising from chemical bonds between the atoms of the two surfaces at their points of contact: very flat surfaces allow more atoms to come in contact.
2) The force pushing the two surfaces together:
Pushing the surfaces together causes the more of the asperities to come together and increases the surface area in contact with each other.

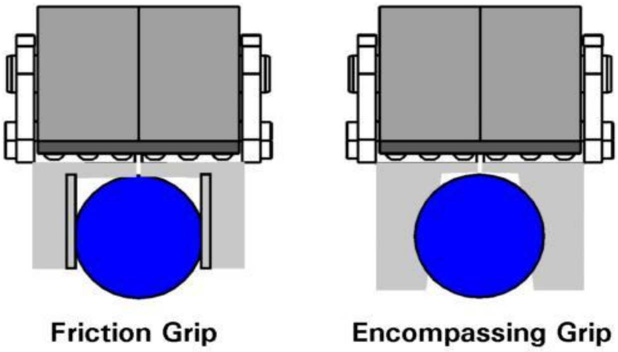

Fig. 2 Friction Grip and encompassing Grip

II. LITERATURE REVIEW

In field of Industrial Robotics and gripper design and analysis, many research works have been done by many researchers. Some of the distinguished ones which are relevant and carry basic information for this paper have been highlighted briefly. At the present moment the system adequately defines the grasping principles capable to perform the required operation together with some fundamental recommendations. However, finding a way to evaluate every possibility, including the variability of the objects, still requires further study and work that could be done iteratively. Since the system is based on a set of rules that can be easily updated, in future it could work as a self-learning system. This turns into an increase in terms of effectiveness and efficiency [1].

Jacopo et al. [2] discussed the concept, design, selection and test procedure for gripping device for heavy and deformable materials handling. The features of the grippers and their grasping reliability on jute coffee sacks were evaluated and scored through MADM criteria. However, being at the prototype phase, such grippers can be modified, in order to improve their features, especially the ones with bad votes. Furthermore, one of the gripper with the highest scores has been selected to be fully designed and tested. The concept resulted to be simple and reliable, the design satisfies all the requirements and both the force exerted and the actuation time meets the unloading requirements. Unfortunately at the present, manufacturing issues and the lack of suitable miniaturized components prevent an extreme downscaling process of the gripper.

Ho Choi and Muammer Koc [3] reviewed and explained the existing gripper types and design strategies, design stages of a flexible gripper based on inflatable rubber pockets concept. Results of numerical analyses on the performance of a simple conceptual design case were presented to reflect the potential effects of process and rubber material on the part handling accuracy. Finally, upon manufacturing and installation a prototype flexible gripper onto a robot, feasibility experiments were performed to demonstrate and obtain an overall understanding about the capability and limitations of the gripper. It was found that rubber material type does not affect the part weight limitation, but butyl rubber showed a superior durability and consistent expansion under cyclic inflation tests compared to neoprene. Thus, selection of rubber material is crucial for accuracy and maintenance aspects. Further, their study revealed that design of other elements of the flexible gripper may also affect the accuracy of part handling. Thickness and elasticity of the side plates (jaws), and also the top plate and its joint to the side plates play an important role in decreasing the deflection of the side plates when pressure is applied into the rubber pockets, thus, onto the side plates. During the feasibility tests, slight opening of the side plates was observed. Similar deflection was also predicted in the 2D FEA when side plate elasticity was taken into account.

A. M. Zaki et al. [4] presented design and implementation of efficient intelligent robotic gripper. In their work, a robotic gripper design and implementation was presented. Robotic gripper performance efficiency appears at handling unknown objects with different masses, dimensions, and coefficients of friction. Verifying most of recommended guide lines described in section II in gripper implementation had proved the gripper efficiency. The advantage of using one fixed finger and the other movable appears in the need for only one motor for actuation and also easier control when avoiding complicated mechanical system.

Peter Kostal et al. [5] stated that the assembly of the grippers for industrial robots has a specific state in manufacturing process as assembly imply major portion of high toilsome and manual work in term of their portion in production total time. For their technical difficulties and heterogeneousness, actual assembly is making manual too, because assembly has large reserves of automation aided. One of the causes of automation assembly lag is higher manipulating ability requirement for assembly devices by joining parts. Often some assembly operations, which are trouble free realizable by manual, by automation are requested very complicated and very expensive device. Robotized workplaces are used at several industrial branches. Request to competitive and effective manufacturing generate pressure to robotics design centers. The end effectors design must take head to lot of special requests apart a common mechanical engineering parts. Trends in this area is a continuous accuracy increasing and develop a new methods to gripper design.

CheSoh et al. [6] developed an adjustable gripper for robotic picking and placing operation. An autonomous robot with adjustable gripper that perform pick and place operation was successfully build. The robot was able to pick the object and place it effectively. The robot was also able to perform lifting upward and downward smoothly. By using PIC microcontroller, the robot performed it tasks perfectly according to program that being made. Beside than that, the adjustable gripper with sensors was able to open its grip according to the size of the object. Due to this advantage, the robot can pick the object within the gripper limitation.

Nina Danisova et al. [7] designed gripper for an intelligent manufacturing - assembly cell. During the design process of intelligent manufacturing cell, and during the design process of automated tool changing system, a sequential diagram methodology was used. This methodology was chosen to describe communication of all devices during the manufacturing and also assembling process. Sensor equipment was selected following information, about the communication and signal transmission.

Moulianitis et al. [8] presented an approach for the modeling of the evaluation process in the conceptual design phase with a view to mechatronics design of robot grippers. The evaluation score is produced through a vector that contains the design criteria for comparison and weight factors that used to indicate the importance of every criterion. The mathematical models are formed mainly by t-norms and averaging operators. The mechatronics index is presented in terms of intelligence, flexibility and complexity of design alternatives. Khadeeruddin et al. [9] presented the design and analysis of parallel two-jaw actuated pneumatic gripper. The force and torque for the gripper were calculated for different set of conditions. CAD Modeling is carried out on Solid works and analysis is carried out on ANSYS tool.

III. DESIGN OF JAW

The jaw material of AISI 1040 (mild steel) was considered while designing and analyzing the concrete pipe suspender jaw system. The composition of AISI 1040 steel and its mechanical properties are given in Table 1 and 2 respectively. Initially, a geometric model was developed using Catia software as shown in Fig. 4. Further, a model was imported in ANSYS for analysis to understand the effects of geometric design parameters on displacement and Von Misses stress at different concrete pipe loads.

TABLE I
Composition of AISI 1040

Element	Content (%)
Iron, FE	98.6-99
Manganese, Mn	0.60-0.90
Carbon, C	0.370-0.440
Sulphur, S	≤ 0.050
Phosphorous, P	≤ 0.040

TABLE II
Mechanical properties of AISI 1040 steel

Properties	Metric
Density	7850 kg/m^3
Poison's ratio	0.27–0.30
Modulus of elasticity	210 x10^3 MPa
Tensile Strength	620 MPa
Yield Value:	290 MPa
Elongation	25%
Ultimate Stress Value	550 MPa

The design and analysis of suspender pipe jaw system was carried out in a systematic way as described below. Initially, a CAD model for the jaw was developed using CATIA software as shown in Fig. 4.

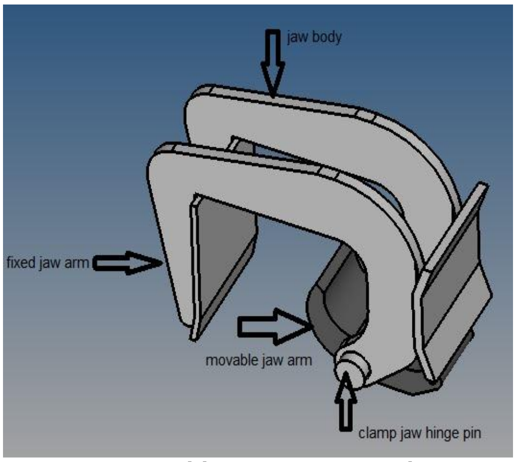

Fig. 4 CATIA model: Concrete pipe suspender jaw

Further, meshing for the suspender pipe jaw system was done using HYPERMESH software as shown in Fig. 5.

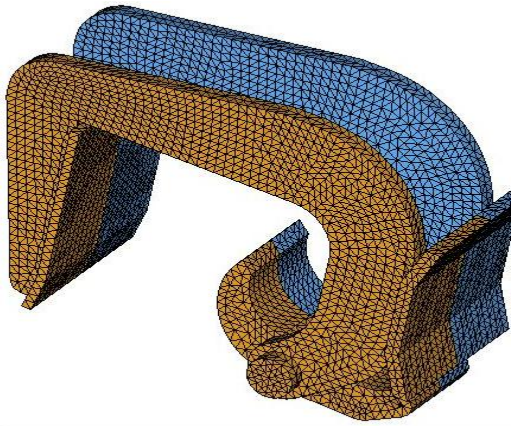

Fig. 5 Meshing of concrete pipe suspender jaw

Further, analysis of the concrete pipe suspender jaw system was carried out using ANSYS. The boundary conditions which were applied during analysis are described below,

1. Assuming the concrete pipe weight of 300 kg.
2. For lifting the concrete pipe 3 jaws are used and hence, while carrying out analysis it was assumed that each jaw bares a load of 100 kg.

Finally, the displacement and Von-Mises stresses plots were obtained for suspender pipe jaw system was for different concrete pipe loads using ANSYS in order to determine whether the design is safe or not. The displacement plot is shown in Fig. 6 and Von-Mises stress plot is shown in Fig. 7.

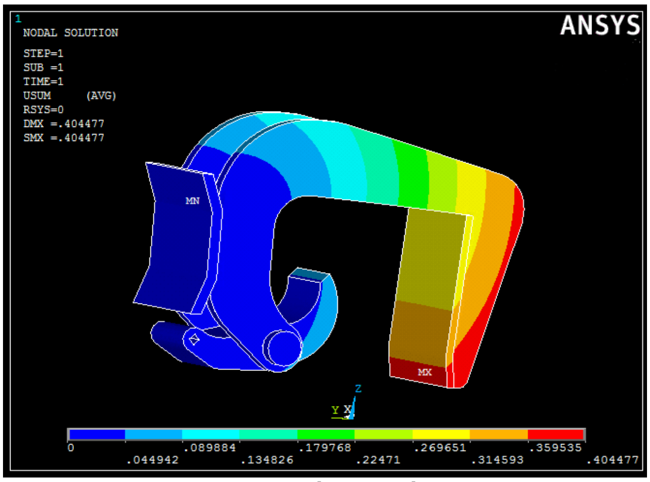

Fig. 6 Displacement Plot

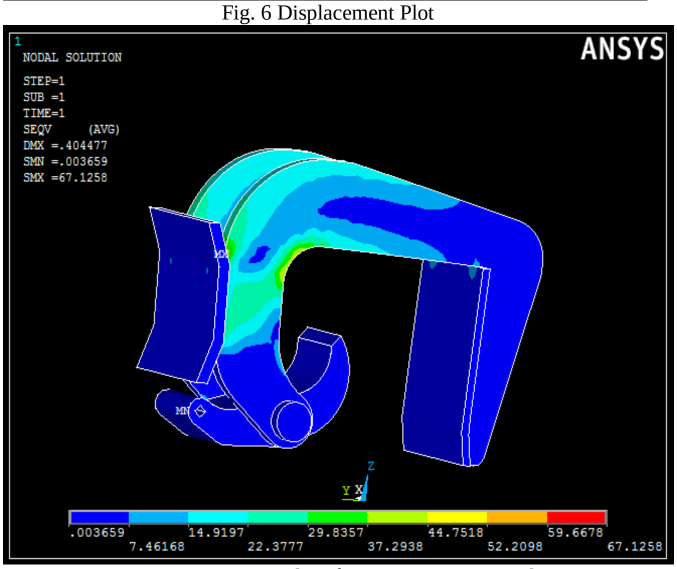

Fig. 7 Vonmises stresses plot of concrete pipe suspender jaw

IV. RESULT

From the plots obtained in Figs. 6 and 7, it can be seen that for load of 100 kg on each jaw, the displacement in each of jaw is negligible. Maximum stress induced in the jaw can be seen as maximum as of 67.12 MPa, which is well within the yield value of the material considered for the jaw (AISI 1040) as shown in Table 2. The design of the suspender concrete pipe jaw system proposed in the present work can be considered to be safe as for is safe maximum stress induced in the jaw is less than the yield value of the material.It is suggested that the present work needs to be carried out considering different jaw materials in order to comparative assessment of displacement and Von-Mises stresses at different concrete pipe loads. In view of validation of the modeling results of the displacement and Von-mises stresses incurred for different concrete pipe loads, authors of the present work will carried out some experimental tests.

V. CONCLUSION

In this paper, the mechanical type gripper was designed and analysed for the suspender concrete pipe jaw system. Initially, a review of the existing work on gripper types and their design strategies was discussed. A mechanical gripper which uses mechanical fingers considered in the present study is actuated by a mechanism to grasp an object. The gripper actually makes contact with the object with the help of friction between the fingers. From the results obtained it can be concluded that the design of the proposed suspender concrete pipe jaw system could be considered safe as maximum stress induced in the jaw was less than the yield value of the material considered in the present work for the jaw.

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