

Experimental study on mechanical properties of saucer tray used in mine

Jia Jinglong¹, Yu Fenghai^{1*}, Tan Yunliang¹, Zhang Yubao¹, and Ma Xingyin¹

¹State Key Laboratory of Mining Disaster Prevention and Control Co-founded by Shandong Province and the Ministry of Science and Technology, Shandong University of Science and Technology, Qingdao 266590, China)

Abstract. This paper takes the saucer tray as the research object, carries on the unidirectional compression test to it in the room, through the monitoring of the deformation characteristics of the saucer tray, analyzes the deformation characteristics of the saucer tray. According to its deformation characteristics, the saucer tray is divided into deformation areas. A static strain gauge was used to monitor the strain at the measuring point on the surface of the tray and the stress distribution on the exposed surface of the tray was studied. It is intended to infer the force of the disk-shaped tray through its deformation degree, which provides a certain theoretical basis and practical guiding significance for the research of disk-shaped tray.

1 Introduction

With the continuous improvement of the requirements for roadway formation, bolt support technology has been gradually developed. As the main roadway support technology, it has been widely used in coal mines at home and abroad. Bolt support components play a very important role in roadway support, bolt standards also stipulate that all kinds of bolts must be installed with trays. However, there are few researches on the mechanical properties of bolt supporting members at home and abroad. It is of great significance to study the mechanical behavior of the tray, which is an important component to realize the supporting action.

The bearing capacity of the tray is a conventional item in the testing of the bolt's mechanical properties. Its bearing capacity and deformation and failure characteristics are related to the stability of the bolt support system, and are generally higher than the tensile strength of the bolt. Once the tray is deformed and fails, the whole bolting system will lose its original supporting effect. Many experts and scholars also to mine the dish tray stress deformation characteristics are analyzed: hong-pu kang, jian-xing wu introduces the method of making the anchor rod load tray, the tray of anchor bolt in the laboratory of the stress distribution was analyzed, and tested the disc plate deformation under different

* Corresponding author: yufenghai2006@163.com

support condition, the relationship between stress and load;Meng Fanjin and Zhang Jinglong discussed the way to increase the bearing capacity of the tray under the same conditions.Liu Shuangyue and Zhang Xuntao proposed the criterion of tray instability and studied the influence of various parameters on the tray strength. Wang Shaokun simulated and analyzed the extremely small area in the stress concentration area at the bolt tray orifice when the bolt is broken. In this paper, an indoor compression test is carried out for the saucer tray used in mine. The deformation characteristics of saucer tray are analyzed. According to the deformation characteristics of saucer tray, the main deformation areas of saucer tray are divided; A static strain gauge was used to monitor the measured strain on the surface of the tray, the stress distribution characteristics on the exposed surface of the tray were studied, and the deformation law of the tray was analyzed.

2 Laboratory test scheme

2.1 Preparation of test samples

According to the coal industry standard MT146.2-2011 resin bolt, metal rod body and its accessories, the mine tray is preferred dish bolt tray. Therefore, the 150mm×150mm and 10mm thick dish tray is selected for the test samples, which are shown in Fig.1.

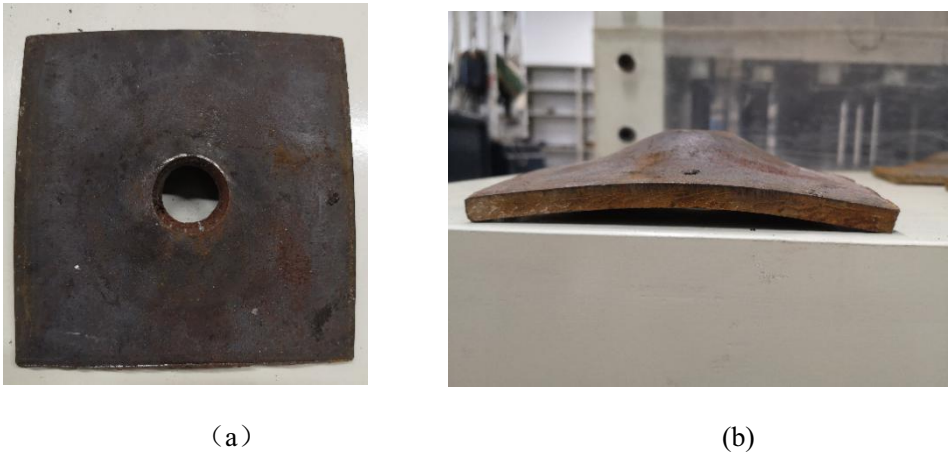


Fig. 1. Saucer tray for mine

Table 1. Dish tray size details

Dish tray thickness	Dish tray bottom radius	Dish tray top size	Dish tray height
9.85mm	52.8mm	24.07mm	17.57mm
9.42mm	53.6mm	23.19mm	17.32mm
10.12mm	53.3mm	24.64mm	18.15mm

2.2 Test instruments

The indoor compression testing machine adopts RLJW-2000 type rock servo pressure testing machine, as shown in Fig. 2. It can realize rock uniaxial compression, rock direct shear, and other types of tests. This experiment intends to use this machine to carry on the compression test to the mine saucer tray, monitors its stress deformation characteristic.

Static strain gauge is an instrument for measuring non-electric quantity such as load of structure and deformation of material. The basic structure is composed of measuring bridge, AC amplifier, phase-sensitive detector, balance indicator, oscillator, power supply and conversion box, etc. This test intends to use this instrument to carry out real-time monitoring on the distribution characteristics of surface stress outside the tray. The monitoring equipment is shown in Fig. 3.

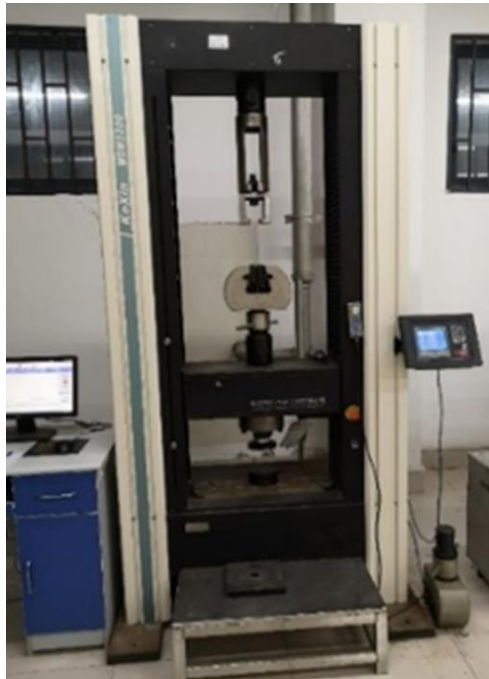


Fig. 2. Uniaxial compression testing machine



Fig. 3 Static strain gauge

2.3 Test monitoring program

Using strain measurement principle, the use of static strain gauge of half bridge circuit (as shown in Fig.4), in the tray on the surface of each measuring point under the condition of unknown magnitude and direction of principal stress, can be in each measuring point by three different direction of paste strain rosette, the stress and strain of three different direction of the measured points is obtained, through calculation and analysis, can get the direction of principal stress and the size of the measuring point.

In addition, during the laboratory test on the saucer tray, the side near the base of the testing machine was affected by friction, which would easily damage the strain flower. Strain flower could not be connected to the static strain gauge, so the strain flower was pasted on the upper surface of the dish tray.

Considering the symmetry characteristics of mine dish tray shape, state of stress and strain distribution on the surface of the disc tray also exists certain symmetry, so according to chronological against each strain rosette point of the dish tray number, respectively 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, a total of 15 points. Five strain flowers (A, B, C, D and E) were used at the test measuring points. Each measuring point measured the strain in three directions, which were 0° (tangent direction of the arch), 45° and 90° (diameter line direction of the arch).The test monitoring points are shown in Fig. 4:

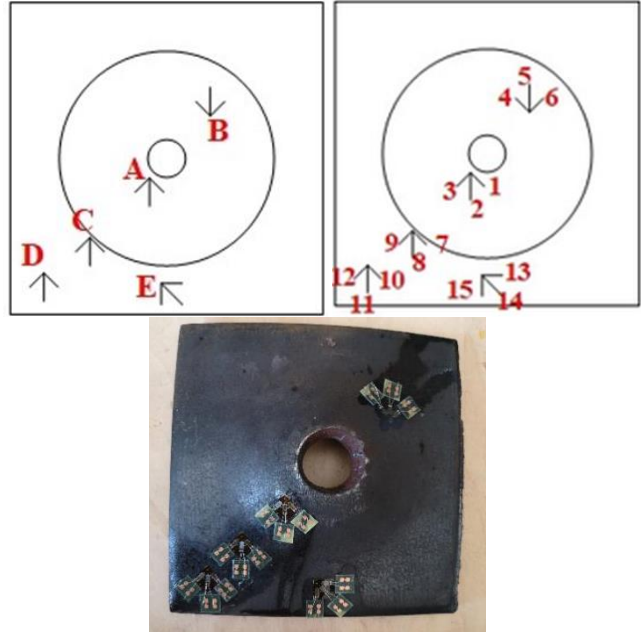


Fig. 4. Strain monitoring position

2.4 Test Process

According to the shape characteristics and metal material properties of the dish tray, in order to study the load-deformation characteristics of the dish tray components in the bolt support system, a uniaxial testing machine was used, displacement control was selected, and the loading rate was set at 5mm/min to carry out compression test on the dish tray (150mm×150mm).In this test, the four-angle contact between the tray and the bearing end of the testing machine is four-point contact, and the surface contact is rigid contact. The test

process is shown in Fig. 5. At the same time of loading, the static strain gauge was used to stick strain flower to the measuring point, and the static strain gauge was used to monitor the strain of the measuring point.

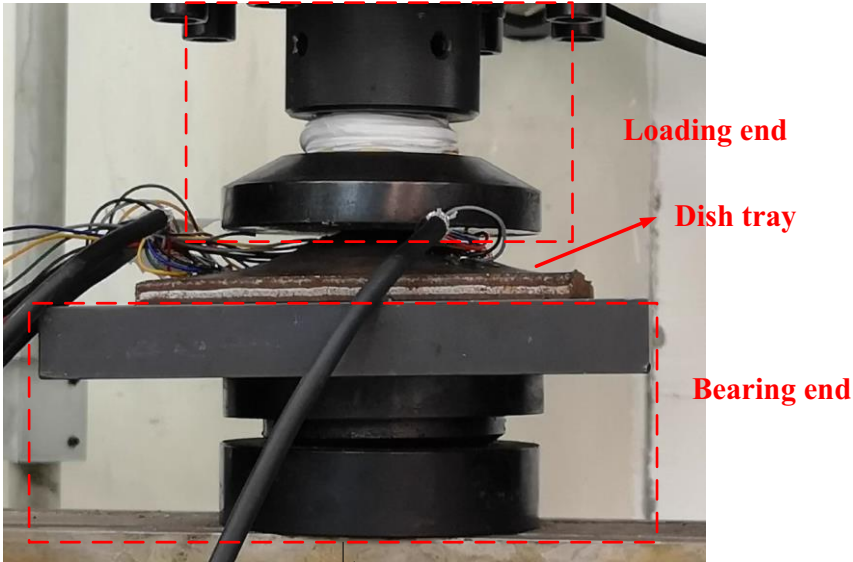


Fig. 5. Tray loading process

3. Results and discussion

3.1 Mechanical deformation

The load-displacement curve obtained by the indoor compression test is shown in Fig. 6. The 3D scanner is used to scan the external surface of the tray before and after the test, and the comparison of the exposed surface before and after the test is shown in Fig. 7.

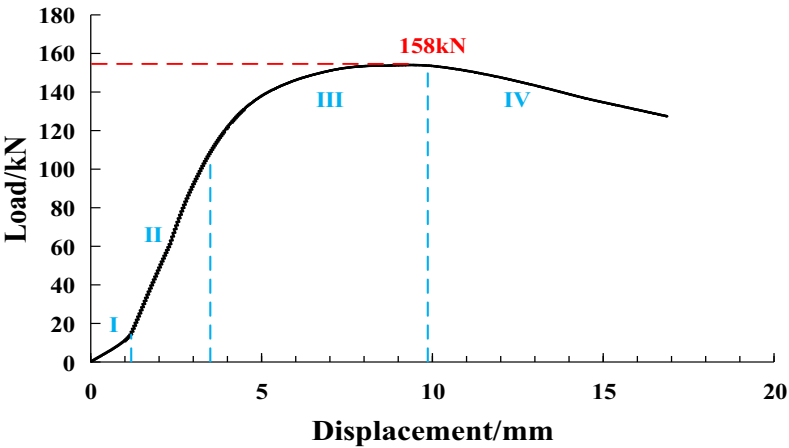


Fig. 6. Piecewise load-displacement curve

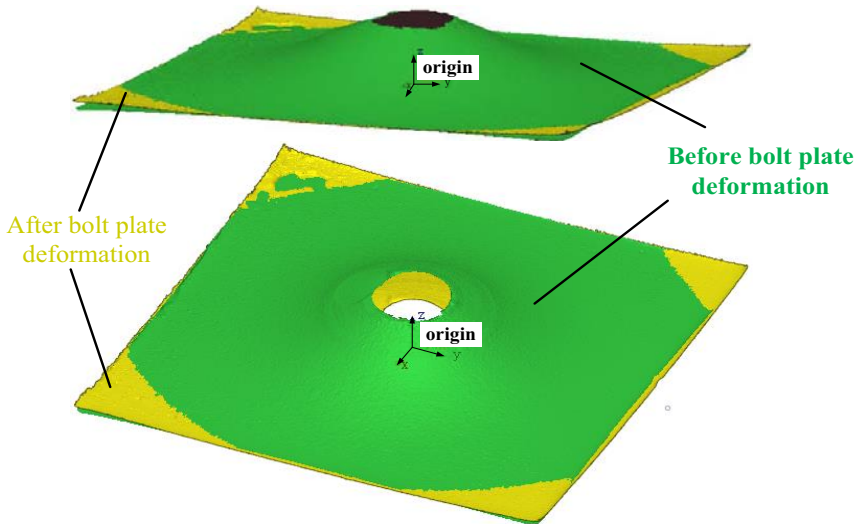


Fig. 7. 3D scanning results before and after the deformation of the tray surface

According to the results of the compression test curve in the saucer tray room, the maximum bearing load of the test sample is 158kN, and the bearing force of the saucer tray presents a trend of decreasing after the line increases, and before the bearing limit, the slope of the load-displacement curve presents a trend of first increasing and then decreasing; When the axial compression of the tray is less than 2mm, the arch foot of the tray is in the compaction stage; When the axial compression of the tray is 2~3.5mm, the slope of the curve is fixed, that is, the tray is in the elastic deformation stage; The axial compression of the tray is within the range of 3.5~10mm, the slope of the curve gradually decreases, and the load gradually increases to the peak value, indicating that the carrying capacity of the tray is gradually decreasing, and the deformation of the tray is 13%~38% of the original height of the tray; When the axial compression of the tray is about 10mm, the tray has reached the peak load and almost fails, and the deformation of the tray is about 38% of the original height. According to the load - displacement curve of different phase slope different section, divided into four phases, as shown in Fig. 6, respectively, II stage, III phase I and IV stage. As can be seen from Fig. 7, obvious warping appears in the corner area after the tray compression, and the orifice is obviously flattened inward.

3.2 Deformation partitioning

According to the main deformation and failure rules of the tray, the saucer tray is divided into three deformation areas, which are O, P and Q respectively, as shown in Fig. 8.

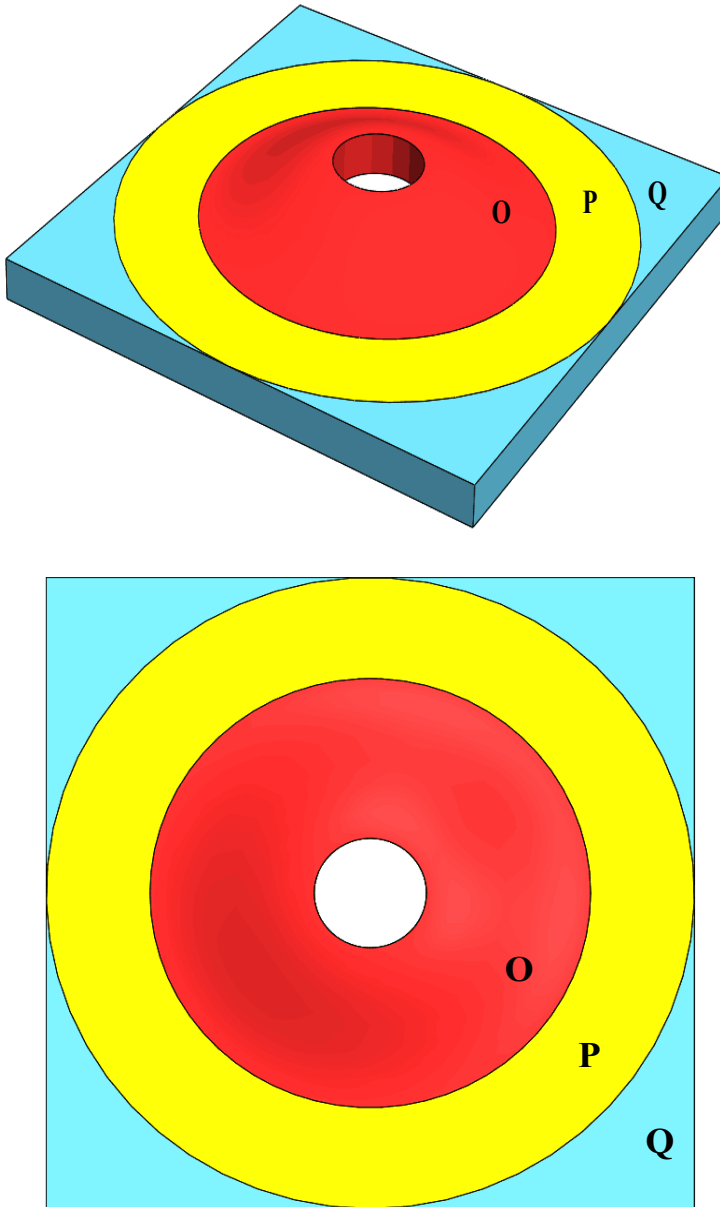


Fig. 8. Deformation partitioning

The main deformation laws in each region are as follows:

In region O, compression deformation mainly occurs; In region P, expansion deformation occurs mainly. In region Q, warping deformation occurs mainly.

Combining the three deformation domains, the compression deformation process diagram of the dish tray is obtained:

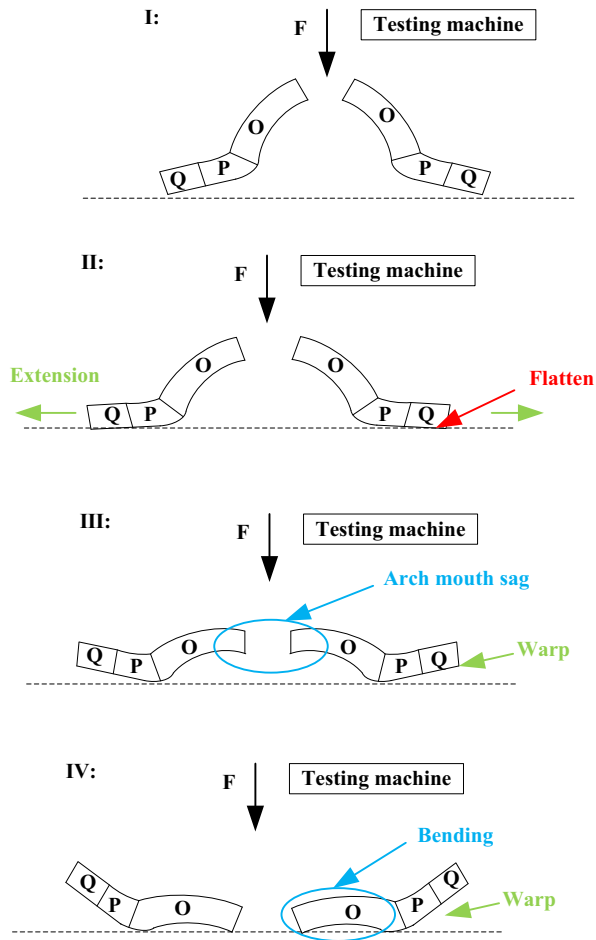


Fig. 9. Schematic diagram of tray compression deformation process

According to the stages, by observing the deformation characteristics of each stage, the following results can be obtained: (1) In the first I stage, the dish tray start loading, until the tray bottom completely flattened. At this stage, the bottom surface of the saucer tray is the main deformation area of the testing machine, and the gap between the bottom surface and the spherical base surface of the testing machine gradually decreases until the bottom surface of the tray is in full contact with the spherical base of the testing machine. (2) In the first II stage, as the pallet load increasing, the tray bottom corners of the up warping deformation area was going on, at the same time tray appear at the top of the arch mouth, deformation shrinkage depression in outward expansion deformation of arch bearing area. (3) In the first III stage, in the tray bottom corner to continue upward warping deformation, tray spherical base area of effective contact with testing machine, tray compression deformation and expansion deformation increases gradually, until it reached the limit of the pallet load. (4) Slightly higher in the first IV stage, load, tray compression deformation increases significantly, tray deformation serious, vaulted gradually disappear, tray appear flat trend.

3.3 Discussion

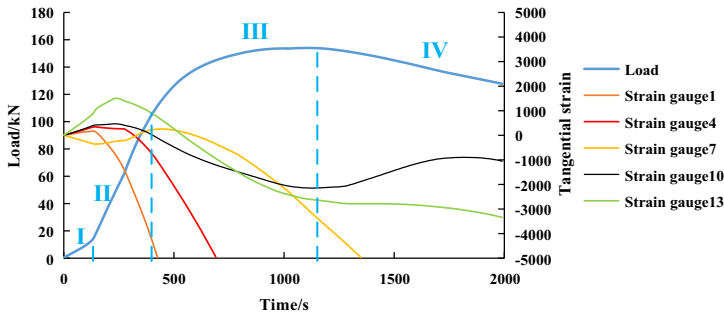


Fig. 10. (0° strain + load) - time curve.

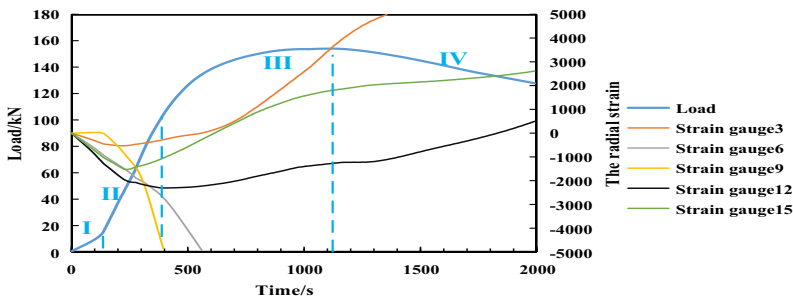


Fig. 11. (90° strain + load) - time curve.

According to Fig. 10 and Fig. 11, it can be concluded that: (1) At the start of the compression test, in the first II phase, the dish tray arch mouth strain rosette slope increases sharply, known dish tray yield from arch mouth location. In the first III stage, in the dish tray of arch bottom and marginal area of the maximum strain changes, may know the yield, namely the dish tray from arch mouth first yield gradually transfer to the bottom of the arch.

(2) Before the yield of the saucer tray, the strain direction of 0° at each measuring point is opposite to that of 90° , indicating that the stress direction of 0° at the measuring point is opposite to that of 90° . (3) Before submission, that is, the first I stage, each measuring point for the dish tray exposed surface, in addition to the center of the tray bottom sides of 0° direction for tensile strain, the rest of the measuring point 0° and 90° direction are compressive strain. Before yield, the 0° strain increases linearly with the increase of load, while after yield, the strain at measuring points A and B increases sharply; The increase of 90° was slow before and after yielding. The main reason for this phenomenon is that the bottom surface of the saucer tray is not flat, and the contact form between the tray and the spherical pedestal of the testing machine is the point of contact at four angles, and the support point of the tray is four angles.

4. Conclusions

(1) Disc tray compression test, segmenting the pallet load - displacement curve slope is divided into four stages, respectively, II phase I, III stage, IV stage, and each phase presents different deformation law.

(2) If the bottom of the tray is flat, the saucer tray is transmitted gradually from the arch

opening to the base of the arch. The B area of the saucer tray is the main deformation area during the bearing process. If the saucer tray is not flat at the front corner, the tray will be in the best state of stress after the bottom surface is flattened, and the tray will be mainly carried by Area B.

(3) The region where the slope of the strain curve increases sharply with time when each region of the saucer tray is loaded indicates that this region is the main bearing region.

(4) When the pallet compression is 13%~38% of the original height, the carrying capacity of the pallet gradually decreases. When the pallet compression exceeds 38%, the pallet fails.

(5) If the disc tray was observed in the engineering practice turning inward pressing arch mouth, or dish tray compression deformation around 38%, shows that the deformation of tray has been at III stage, will arrive bearing limit.

Acknowledgments

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