ABSTRACT
Screw (Auger) conveyors are widely used for transporting and/or elevating particulates at controlled and steady rates. They are used in many bulk material applications in industries ranging from industrial minerals, agriculture, chemicals, pigments, plastics, cement, sand, salt and food processing. They are also used for metering (measuring the flow rate) from storage bins and adding small controlled amounts of trace materials such as pigments to granular materials or powders. Many studies on screw conveyors were conducted to examine performance and to develop new types [1]. Most of these studies were experimental in nature. The purpose of this paper is to present a critical review of current explanations on the working concept of a screw conveyor. Although many experimental and numerical studies on the screw conveyor have been made. In this paper, design and analysis of screw conveyor for different material is discussed. Some researcher used a DEM method to predict the performance of screw conveyor is also discussed. This discussion will be helpful for future research.

KEYWORDS - Screw conveyor, DEM, Auger.

I. INTRODUCTION
A screw conveyor consists essentially of a shaft-mounted screw rotating in a trough and a drive unit for running the shaft. The material is moved forward along the axis of the trough by the thrust of screw thread or flight. The trough is usually of the U-shape. The basic principles of operation may be explained with reference to Fig.1.1. A helical blade is attached to a drive shaft which is coupled to a drive unit. The shaft is supported by end bearings, and intermediate bearing. The U-shaped trough has a cover plate with an opening for loading the conveyor. A discharge opening is provided at bottom of the rough. The loading and discharge points can be located anywhere along the trough. More than one feed hopper and discharge hopper may be fitted according to the necessity. The basic principle of material along the trough is similar to the sliding motion of a nut along a rotating screw when the nut is not allowed to rotate. The weight of material and the friction of the material against the wall present the load from rotating with the screw.

II. EFFECT OF PITCH ON OUTPUT OF SCREW CONVEYOR
The feed is under a head, as from a storage bin or hopper, the pitch of helix in the loading zone should be less than the pitch of conveying section A-A, while beyond the feed section the helix is uniformly loaded to about 40 percent as seen in section B-B as shown in Fig. 2.1 and Fig. 2.2

III. EXPERIMENTAL&NUMRICAL ANALYSIS
There is no. of articles are published on Screw conveyor. Not all the articles are directly related to our work, especially, those articles which were focused on numerical work. Many articles addressed experimental findings and remaining discussed various theories explaining effect of working parameter on performance of screw conveyor. In this subsection, we are going to discuss only those articles (experimental and/or theoretical work) which are directly related to current work. First screw conveyor was invented by Archimedes (circa 287–212 B.C.) for elevating water from the hold of a King Hero of Syracuse ship.[2] The geometry of an Archimedes screw is governed by certain external parameters (its outer radius, length, and slope) and certain internal parameters (its inner radius, number of blades, and the pitch of the blades). Chris Rorres[3] found that the inner radius and pitch that maximize the volume of water lifted in one turn of the screw. He compared optimal parameter values which he found with the values used in a screw described by the Roman architect and engineer Vitruvius in the first century B.C. and with values used in the design of modern Archimedes screws.
Vitruvius’s screw is fairly close to that of the optimal 8-bladed screw. In addition, its radius ratio is within 7% of the optimal value (0.5 versus 0.5354), its pitch ratio is within 27% of the optimal value (0.375 versus 0.2957), and the construction lines associated with its design are much simpler than those that would be needed to construct the optimal screw. No doubt many generations of experience went into the design of the screw that Vitruvius described.

Alma Kurjak, 2005 has investigated the effect of powder property on screw conveyor performance and capacity. Powders with coarse particles will flow into a screw easier than powder with fine particles. This results in a greater mass flow. The screw capacity will also be higher if dense powder is used. Round powder, have lower internal friction that results in a greater screw capacity. Hausner Ratio and angle of repose are most likely efficient methods to measure if powder is free owing or not. Particle size has innocence on flow ability of a powder. In general, fine particles with very high surface to volume ratios are more cohesive than course particles. Particles larger than 250 µm are usually relatively free owing, but as size falls below 100 µm powders become cohesive and flow problems are likely to occur. Powders having a particle size less than 10 µm are usually extremely cohesive. Particle shape has a large influence on flow properties. A group of spheres has minimum inter particle contact and generally optimal flow properties, whereas a group of takes have a very high surface-to-volume ratio and poorer flow properties.

The Hausner ratio is a measure of how compressible a powder is in relation to bulk density. It is derived from the quotient between tapped density (TD) and apparent Density (AD)

Values less than 1.25 indicate good flow whereas values greater than 1.25 indicate poor flow.

The angle of repose given in table 1 may be used as a guide to flow performance.

Table 1: Angle of repose as an indication of powder flow properties

<table>
<thead>
<tr>
<th>ANGLE OF RESPONSE</th>
<th>TYPE OF FLOW</th>
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<tbody>
<tr>
<td>&lt; 20.5</td>
<td>Excellent</td>
</tr>
<tr>
<td>20.5-30</td>
<td>Good</td>
</tr>
<tr>
<td>20.5-34</td>
<td>Possible</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>Very poor</td>
</tr>
</tbody>
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Figure 3.2: Measurement of drained angle of repose

The clearance and the free length of intake have a large influence on screw capacity. No correlation was found between conveying length and conveyor capacity.[4]

Philip J. OWEN and Paul W. CLEARY 2009 were carried out use of discrete Element Method (DEM) to predict screw conveyor performance. This paper shows that the DEM modeling gives predictions of screw conveyor performance in terms of Variations of: particle speeds, mass flow rate, energy dissipation and power consumption, due to changes in the operating conditions. A series of DEM simulations was carried out for a range of screw conveyor operating conditions. Three different rotational speeds and three different volumetric fill levels were used, and the inclination of the screw conveyor was varied from 0° to 90° in steps of 10°. Summarizes the series of operating conditions simulated in this study. The DEM modeling gave predictions of the changes in the screw conveyor performance due to changes in the operating conditions in terms of variations of: particle speed, mass flow rate, energy dissipation and power consumption.

Figure 3.3. Particle distributions within the screw conveyor inclined at angles from horizontal to vertical. Particles are colored by diameter: smaller ones are light grey and larger ones are dark grey.

Fig. 3.3 shows the distribution of the particles inside the screw conveyor for a 30% by volume fill level and with the screw rotating at 1000 rpm for angles ranging from horizontal to vertical. The particles are colored according to their diameter, with the smaller particles (~2 mm diameter) being light grey and the larger particles (~3 mm diameter) colored dark grey. Note that the change inclination was obtained by changing the orientation of the gravity vector For the horizontal screw conveyor (Fig. 3.2(a)) the particles form a heap against the leading face of the screw. After reaching the top of the screw most of the particles tumble down the surface of the heap and a few particles fall behind the screw shaft as pictured. The next three frames of Fig. 3.2 show the changes in the distribution of the particles as the inclination of the screw conveyor is increased to 30° in 10° steps. The screw conveyor exhibited two principle types of flow patterns:

A recirculatory flow in a heap of particles being bulldozed along by the screw with avalanching down along the free surface of the heap and vertical transport up the face of the screw. When viewed along the axial direction the flow exhibits behavior observed in rotating drums and mills with cascading and centrifuging behavior.

A shearing flowing a bed of uniform depth flowing, driven by gravity to be spread evenly across the screw surface and a centrifugal component pressing the bed against the screw casing and away from the screw shaft.

Increases the power needed to move the particles. The relationship between the power draw and rotational speed is non-linear.

Increases the average axial, average swirl speed and average overall speed of the particles, however, no consistent power laws could be found between these speeds and the rotational speed of the screw. For a given rotational speed of the screw conveyor and a given angle of inclination, increasing the fill level:
Increases the power needed to maintain the particle flow. The relationship between the power draw and fill level is non-linear. The average axial speed of the particles is almost invariant to fill level. The average swirl speed of the particles increases for low screw inclination angles but decreases for inclinations above 25°. The overall average particle speed is insensitive to changes in fill level.[5] Philip J. OWEN and Paul W. CLEARY - DEC 2009 were carried out comparison of description element modeling with laboratory experiment of screw conveyor performance. In this paper, they use the Discrete Element Method (DEM) to examine how variations of particle properties (such as: particle shape, particle-particle and particle-wall friction) influence the performance of the screw conveyor. The primary focus of our study is comparing predicted mass flow rates with experimentally measured values. The secondary focus is to study how other performance measures (such as: particle speeds and power consumption) vary due to changes in the properties of the particles.

![Figure 3.4: Particle flow patterns within the screw conveyor inclined at various angles for different particle shapes.](image)

The particles are colored by their speed: from blue to red for 0.4 to 0.9 m/s respectively. Fig. 3.4 shows particle flow patterns inside the screw conveyor for three different particle shapes after the simulations had reached steady state operating conditions. These steady state conditions were reached within 2–3 turns of the screw, when the power draw became quite stable. The screw conveyor operating conditions are the same for all 3 cases, namely: 30% by volume fill level, and the screw is rotating at 1000 rpm. They found that increases in non-sphericity have negligible effect on the particle flow patterns. The particle velocities and their axial and tangential (swirl) components were invariant to changes of particle shape and particle–particle and particle–wall friction. However, there were two notable exceptions. The first exception is the swirl velocity for the blockiest particles (case SQD), which was an outlier when compared to all other cases. As the blockiest particle is likely to be a more extreme shape than that of the Japanese millet seed used in the experiment, we can concluded that all particle speed components are invariant to realistic variations in particle shape. The second exception is that the swirl speed in a horizontal screw conveyor, which increases modestly with increasing particle–boundary friction.[6]

Alan W. Roberts were carried out Experimental investigation of Design and Performance evolution of screw conveyor. Screw conveyors with fully enclosed tubular casings were used in experiment. The throughput, torque and power are significantly influenced by the vortex motion of the bulk solid being conveyed. The vortex motion, together with the degree of fill, govern the volumetric efficiency and, hence, the throughput. This, in turn, influences the torque, power and conveying efficiency. A theory is presented to predict the performance of screw conveyors of any specified geometry. The influence of the flow properties of the bulk material on the conveyor performance is given. Performance of screw conveyors is significantly influenced by the vortex motion of the bulk solid being conveyed. The vortex motion, together with the degree of fill, govern the volumetric efficiency and, hence, the throughput. This, in turn, influences the torque, power and conveying efficiency. The flow properties of the bulk material being conveyed are shown to have a significant influence on the performance.[7]

Yoshiyuki Shimizu and Peter A. Cundall 2001 were carried out numerical analysis using the 3D distinct element method (DEM) of screw conveyor for bulk material. A numerical analysis using the 3D distinct element method (DEM) is conducted in order to examine the performance of screw conveyors. They compared their result with previous work and empirical equations. They show that their method is sufficiently well developed and useful to analyze the performance of screw conveyors. In this paper, simulations of horizontal and vertical screw conveyors are conducted. Some results from analysis are listed below.

**For Horizontal screw conveyor:**
The critical angle was considerably smaller than that predicted from static force equilibrium because of the spherical shape of modeled particles. The particles are likely to rotate rather than slip on the screw conveyor components. The transfer velocity of particles was almost equal to the advance velocity of the screw. The overall power is larger by about 15% than that derived from static force equilibrium using calculated results of the critical angle and the center of gravity.

**For Vertical screw conveyor:**
As the revolution speed increases, the particles move faster as a bulk mass, which has a compact form in the axial direction. On the other hand, as the revolution speed decreases, the particles move slower, and the mass concentration spreads out in the axial direction. The computed flow rate differs somewhat from that observed in experiments. One reason is that a different way of feeding materials at the inlet is used. [8]

Y. Yu, P.C. Arnold has investigated on design or selection of a screw feeder. They found that the torque requirement is a principal parameter which is related to the feeder loads, properties of the bulk solid and constructional features of the screw. In this paper they assumed that the load which is imposed on a screw feeder by the bulk solid in the hopper is to be the flow load determined on the basis of the major
consolidation stress. Five boundaries around the bulk material within a pitch are considered and forces acting on these surfaces are analyzed. Particular attention is paid to the pressure distribution on the lower region of the screw. An analytical solution for the calculation of torque is determined, which allows the torque characteristics of screw feeders to be predicted. Experimental studies on the required torque for screw feeders are also reported. Two types of material, three troughs with different inside diameter and two screws with different configurations have been investigated. The results from the experiments are presented and compared with the theoretical predictions. In this paper the theoretical model for the torque requirement of a screw feeder is developed by applying principles of powder mechanics to a moving material element within a pitch. The model indicates that the torque requirement is proportional to the stress exerted on the feeder by the bulk solid in the hopper and to the third power of the screw diameter. Consideration of the forces acting on the five confining surfaces surrounding the bulk solid contained within a pitch, and the pressure distribution in the lower region of the screw, leads to a reasonable prediction of the torque requirement for a screw feeder. Detailed experiments under three different filling states in the hopper and for a screw speed range of 10–80 rpm were carried out using a trough with clearance cs5 mm Fig. 3.4. The experimental results did not show any obvious difference due to the different filling states and screw speeds for the test materials.

**Figure 3.5 Comparison of torques for a screw feeder using the screw with a stepped shaft and stepped pitches**

In Fig. 3.5 shows the comparison between the theoretical predictions and the experimental results for two screws with three troughs. The analytical solution for the calculation of the torque requirement can reveal the relationships among the screw geometry parameters, properties of the bulk solid and feeder load arising from the hopper. Thus, the torque characteristics can be better understood. Based on the parameters used for this study, the torque required for a screw feeder is determined mainly by the resisting torques acting on the shear surface; the proportion of the total torque requirement is about 50%.

Experimental results indicate that the starting torque is close to the running torque for the test materials and situations. The feeder load exerted by bulk solid in the hopper can be determined by the flow load based on the major consolidation stress.[9]

**IV. CONCLUSION**

From above study we found that the main issue concerned in all explanations is the flow pattern of a moving material and power consumption at different speed and pitch and diameter ratio. When material is transferred from the inlet to the outlet, the flow pattern of material particles is very difficult to examine. Clear understanding of the material particles flow pattern inside the screw coil is required for further investigation. So from above survey there is possible to predict performance of screw conveyor using finite element method (FEM) instead of discrete element method (DEM).

So for further investigation on performance and flow pattern of material particles we like to use Finite Element Analysis to get better understanding.

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