Standardization of Packing Dimension for Loading and Shipping Based on the Packaging Module and Logistics Module

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Abstract: This paper studies the rationality of current packing dimension standard; and based on packaging module and logistics module, it puts forward the method of formulating the transport packaging dimension series, analyzes the key point in optimizing transport packaging dimension, brings forward the method of outer packing on bin packing and conducts the optimized choice of container and means of delivery for pallet.

Keywords: packaging dimension standard; packaging module; dimension series; optimization research

Standardization of packing dimension is to increase logistics efficiency by normalization of packing dimension and all space dimensions related to circulation of materials. In the process of standardization of packing dimension, the harmony of packaging module with logistics module is the most important solution[1]. The application of packaging module and logistics module is the key factor in realizing rationality and standardization of general logistics system. In order to realize packing standardization, normalization and serialization, packaging module and logistics module must be studied to adapt to modern high efficiency transport system[2]。

1. Present condition and analysis at home and abroad

As an important general basic standard, packing dimension standard has been given wide attention in all countries. International Organization for Standardization (ISO) formulated over 30 logistics basic standards, such as packing, unit material, handling facilities, pallet, storage facilities and transport equipment; among them, ISO 3394 *Dimensions of Rigid Rectangular Packages—Transport Packages*, ISO 3676 *Packaging; Unit Load Sizes; Dimensions*, and ISO 6780 *General Purpose Flat Pallets for through Transit of Goods; Principal Dimensions and Tolerances* are included. Referring to the ISO standard, each country formulated a series of packing dimension standards. For example, consulting ISO 3676 *Packaging; Unit Load Sizes; Dimensions*, Japan formulated JIS Z0161-1984 *Unit Material Dimension*, American army formulated ANSI MH10.1M-1980 *Unit Material and Transport Packing Dimension, and* China formulated GB/T 15233-2007 *Packing Unit material Dimension.*

Logistics module is the benchmark size of logistics facilities and equipment. Currently, ISO Central Secretariat and European countries basically identify 600mm×400mm as basic modular size. The containerization system with logistics module as its core is the keystone to form a full-process smooth logistics; and based on this, the mechanical equipment and facilities used on all logistics links can form the integrity.

Looking back on the development history of Chinese packing dimension standard, there are roughly three stages. The first stage is early 1980s, when series of packing dimension standards were formulated, and the making of standard then mainly referred to international standard, such as ISO standard, USSR standard, and etc. The second stage is the end of last century, or around the years of 1997 to 2000, when most part of the standards were modified. These modifications reduced categories of packing dimension standard, and embodied some of its own features, but it failed to solve the then existing problems in packing dimension standard of China. Taking pallet standard as example, according to the survey result on pallet size of over 60 domestic pallet producing and circulating enterprises and organizations in 2005 when modifying pallet size national standard, there were more than 10 pallet plane sizes in service, and most of them were used within the enterprise, of which the usage is very chaotic. Therefore, since 2006, China started to make the packing dimension standard that accords with Chinese own situations, and some modifications on the most important four items were made in 2007 and 2008 respectively.

Two types of packing module were stipulated in GB/T 4892-2008 *Dimensions of Rigid Rectangular Packages—Transport Packages*, i.e. 600mm×400mm and 550mm×366mm[3].

2. Formulation method of packing dimension series based on packing module

The formulation of packing dimension series should

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follow the principles in relevant standards. China follows the principle stated in GB/T 4892-2008 *Dimensions of Rigid Rectangular Package — Transport Packages*.

2.1. Analysis of formulation principle for packing dimension series

GB/T 4892-2008 *Dimensions of Rigid Rectangular Packages—Transport Packages* stipulated that the recommended packaging modulus in China are 600mm×400mm and 550mm×366mm. The making of packing dimension series should depend on combination or segmentation of packaging module. The principle given in this standard to formulate dimension series is that the plane dimension of transport packing unit is available via multiplying or dividing packing module dimension by integer.

GB/T 4892-2008 *Dimensions of Rigid Rectangular Packages—Transport Packages* is the substitute for GB/T 4892-2000 *Dimensions of Rigid Rectangular Packages—Transport Packages*. There are two main differences relevant to making principle of dimension series by comparing these two standards. Firstly, in the "principle", "the plane dimension of transport packing unit is available via multiplying or dividing packing module dimension 600mm×400mm by integer; or taking packing unit material dimension as base to calculate by segmentation method" was modified as "the plane dimension of transport packing unit is available via multiplying or dividing packing module dimension by integer". Secondly, it deleted four inappropriate plane dimensions and their arrangement figures that do not fit 1200×1000mm unit material arrangement, i.e. 1200mm×800mm, 1200mm×600mm, 1200mm×400mm and 800mm×400mm. The first modification means the making of packing dimension series is mainly decided by packing module, and the second one deems that whether it fits unit plane arrangement cannot be neglected either.

After principle analysis, this paper deems the formulation of packing dimension series is related to not only the packing module but also the plane size of packing unit. The plane size of packing unit is often the same as that of standard pallet, which is the commonest logistics module. Therefore, this paper suggests minor modification to GB/T 4892-2008 *Dimensions of Rigid Rectangular Packages—Transport Packages*, and the revised version is: the dimension series of transport packing is to get multiple dimension series and segmentation dimension series based on unit packing dimension via multiplying or dividing packing module dimension by integer.

2.2. Formulation method of packing dimension series

According to modification suggestion of principle to formulate rectangular package dimension series for GJB 182A-2000 *Military Materials Rectangular Packages Dimension Series* in previous section, the content of principle is, on the basis of packing dimension series, to use integer to multiply or divide packing module dimension to get rectangular transport packing dimension series. If the integer is used to multiply packing module dimension, the multiple series of rectangular package is available; and the packing module divisor series is available if the integer is used to divide the packing module dimension. The multiple series and divisor series together form the packing unit dimension series.

2.2.1. Formulation of multiple series

Multiple series refers to the calculated dimension series by multiplying the packing module by integer on the basis of unit plane, also called multiple-increase series.

When formulating the multiple series of packing dimension, there must be a unit plane, of which the selection principle is that packing module can array in this unit plane and take the unit plane size as the maximal value in dimension multiple series. For example, the packing module value 600mm×400mm can be arrayed in the packing unit plane of 1200mm×1000mm instead of 1100mm×1100mm; so, it would select the unit plane of 1200mm×1000mm as the maximal value in multiple series, and then calculate the packing module multiple value and unit plane segmentation value, and the two together can calculate multiple series.

Suppose the dimension of packing module is L×B, the integer is 1, 2, 3…n. Then, the formulation process for multiple series of packing dimension should conform to the following flow.

① Select the unit plane dimension M×N conforming to the array of packaging module L×B, and take it as one value in multiple dimension series.

② Calculate the multiple value of packing module L×B. The multiple value of packing module is to multiply packing module by the integer from 1, and the obtained maximal multiple value should not exceed the length and width of unit plane dimension.

③ Calculate the segmentation value of unit plane dimension M×N. It is available via dividing unit plane by the integer from 1, and the obtained length and width of segmentation value should be no less than the length and width of packing module.

④ Compare the packing dimension value in ② and ③, the same value shall be taken as multiple dimension

Table 1. The process of making packaging modulus multiple series.

Packing module multiple dimension				**Unit plane segmentation dimension**		
Multiple	*Side length*			*Segmentation line*	*Side length*	
1	L	B		1	M	N

Packing module multiple dimension				Unit plane segmentation dimension		
Multiple	*Side length*			*Segmentation line*	*Side length*	
2	2L	2B		2	M/2	N/2
3	3L	3B		3	M/3	N/3
:	:	:		:	:	:
n	nL	nB		M	M/m	N/m

series of packing module.

The formulation of packing dimension multiple series is shown as Table 1.

When selecting packing dimension, the value of length at both sides can be taken as packing dimension respectively, that is to say, the packing dimension should not just be restricted in the corresponding relation of dimension on both sides in the table above, whereas it should be their combination. For example, when the value of one side is L, another side can use any of the values of B, 2B , … nB, and their combination forms multiple dimension. In a similar way, the segmentation dimension of unit plane can be obtained.

When comparing the two, compare the length from both sides in the table respectively. The identical value shall be recorded into new table, and the permutation and combination value of the new table is the multiple dimension series of the desired packing dimension series.

The formulating flow of multiple series of packing dimension series is shown as Fig. 1.

2.2.2. Formulating of divisor series

The divisor dimension series formulating is simple, which is similar to the method of standard pallet segmentation. The two sides of packing module dimension is divided by continuous integer from 1, so as to calculate the dimension of all sides, where the maximal value is L×B and the minimal one is M/10, N/10. This step is similar to the standard pallet segmentation process when making multiple series dimension, and packing module is divided by integer to form divisor dimension series, as shown in Table 2.

The flow of the process of making packaging modulus divisor dimension series is shown as Fig. 2.

Table 2. Divisor dimension series.

Segmentation line	**Side length**	
1	L	B
2	L/2	B/2
3	L/3	B/3
:	:	:
n	L/n	B/n

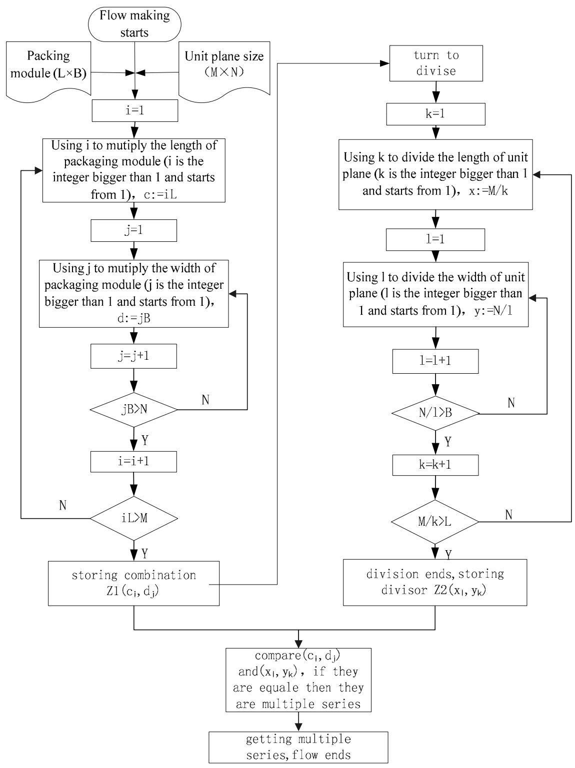

Figure 1. Flow of the process of making multiple series.

3. Coordination of packing module and logistics module

3.1. Analysis of coordination relation

Packing module refers to the dimension base of packing container length and width[4]. The packing container designed according to packing module can better make use of storage and transport space[5]. It takes containerization packaging dimension as base, studies the segmentation of containerization packaging, and conducts combination or dimension that fits combination. Logistics module is the standard dimension of all element dimension of logistics system indicated by numerical relation for logistics rationalization and standardization[6]. It is composed of all elements in logistics system, including: grouping of material, handling equipment for grouped material, moving equipment and equipment truck, lorry, container and transporting facilities, machine and equipment for materials storage, etc. The packing modulization process refers to the module coordination of packing specification, and dimension, and product carrier space or

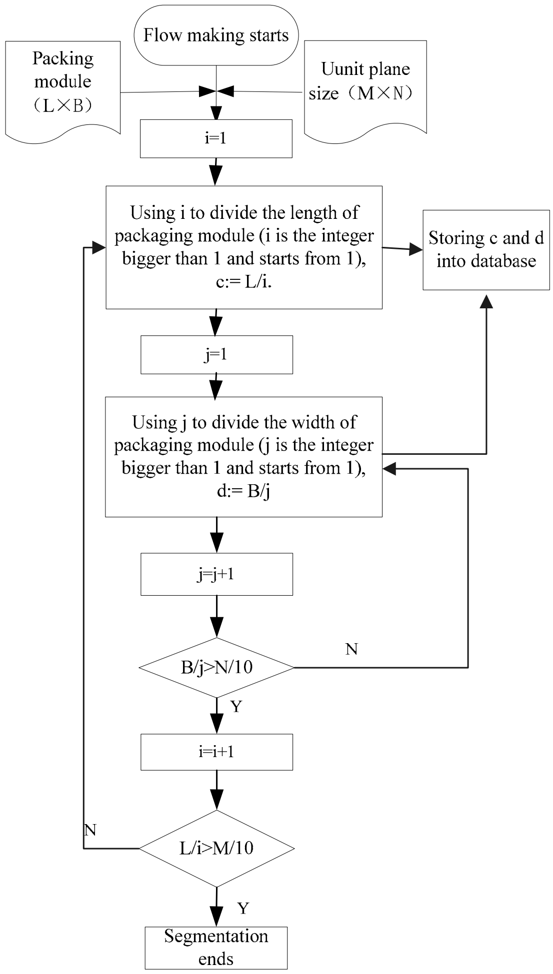

Figure 2. Flow of the process of making packaging modulus divisor dimension series.

plane dimension in circulation environment, and making standard dimension series for the rationalization, serialization and generalization of packing dimension.

This paper studies the interrelated system of bin packing, outer packing, containerization packaging and means of transport. The commonest case among containerization packaging is pallet and container. Due to large volume of container, it is discussed together with means of transport in this section. There is certain interrelation among bin packing, outer packing, pallet packing, container and means of delivery. Their bilateral relation includes the following six types.

(1) Relation of bin packing and outer packing.

(2) Relation of bin packing and pallet packing.

(3) Relation of bin packing, container and means of transport.

(4) Relation of pallet packing and outer packing.

(5) Relation of outer packing, container and transporting tool.

(6) Relation of pallet packing, container and transporting tool.

The six relations are shown as Fig.3. If the bin packing needs neither outer packing nor pallet packing, instead it is directly packaged into container or means of delivery, then the relation of bin packing and container or means of transport shall be studied.

It can be seen from the Fig.3, the packing dimension series formulated through segmentation and combination between unit plane dimension and packing module segmentation is the key to the system. Dimension of bin packing and outer packing should be selected from packing series with pallet as unit plane, which is a value of dimension series. The six relations above can be analyzed on the basis of the two points. Sine bin packing size is small, when having outer packing, the relation between bin packing and outer packing shall be discussed. Selection of bin packing and outer packing should come from packing dimension series, while all values in dimension series can satisfy the requirements for the plane dimension segmentation of pallet. Therefore, there is no need to discuss relation among bin packing, outer packing and pallet. The relation among bin packing, outer packing and pallet packing with container and means of transport can be concluded as the relation between pallet packing and container as well as transporting tool.

From the analysis above, it could come to the point that among the six relations, the relation between bin packing and outer packing, between pallet packing and container, and among transporting tools is the key point of study. That is the 1st and 6th ones among the above-mentioned six relations. Therefore, the following two sections will focus the study on optimizing the selection of outer packing dimension based on bin packing and the selection of pallet based on container and means of transport.

3.2. Optimized selection method of bin packing on outer packing

The relation between bin packing and outer packing is decided by many factors, for instance, their relation on space utilization, economic factor of total cost between bin packing and outer packing, limit of packing materials itself, etc. If the bin packing could satisfy packing module dimension series, then the utilization ratio of outer packing, regardless of the value of selected packing module will reach 100%. The optimized selection for outer packing then shall be decided comprehensively according to actual conditions.

This paper, considering diversified bin packing and starting from the viewpoint of utilizing space alone, supposes x, y is the sizes of the packing dimension series, and m, n is the length and width of bin packing when put in the container at placement state, α , β is the spacing or expansion coefficient among bin packings, that is also the spacing between length and width of every bin packing after placement. θ is the thickness of outer packing container. It can come to the target function as shown in (1) and (2).

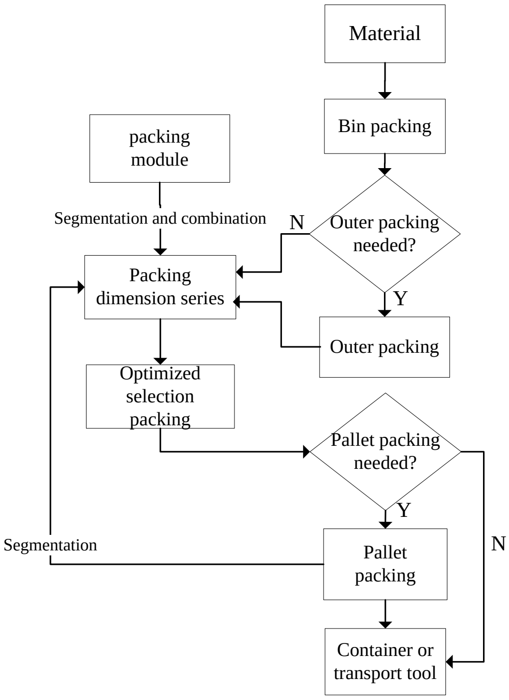

Figure 3. Sketch map of material loading process.

$$\max Z = \frac{xy - [x\%(m+\alpha)-\theta][y\%(n+\beta)-\theta]}{xy} \quad (1)$$

$$\text{s.t}\begin{cases} x \ge m+\alpha \\ y \ge n+\beta \\ x, y, m, n, \alpha, \beta, \theta > 0 \end{cases}$$

or

$$\max Z = \frac{xy - [x\%(n+\beta)-\theta][y\%(m+\alpha)-\theta]}{xy} \quad (2)$$

$$\text{s.t}\begin{cases} x \ge m+\alpha \\ y \ge n+\beta \\ x, y, m, n, \alpha, \beta, \theta > 0 \end{cases}$$

Where the value range of x and y is certain packing dimension series, % is remainder operator, $x\%(m+\alpha)$, $y\%(n+\beta)$, $x\%(n+\beta)$, $y\%(m+\alpha)$ refers to the calculation of x or y on m or n to get remainder. The value z refers to the plane utilization rate of outer packing [the maximum of z should choose the biggest one from (1) and (2)]. The bigger z value is, the higher the space utilization becomes. The corresponding x, y value, when value of z gets maximal, is the optimized packing dimension, and this dimension should be selected as outer packing dimension from dimension series. The flowchart of packaging dimension selection is shown as Fig. 4.

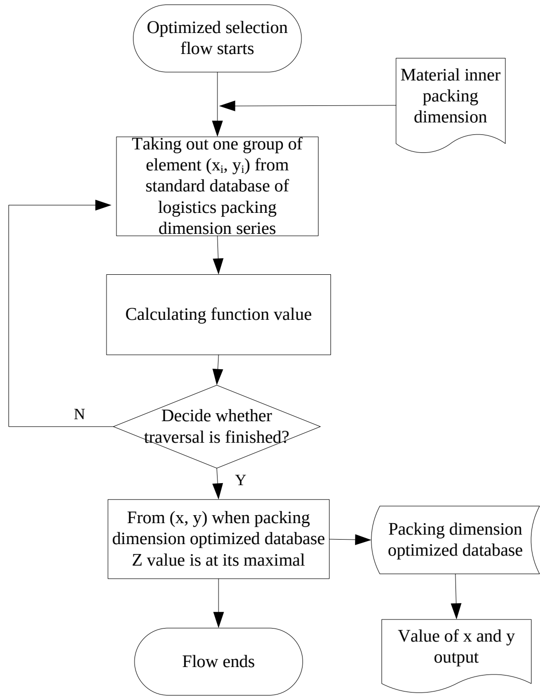

Figure 4. Process of packaging dimension choice.

3.3. Pallet optimized selection method aiming at transporting tool

Pallet specification and dimension are conditioned by goods rack, transport vehicle and container dimension. Only when their specifications are in harmony, could the system be rationalized. There is no direct corresponding relation between goods rack and transport vehicle dimension, but they are all required to match with pallet. Therefore, in deciding the basic parameters of all logistics system equipments, the selected pallet specification should be the first consideration. It can be seen that the pallet standardization is a necessary condition to increase the efficiency and benefit of logistics system. The specification of other equipment should be also matched with pallet specification for coordination so as to enhance the overall efficiency of logistics system. Therefore, pallet standardization, working as ties, plays a very important role in logistics standardization.

GB/T 2394-2007 *General Purpose Flat Pallets for through Transit of Goods; Principal Dimensions and Tolerances* states currently, the recommended pallet in use is 1200mm×1000mm and 1100mm×1100mm[7]. This section conducts optimized selection of means of transport on the basis of these two models of pallet.

1200mm×1000mm pallet is cuboid, so there is a directional problem for placement. There are horizontal

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and vertical directions, and different direction can result in difference in basal area utilization. Suppose the length and width of means of transport is M and N, the following three formulas can be concluded.

$$Z = \frac{MN - (M\%1200)(N\%1000)}{MN} \tag{3}$$

$$\text{s.t} \begin{cases} M \geq 1200 \\ N \geq 1000 \end{cases}$$

or

$$Z = \frac{MN - (M\%1000)(N\%1200)}{MN} \tag{4}$$

$$\text{s.t} \begin{cases} M \geq 1000 \\ N \geq 1200 \end{cases}$$

or

$$Z = \frac{MN - (M\%1100)(N\%1100)}{MN} \tag{5}$$

$$\text{s.t} \begin{cases} M \geq 1100 \\ N \geq 1100 \end{cases}$$

Where (3) represents area utilization of horizontally-placed pallet of 1200mm×1000mm large, while (4) refers to that of vertically-placed pallet of 1200mm×1000mm large, and (5) represents that of placed pallet of 1100mm×1100mm large. By comparison of the three formulas, if any Z value of (3) and (4) is bigger than that of (5), this means of transport fits the 1200mm×1000mm pallet; if that of (3) and (4) is smaller than that of (5), this means of transport better fits 1100mm×1100mm pallet.

4. Conclusion

This paper, by analysis of current condition, study on relevant modulus and determination on packing dimension series making and optimum selection method, provides effective solution to packing dimension standardization. In actual condition, packing dimension optimum selection is complicated, including economic factor, limit of contained goods. This paper conducts some preliminary discussion from the viewpoint of plane utility, and there shall be further study and completion.

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