Stripping Process for Removing Grains; History and Consequence

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Abstract

The process of stripping for removing rice grain was attained before the modern era in Japan and led to the development of the head-feeding type thresher. The head-feeding type thresher incorporates ‘the potential of the stripping principle’— high performance of removing rice grain with low requirement of energy. On the other hand, the stripping action has been generally recognised as the reaping of standing crops. This paper reviews the history of the action and process of stripping with a view of defining the fundamental consequences for further development of existing discussions on removing grains.

[Keywords] stripping action, stripping implements, removing grain, comb shaped instrument,

I Introduction

Removing grain has been one of the highly interesting research targets in academic and technical sectors. Numerous devices have been proposed and some have been developed and put on the market. Those concerned have considered the matter an eternal or perpetual topic and a research target. During the past decade, however, few papers on new concepts for grain removing methods have been presented in dominant journals. This may be attributed more to the accumulation of discussions on the topic through decades and less to convincing practical basic and phenomenal research aimed at device design.

The remarkable research rice paddy threshers (Umeda, 1992a, 1992b, 1992c, 1992d), written in Japanese, have presented an overall solution by fully considering the movement of rice paddy around the threshing cylinder, the relation between impulse and removing, the analysis of removing and the dynamics of the power of threshing. Those papers show that the beating and stripping action of the threshing tooth generate the tensile force and the bending moment that act on the grain and the pedicel. The stripping action of the threshing tooth is characteristically produced by the head-feeding type thresher. The grain removing function of the head-feeding type thresher has its origin in the stripping process with the removing teeth array, senba-koki, which was invented and diffused before the modern era in Japan.

The stripping process itself, for removing and reaping, has been incorporated in some implements since the Ancient Roman Area. This paper discusses the consequences of the stripping process from historical and fundamental viewpoints.

Here, we define some terms used in this paper. ‘Removing’ means fracturing the abscission layer by general external forces, as distinct from the general meaning of ‘shattering’. The removing process is considered a series of actions by external forces that fracture the abscission layer: beating, pressing, grinding and stripping. ‘Threshing’ is the overall term for the removing process, as opposed to its original meaning of beating out grains from the husk. The word ‘stripping’ is used in two ways: the harvesting operation to reap the heads from standing crops (head stripping) and to remove grains from the head (grain stripping).

II Stripping Implements for Removing Rice Grain

The devices of the generic mechanism for removing rice grain by the stripping process were tried out during the decades between the 19th and 20th centuries in Japan. The basic machine of the head-feeding type thresher was developed as a result of these trials, and a patent was applied for it in 1910. Those machines including the head-feeding type thresher originated in the teeth array implement developed at the end of the 17th century and diffused through the 18th century.

The teeth array implement is called Senba-koki, stripping apparatus (koki) with many teeth (senba), for removing rice grains by pulling the sheaf between the teeth (Fig.1). In the history of Japanese rice farming, the removing of rice grain has usually been done by the stripping method and not by the threshing or beating method. The Japonica varieties were grown as usual plants, and the Indica varieties were grown only in primitive farming. Therefore, the threshing method was not widely used, and the stripping method was adopted.
exclusively. Stripping grains at an earlier period was done with Koki-hashii: the grains were stripped from the head with a pair of chopsticks while the stalk was grasped in the other hand. The work efficiency with Senba-koki is not clear from the literature, but it is estimated to have been three to ten times faster than the rate with older tools. At any rate, the new implement solved the labour shortage at that time (Horio, 1974).

Another teeth array implement, concurrently used for cutting off barley heads, was also called Senba-koki or Mugi-koki (mugi is the general Japanese word for wheat, barley and so on) to distinguish it from the implement used for removing rice grain Ine-koki (ine means paddy). The implement for removing rice grain consisted of teeth spaced at 1.5 to 2.0 mm from each other. The slight enlargement of the space does not obstruct the passage of grains. The teeth were made of iron for resisting abrasion by paddy stalks and branches. The implement for cutting off wheat or barley heads consisted of bamboo teeth spaced at 4 to 5 mm. The abrasion by the wider spacing was tolerated (Horio, 1982).

The implement for barley or wheat required the additional process of removing grain with a threshing flail or a threshing table. That may have been the reason that this implement was not as widely used as the one for rice.

III Stripping implements and Implement in the Roman World

The earliest description of the stripping process is found in “Naturalis Historiae (Natural History)” by Plinius (Roman writer, 23-71 AD); ‘Gallic farmers gather both varieties of millet ear by ear with a comb held in the hand’ (Leob Classical Library no. 371, p.347), where ‘both varieties’ were common millet and Italian millet. Columella (a contemporary of Plinius) also described the comb in his “De Re Rustica (On Husbandry)”: ‘many gather the head only with forks and others with combs.’ (Leob ibid, no.361, p.216).

Those demonstrate that the reaping operation was done by selecting ripe heads. This comb-shaped tool, pecten (generic Latin word for comb), was also used for millets harvested in Egypt and in the northern area of West Africa (White, 1967).

The reaping implement cited in the Roman literature was the two-wheeled carrier on the front edge of which a comb-shaped device was attached. Plinius called the implement vallus in “Naturalis Historiae”: ‘On the vast estate in the province of Gaul very large farmers fitted with the teeth at the edge and carried on two wheels are driven through the crop by a pack-animal pushing from behind, the ears thus torn off into the frame’ (Leob ibid, no. 371, p.374). Palladius (Roman writer in the 4th century AD) provided another description, carpentum, in “Opus Agriculturae (Treatise on Agriculture, sometimes known as De Re Rustica (On Husbandry)): ‘In the plane of the province of Gaul people employed the implement of labour and time saving for harvesting with the aid of a single ox. They made the two wheeled cart of which square surface is made of planks, slope outwards from the bottom, and so provide a large space at the top. The array of teeth is set up on whole width of the front end and bent back at the tips; the height is lower than other planks, to match the height of crop head. The teeth are bent back. (some lines omitted) When the implement is driven through the standing crop all the head are sized by the teeth and piled up in the cart, leaving the straw in the field.’ (Collection des universités de France, VII, 2, p.2-4). The optimum period operation of harvesting is described in “Rei Rutica” (Leob ibid, no.361, p.215). Those cutting implements were introduced for a short operating period to develop a management strategy for large-scale farming, latifundium (Fig.2).

The material of the teeth, not mentioned in either description, was probably some metal because the teeth were made bent backward. When the head of the crop was pulled,
the deflected teeth snapped the head back into the cart. The heads reaped by the implement were brought to the house and threshed by sledge, flail or animal tapping ("Naturalis Historiae", Leob ibid, no. 376).

The rotating-combs reaper was proposed by William Pitman, and an illustration was published in Arthur Young’s “Annals of Agriculture and other useful Art” in 1787. It was composed of rotating combs arranged on a cylinder driven by a pair of animal-driven ground wheels through speed-increasing gears and belt-pulley train. Accordingly, the proposal suggesting that the heads stripped by the combs will be flung into the container set behind the stripping mechanism, might have been inspired by Capel Lofft’s translation of carpentum, but Lofft suggested the impracticality of the use of ‘mechanized’ carpentum (“Annals” ibid).

IV Stripping Implements in the Modern Era

The concept of harvesting standing cereal crops has been adopted for developing practical designs for many trial machines. The stripping device for reaping cereal heads was introduced in engineering publications at the beginning of the 20th century (Fischer, 1910).

The monument of valulus in relief was discovered in 1958 at Montaubau-Buzenol, Southern Belgium. The relief was described as one of a pair of another relief discovered in 1854 at Arlon, details of which were vague because of damage, and which represented monumental evidence elucidating descriptions in the Roman literature. Discussing the reconstruction of carpentum became the object of interest in the field of agricultural engineering (Schweigman, 1962).

The stripper harvester developed at Silsoe Research Institute UK in 1984 and commercially produced by Shelbourne Reynolds Engineering Ltd. was the most successful design, demonstrating the possibility of low energy requirement and considerably good performance because of less front-end losses for hard shattering cereal crops. The discussion on the Silsoe stripper harvester stated ‘Performance of the stripper is more sensitive to machine setting as well as weather conditions than the cutter bar. Reduction of front-end losses certain crop conditions in multi-crop capability are areas that still need further research’ and also ‘Good performance in rice shows the potential of the stripping principle in this crop’ (Tado, 1998).

Another successful prototype of a stripping machine is the flux boll remover in which the stripping cylinder consists of four rotating combs suspended by parallel linkages. The teeth are spaced along the comb, widely to closely, in the direction of stalk movement (Karpenko, 1968). This was the mechanized flux remover of the indigenous stripping comb, which originated in ancient Egypt (White, 1967) and has been propagated and used in Eastern Europe.

V Stripping Procedure for Reaping Heads and Removing Grains

The stripping process has merit as a head-cutting device for harvesting standing crops, has not? The drawbacks accompanying the stripping action are shown in the illustration in the review by Tado et al., 1998, where the author describes the conditions of the experiment as follows: when the wheat head was stripped by the comb, the grains at one quarter or one third from the bottom of the rachis were removed before the rachis was broken. This tendency may occur in any design of comb-type stripping device.

Such tendency is observed in wheat and barley, but not in rice; therefore, the difference between these cereals has to be considered; the fundamental differences are the location where the grain is borne and the structure of the head (spike type). Some wheat and barley grains near the bottom of the rachis are borne on the rachis through small rachises, and the grains near the upper part are borne directly on the rachis and in tight contact with each other. The grain near the bottom of the rachis subjected to the force of the stripping action moves with the deflection of small rachises, and fracture stress occurs in the abscission layer. The removal of the grain forces neighbouring grain to be removed. With the stripping action moving forward, the applied force is distributed over multiple grains and the cross-sectional area of the rachis decreases, leaving some grain non-removed and the rachis broken. On the other hand, rice grains are independently borne through pedicles on a branch. The force of the stripping action is applied directly to each grain. This clearly explains ‘good performance in rice’ in the review (Tado et al., 1998). ‘The potential of the stripping principle’ in the rice paddy has been shown in studies on harvesting standing crops with the use of comb removing implements, and the quantitatively lower energy requirements compared with the head-feeding type (Kawamura et al., 1971, Horio et al., 1972).

The good performance of the flux boll remover is also explained from the same viewpoint.

The reaping implements in the Roman World went out of existence with the decline of the Roman Empire, and historians explain that the need for time and labour saving in large scale farming, latifundium, disappeared. Besides the socio-economical reason, a fundamental mismatch existed in the front-end layout of comb device: the stripping process for reaping heads involved removing grains from spike-type millets, grains borne on branches. Many of the removed grains could be gathered by manual operation of pecten, but implement operation resulted in front-end losses by the stripping device.
VI Concluding Remarks

The discussion might be remarked by the consideration on the bearing of a rice grain. A pedicel is crooked, therefore the tensile force applied to the grain produces the stress distribution on the abscission layer where the magnitudes of tensile, compressive and shearing stress are given by the curvature of the pedicel, depending on the number of days after heading and on varietal characteristics (Fig.3, Kawamura et al., 1968). This discussion has focused on hard-shattering varieties, Japonica, considered suitable for removing by stripping, and has led to several studies (Lee et al., 1984; Ichikawa et al., 1994a, b). The abscission layer fracture at stress level will provide data for developing new methods of harvesting rice not only by the stripping process but also by other threshing processes. The characteristics of shattering in Indica varieties have become harder during these past decades; some behaviour is not explainable without taking into account the abscission layer at stress level, which the author has ascertained through experience and some measurements. Similar viewpoints will, hopefully, promote research on removing rice and other cereal grains, by the readers of this Journal.

References


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