Impact Machines in Flour Mills: Are they Still Needed?

Bhadriraju Subramanyam (Subi), PhD
University Distinguished Professor
Department of Grain Science and Industry
Kansas State University, Manhattan, KS 66506
Email: sbhadrir@ksu.edu
Tel: +1 785-313-7178
Website: www.grains.ksu.edu/spirel

IAOM-SEA Conference & Expo
October 2-4, Penang, Malaysia

Impact

- Impact, abrasion, or crushing occurs when
  - Harvesting, moving product, processing, and impact machines
  - Elevators-grain turning (why do you turn the grain?)
    - Grain turning means moving grain from one bin into another to break up temperature differences
  - Higher insect mortality with pneumatic conveyors (multiple impacts) than with drag, belt or screw conveyors

Advantages and Limitations

- Advantages
  - Non-toxic, no chemical residue, insects may not develop resistance (physical method of killing insects)
  - Can be placed in stream (on-line system)
  - Operating costs-may be cheap or expensive
- Disadvantages
  - Kernel damage - Depends on product, process, speed of impact and moisture of grain
  - 100% insect control not reached in all methods
  - Not a long-term control method

Insect Mortality from Impact

- Instantaneous effects
  - Kills or damages adults/immature stages
- Delayed effects
  - Affects development if insect is damaged
  - Moisture loss from abrasion or wounds on insect's body caused by impact

Sources of Impact

- Conveying
  - Screw – 80% adult and 60% larval mortality
  - Pneumatic
    - wheat 90-100% adult mortality of rusty grain beetles
    - Longer the distance, higher the mortality
- Turning – impact grain-to-grain, conveying, disturbs the grain mass and insects, helps break up hot spots
- Processing – Hammer mills, roller mills, etc.
- Impact machines and infestation destroyers

Examples of impact machines

SERIES 27-3CBP ESA®
BELT DRIVE

SERIES 40-1CDP EID®
DIRECT DRIVE
1000CWT

More pictures of impact machines

Location of motor can vary. The motor provides the needed velocity for the rotor

Locations where the machines are installed

- To break open kernels with internal insects and external insects-all stages-in tempered or untampered grain
  - To extricate insects from insect-damaged kernels (IDK): tunneled or bored kernels are IDK
  - IDK contribute to fragment counts in flour if not removed
  - Primarily in cleaning house before milling
- To kill red and confused flour beetle eggs in flour prior to packaging

Internal Feeders

Weevils

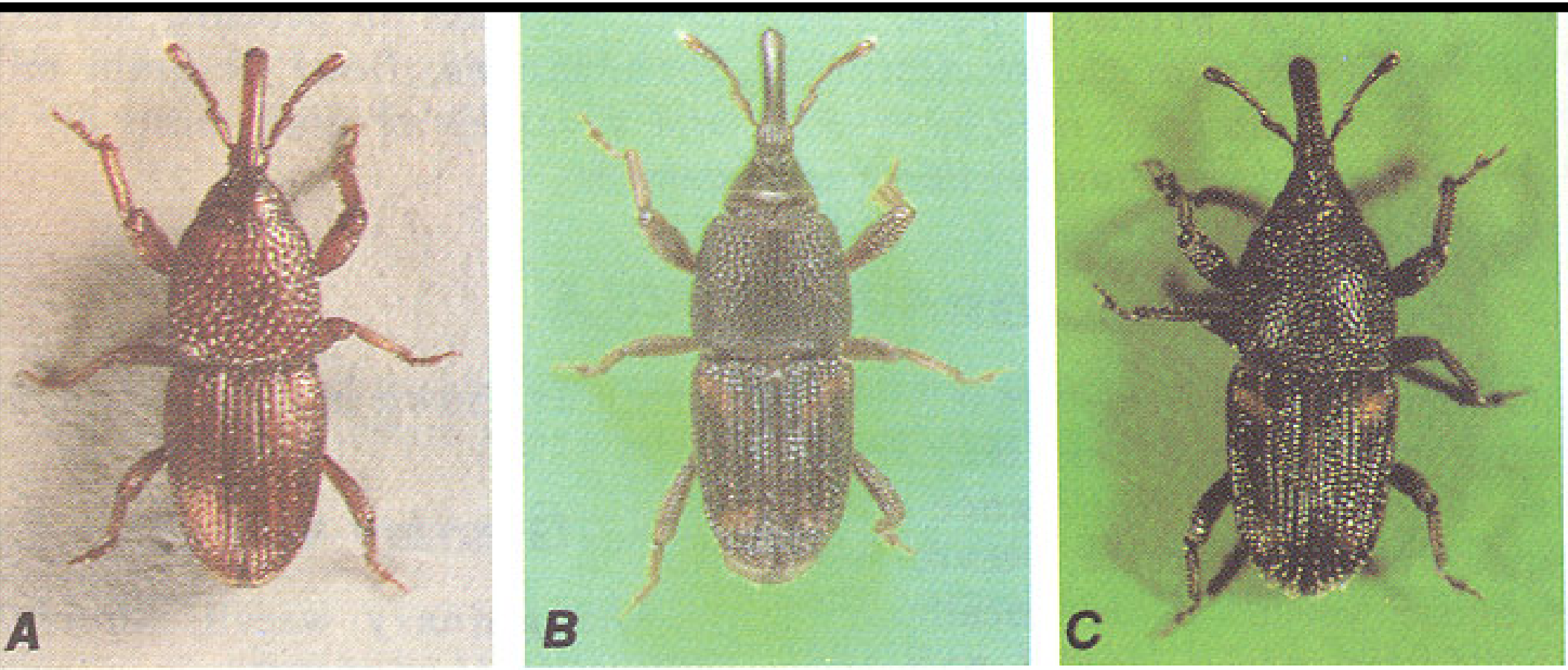
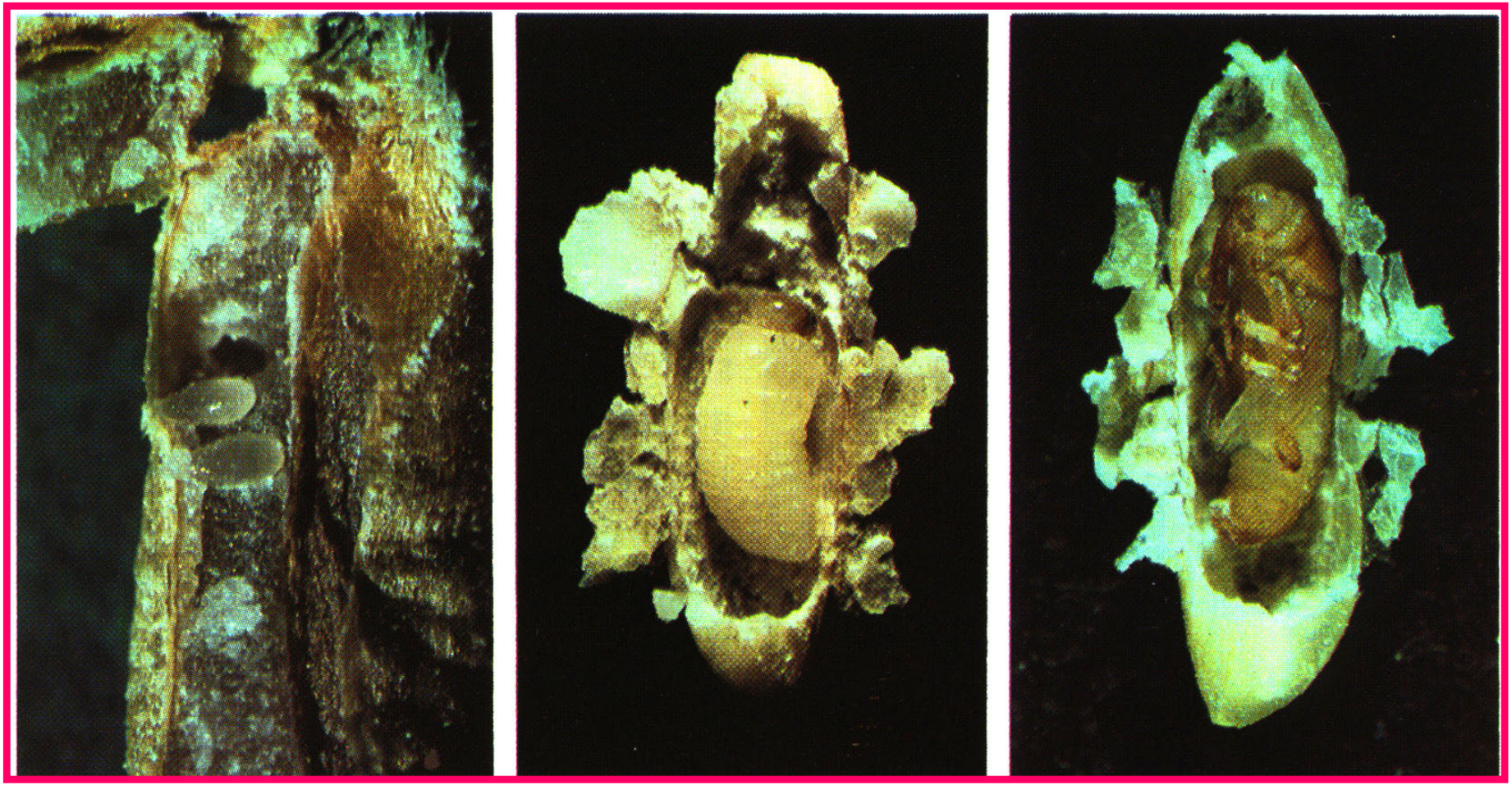


Figure 1.—Grain weevils: *Left*, Granary weevil adult; *center*, rice weevil adult; *right*, maize weevil adult.

Immature Stages of Weevils



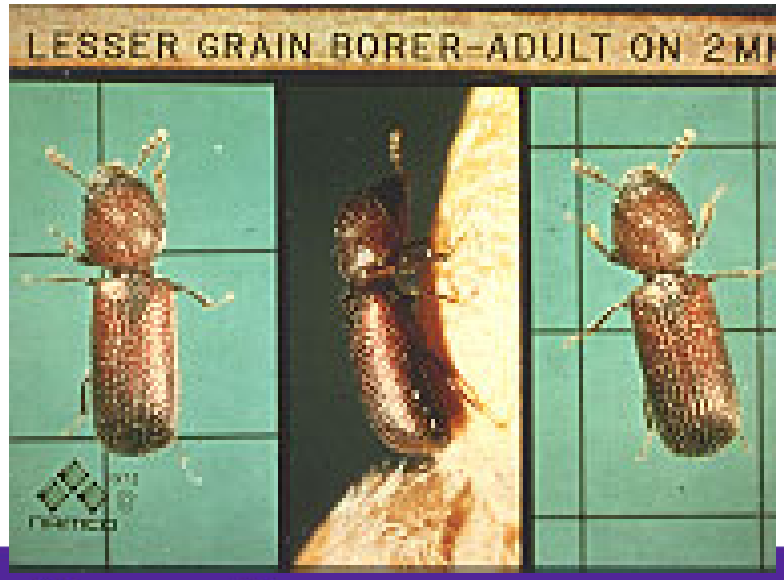
KANSAS STATE UNIVERSITY

Egg Larva Pupa

Internal Feeders

Moth

Borer



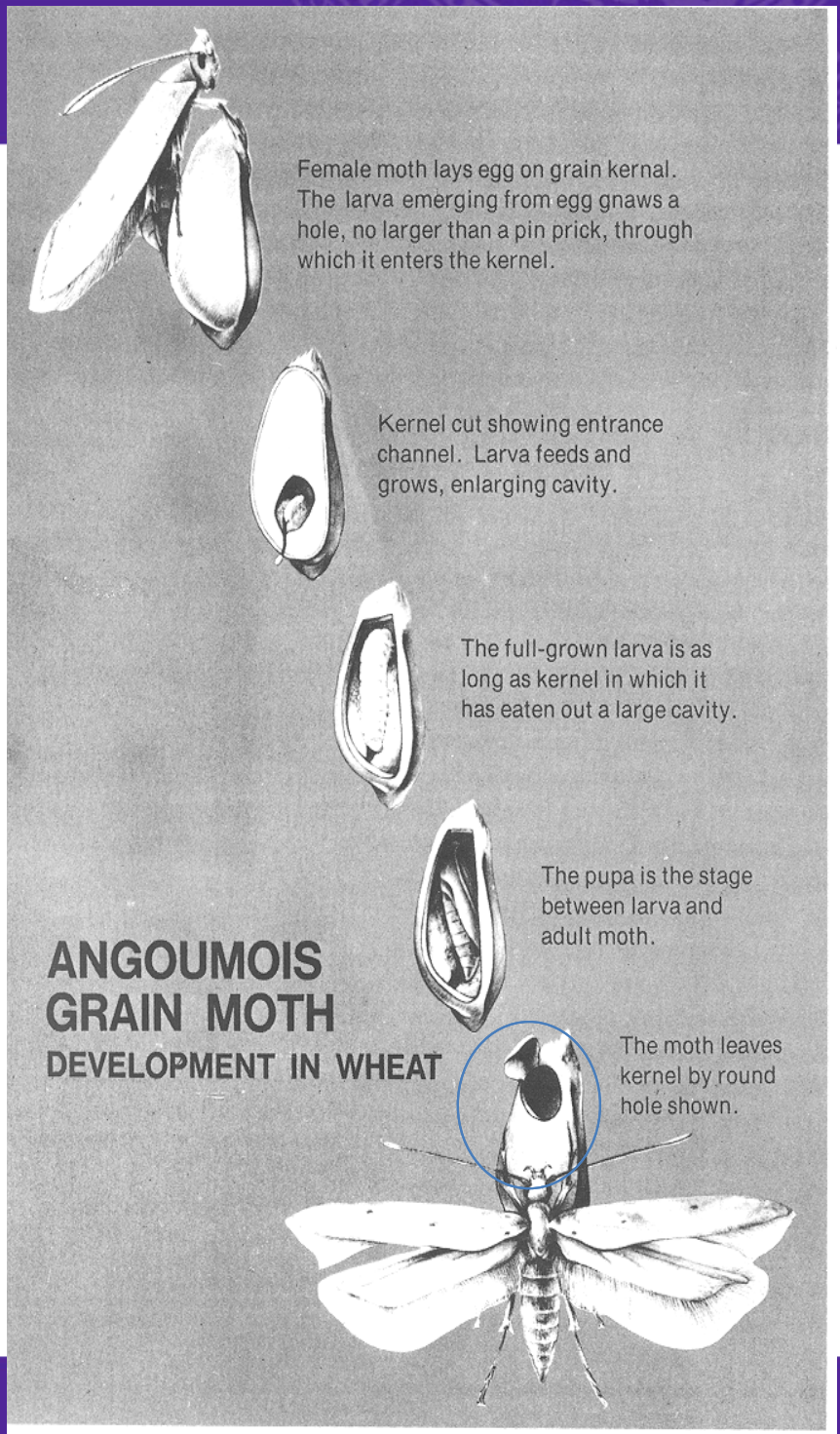
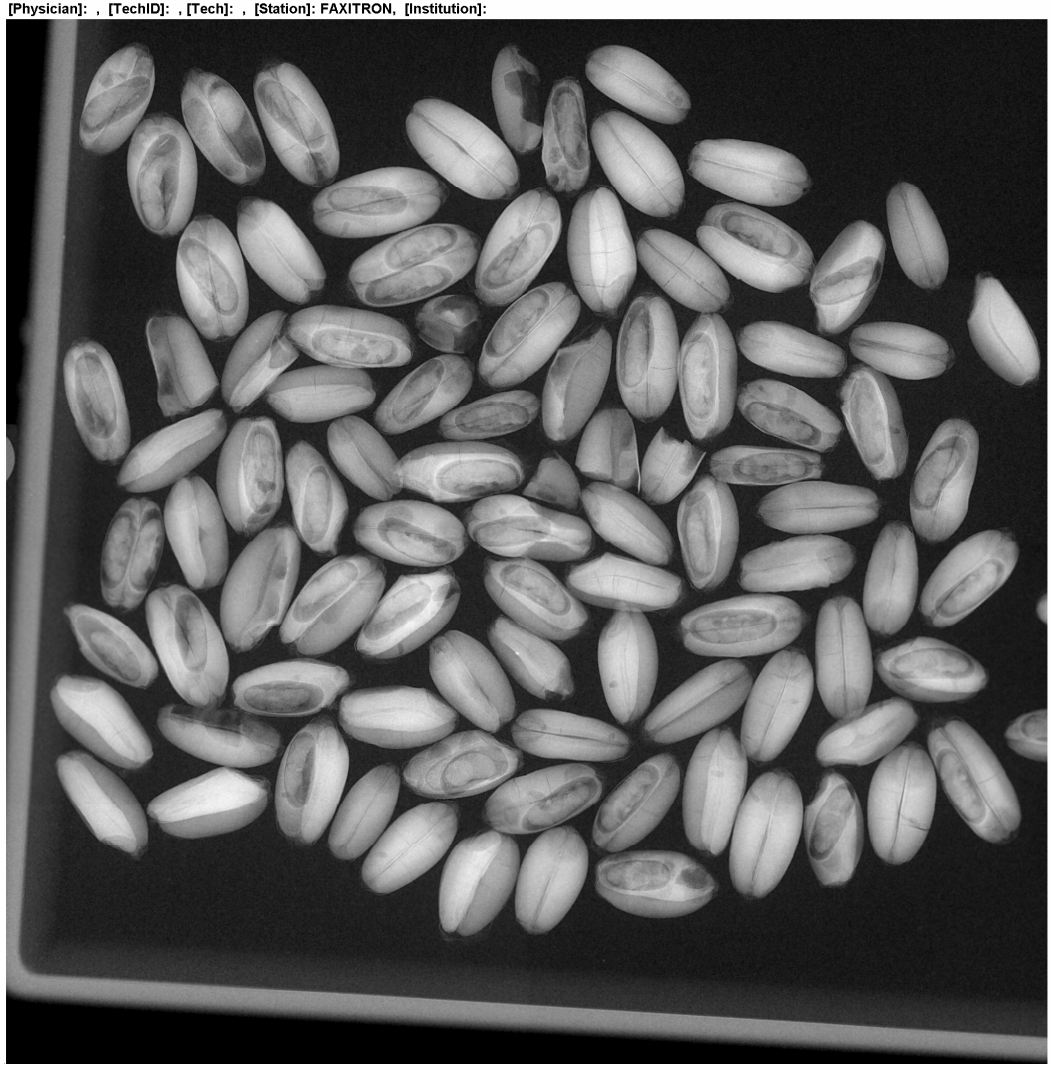
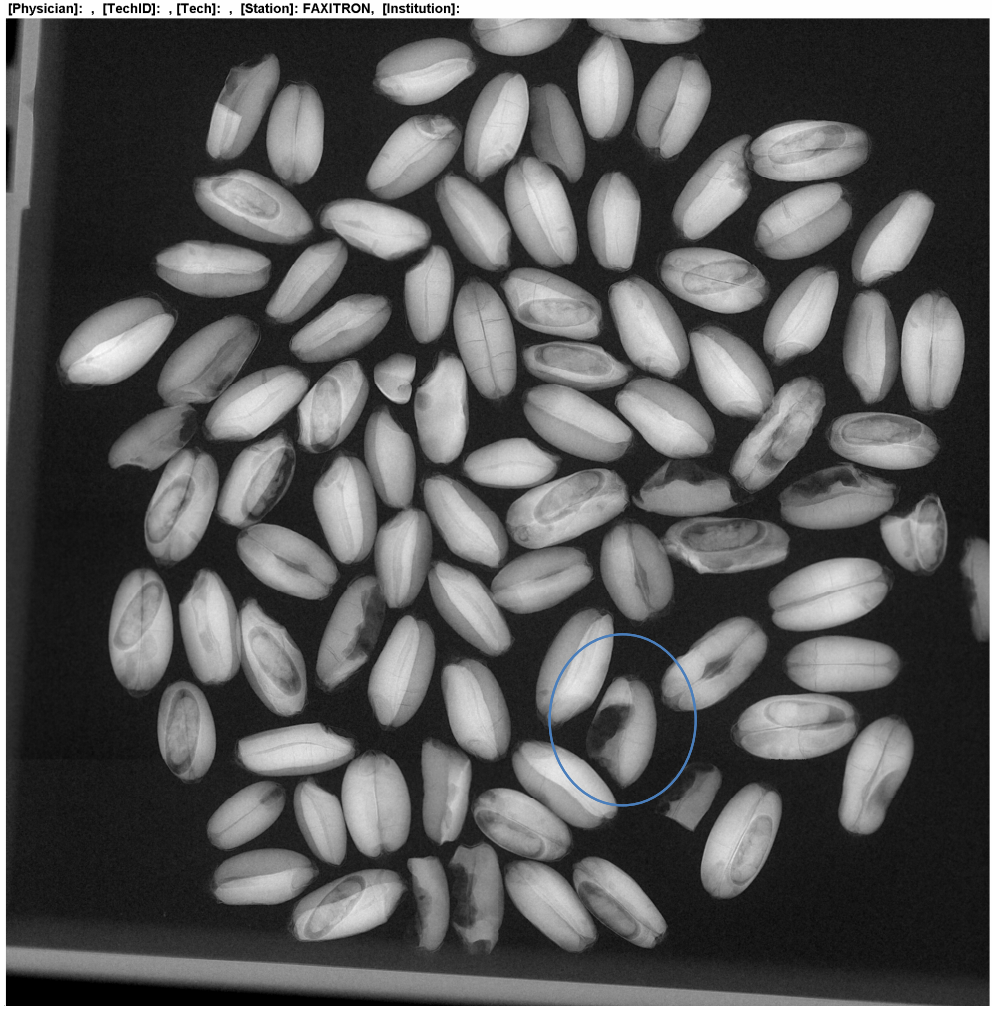


Figure 11.—Life cycle of the Angoumois grain moth on wheat.

[PatientID]: 1-1, [Access#]: 1, [Name]: RW1, RW, [Gender]: , [Time]: 2008/06/23 11:55:29
[File]: I20080623115529, [StudyID]: , [Study]: , [Proc]: , [Position]:
[Physician]: , [TechID]: , [Tech]: , [Station]: FAXITRON, [Institution]:

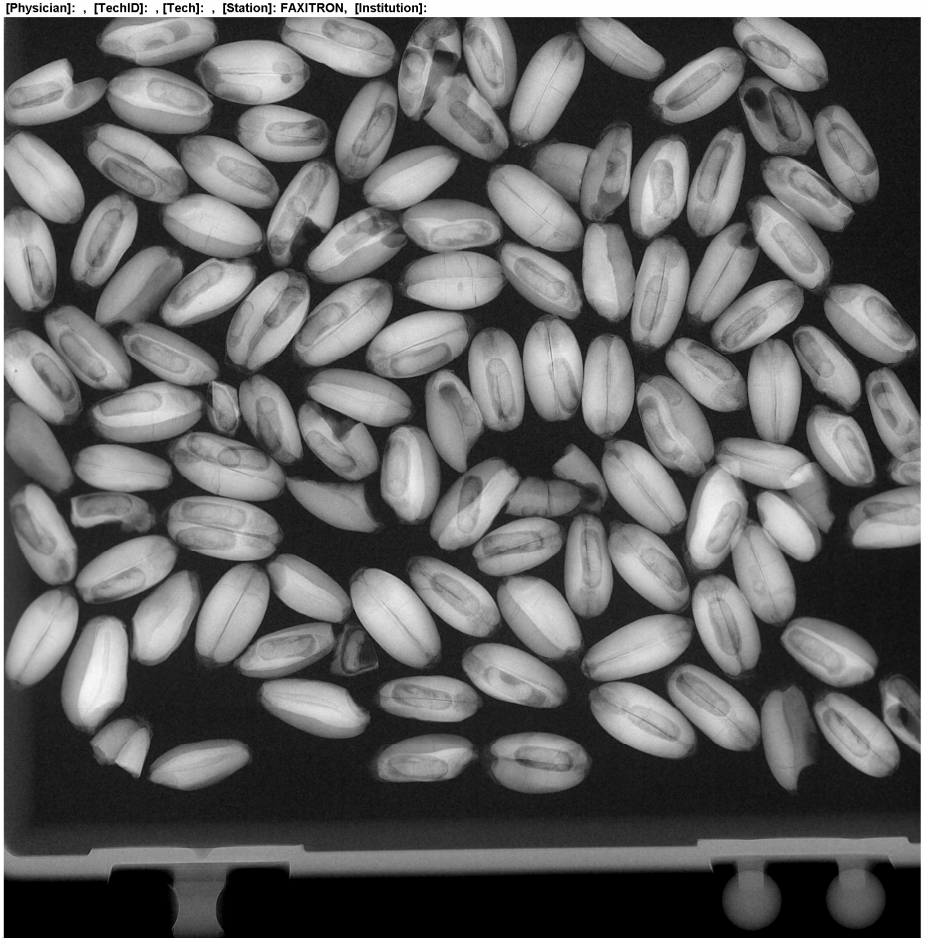


[PatientID]: 1-1, [Access#]: 1, [Name]: RW1, RW, [Gender]: , [Time]: 2008/06/23 12:03:22
[File]: I20080623120322, [StudyID]: , [Study]: , [Proc]: , [Position]:
[Physician]: , [TechID]: , [Tech]: , [Station]: FAXITRON, [Institution]:



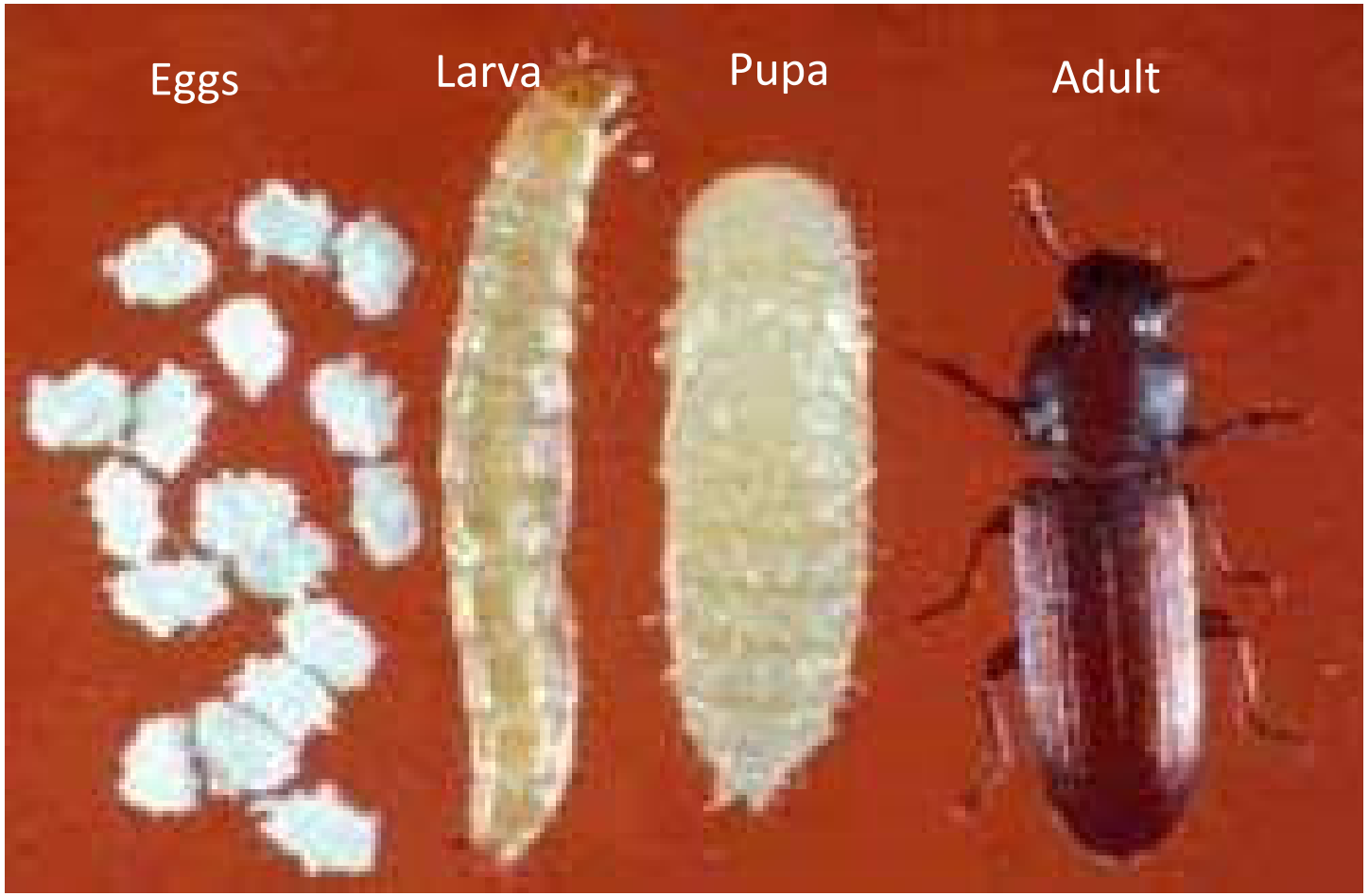
CT scan of rice weevil immatures (larvae/pupae) showing insects developing inside kernels

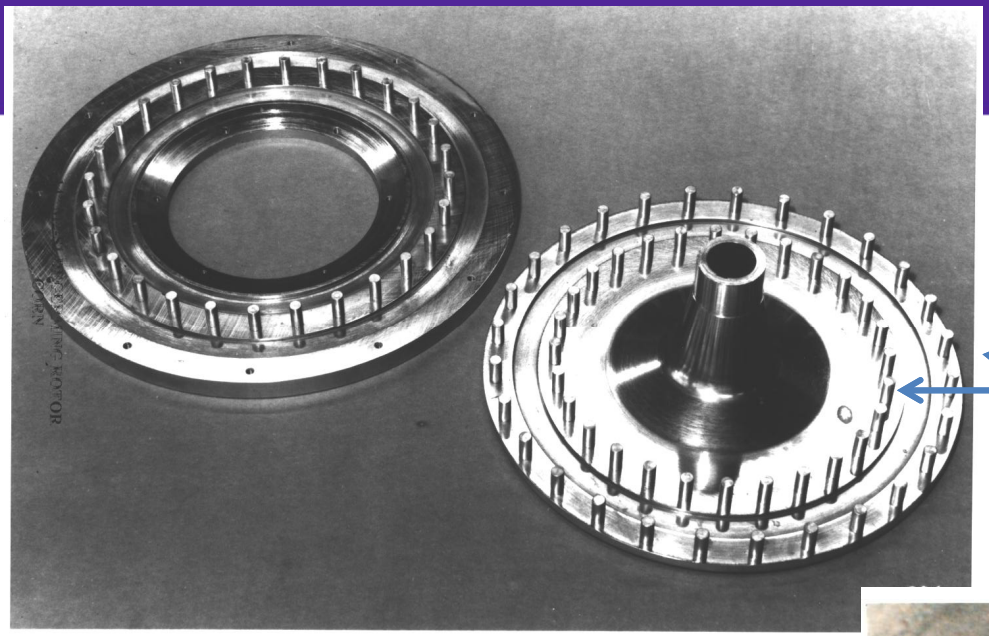
[PatientID]: KMK, [Access#]: 1, [Name]: MK, KM, [Gender]: , [Time]: 2008/06/27 11:34:38
[File]: I20080627113438, [StudyID]: , [Study]: , [Proc]: , [Position]:
[Physician]: , [TechID]: , [Tech]: , [Station]: FAXITRON, [Institution]:



CT scan of lesser grain showing larvae, pupae, and teneral adults

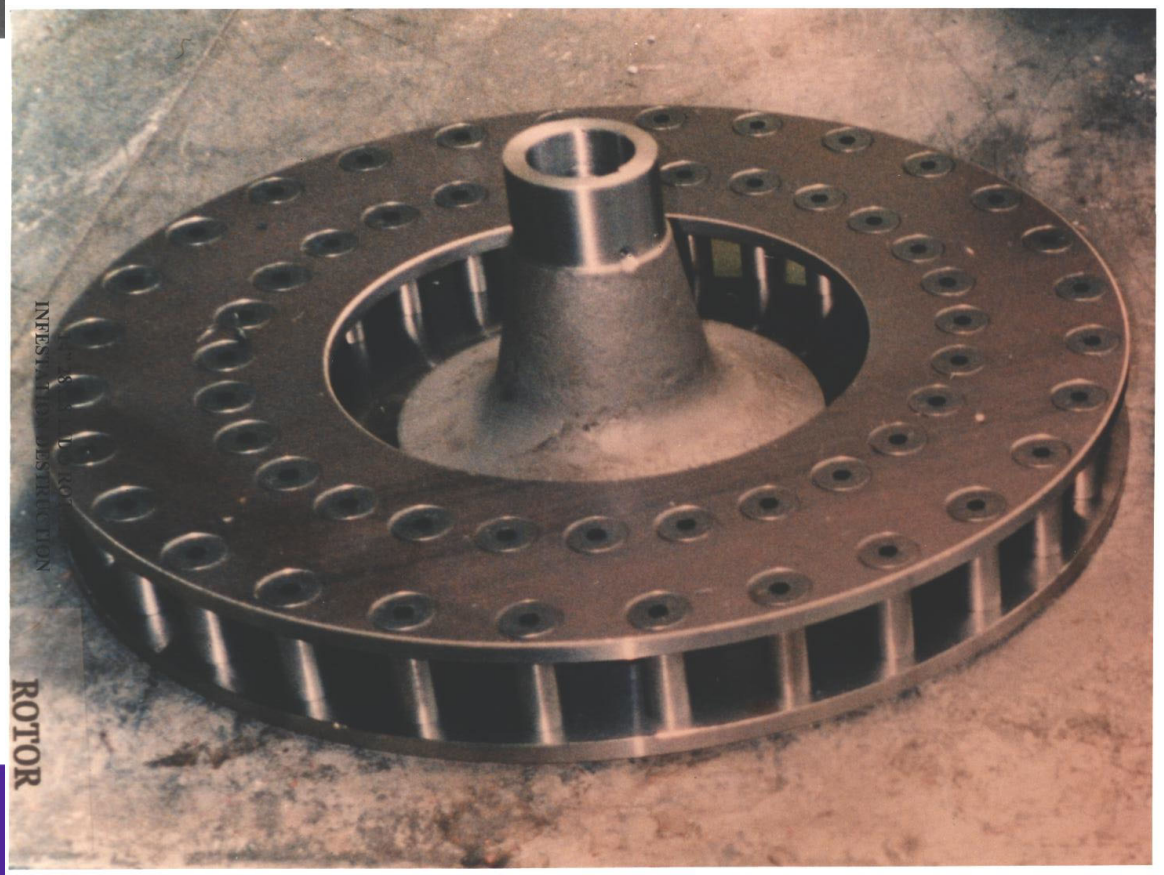
Stages of flour beetles



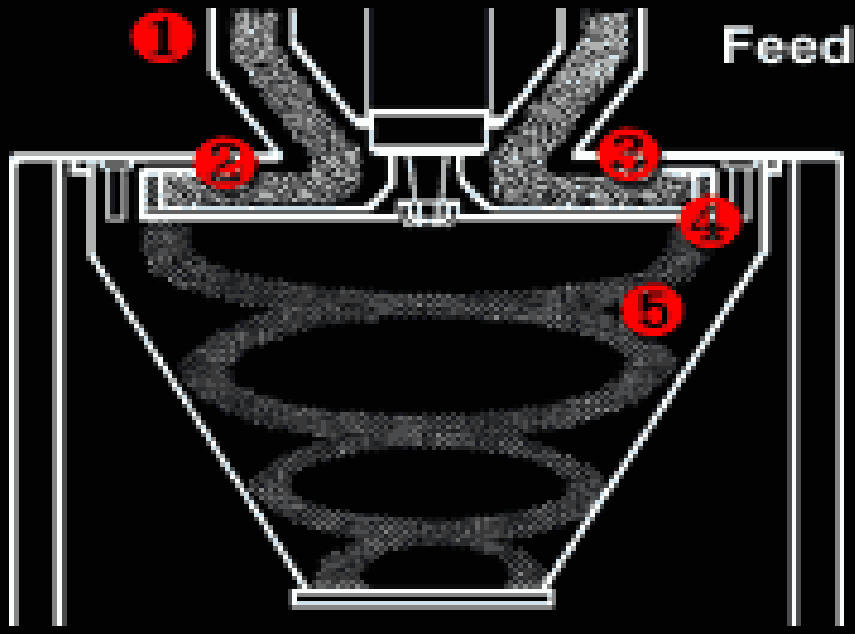


Impact machine rotor exposed

Pegs in two rows offset



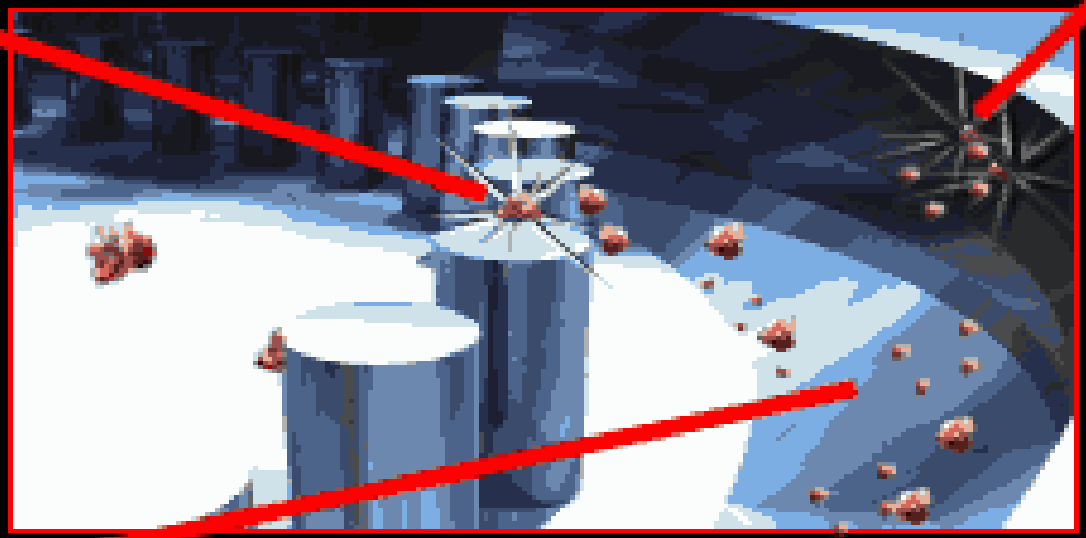
Impact machine rotors
Rotor diameter and velocity may vary



Feed material enters through the top of the mill and is distributed onto the spinning rotor. Centrifugal force hurls the material outward at high speed.

3

Primary size reduction occurs when the material impacts the row(s) of pins.

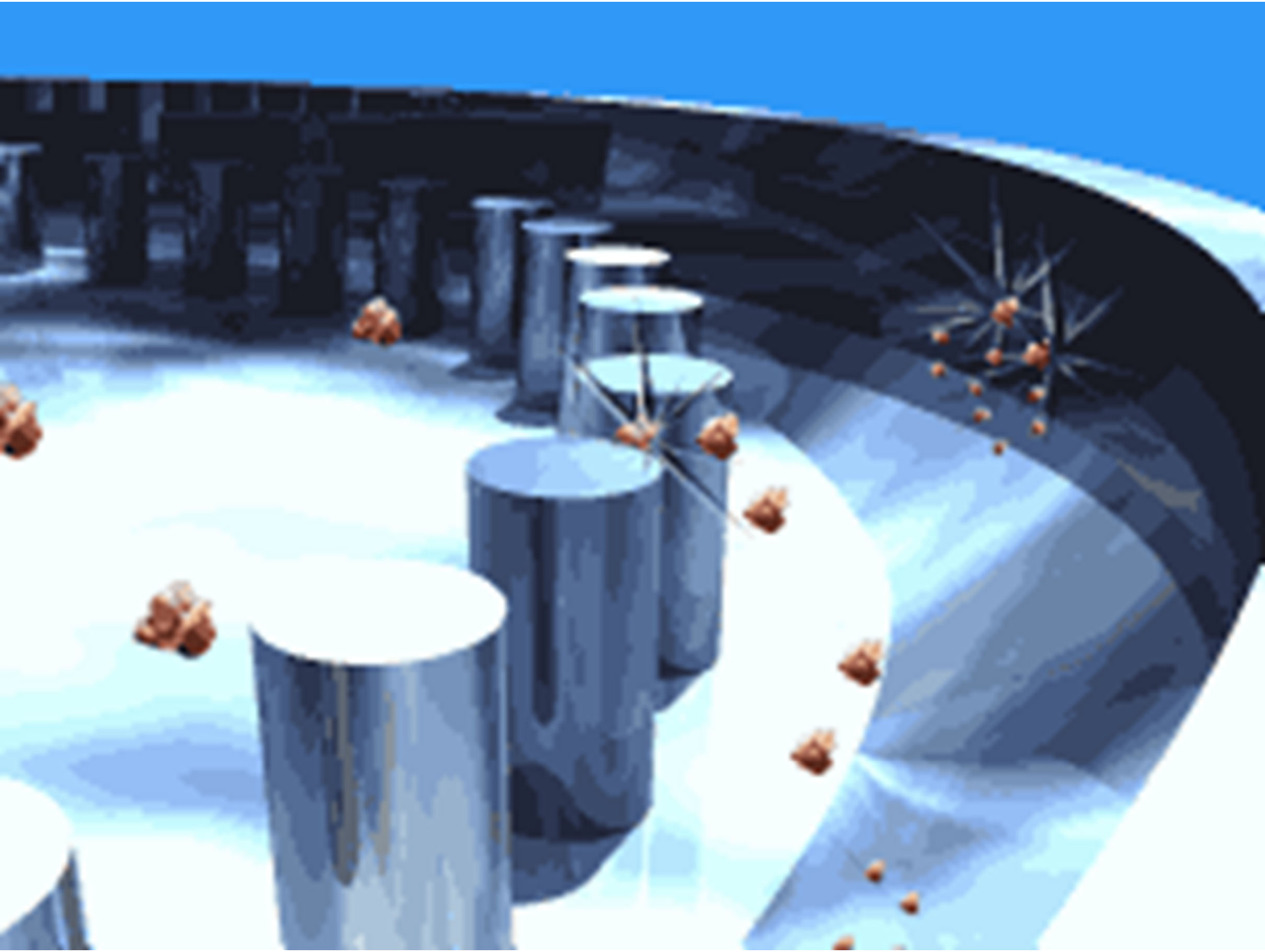


4

After impacting the rotor pins, feed material is discharged off the rotor against a stationary liner for further particle size reduction.

5

The processed material then spirals to the bottom of the conical discharge hopper and into a bin or a conveyer.



Impact Machines or Infestation Destroyers

- NEED IMPACT with STEEL Pegs
  - insects are more susceptible to impact than acceleration
  - Acceleration of 20,000 times gravity (9.91 meters/second) for 1 hour results in only 50% mortality
- Factors affecting effectiveness
- Mortality increases with rotor velocity
- Kernel breakage increases with increase in velocity
- Moisture affects mortality
- Throughput (amount fed to machine) affects mortality

Influence of wheat moisture on broken kernels

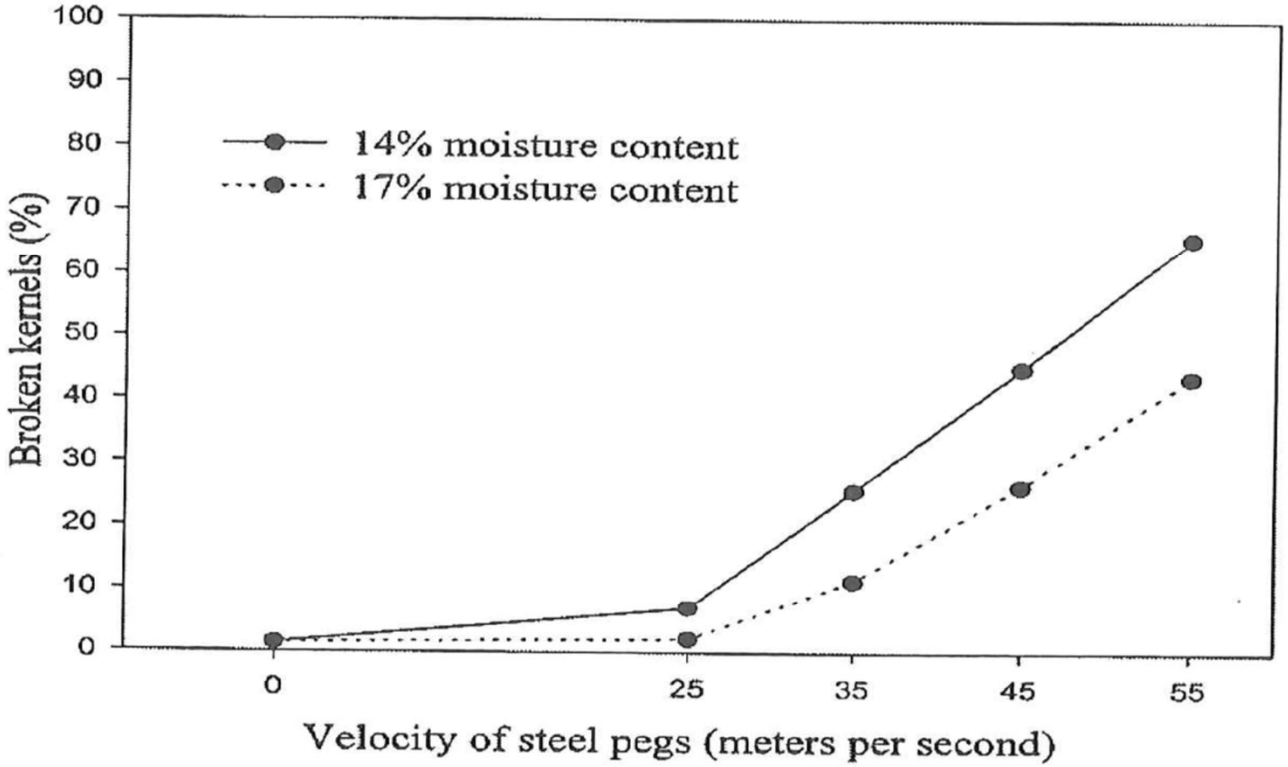


Figure 3 Influence of wheat moisture content on kernel breakage at various steel peg velocities. *Source*: Stratil et al. (1987)

Influence of throughput on broken kernels

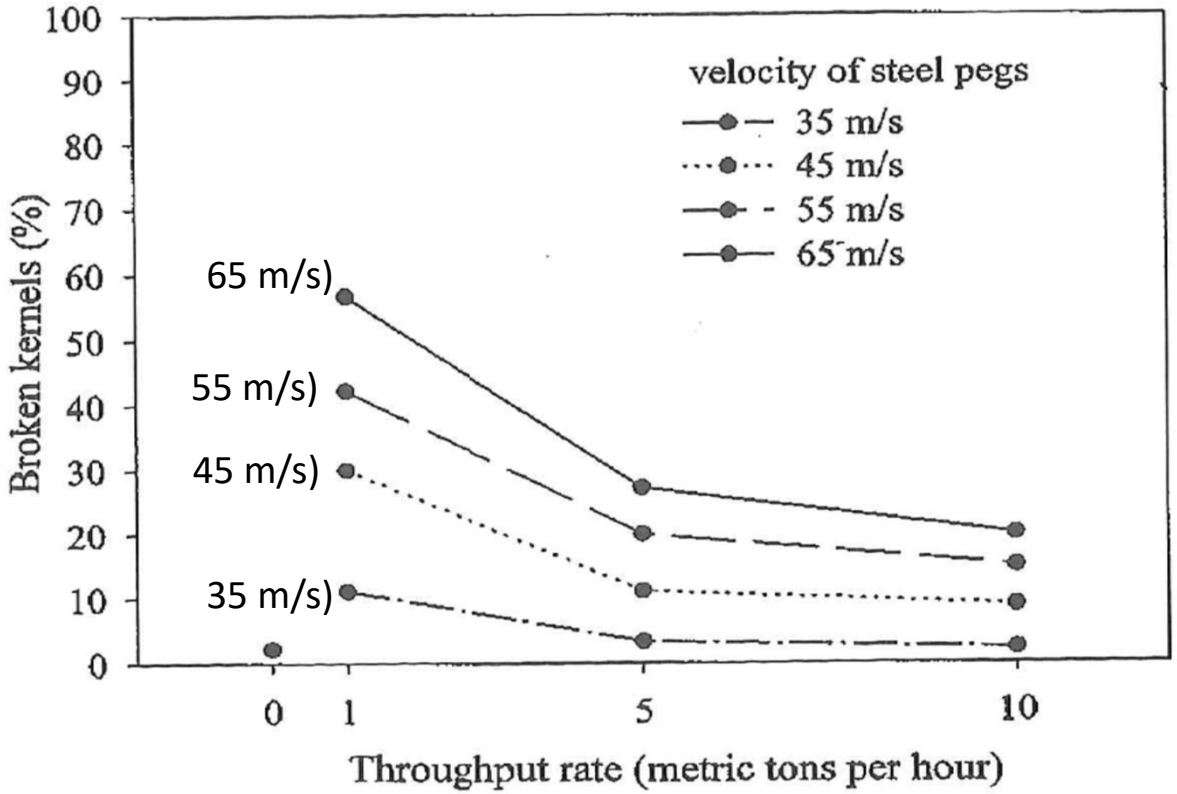
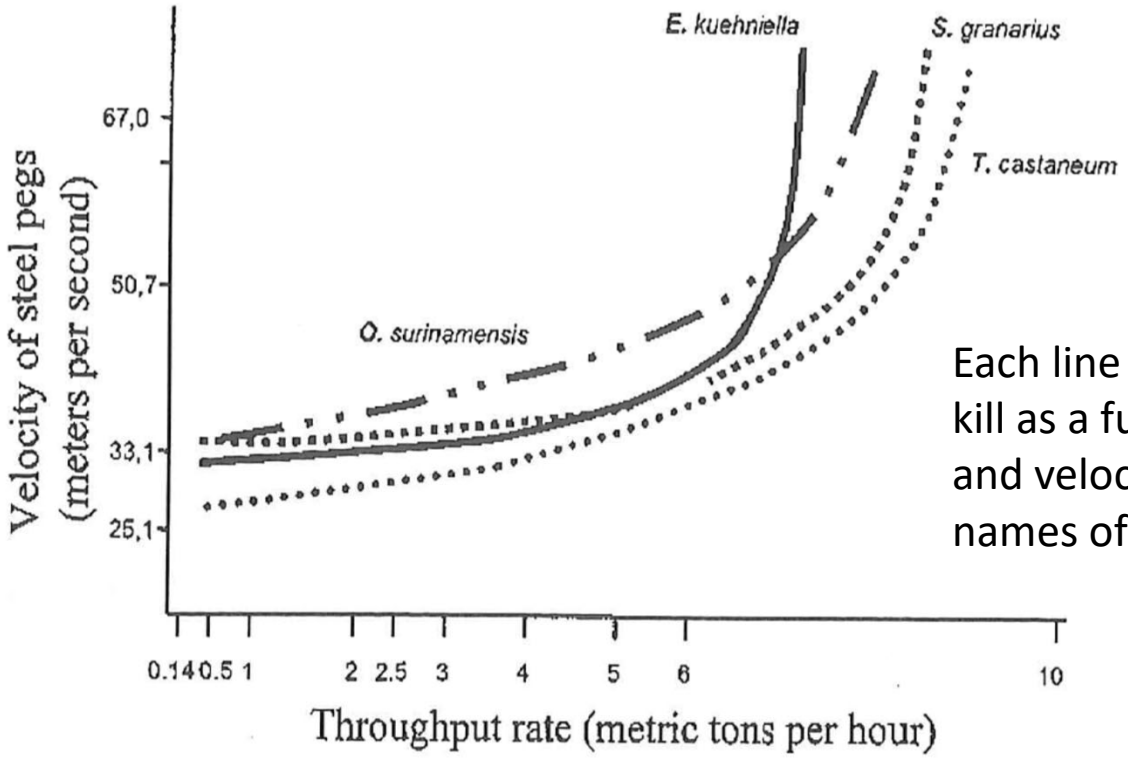


Figure 4 Influence of throughput rates and velocity on percentage of broken kernels. *Source*: Zwingelberg (1988)

Ability to kill 100% of different species varies with throughput and velocity of steel pegs



Each line shows 100% kill as a function of throughput and velocity; see notes for common names of species

Figure 5 Velocities necessary for control of various insect species at different throughput rates. *Source*: Wohlgemuth (1988)

Effect of particle size on power required

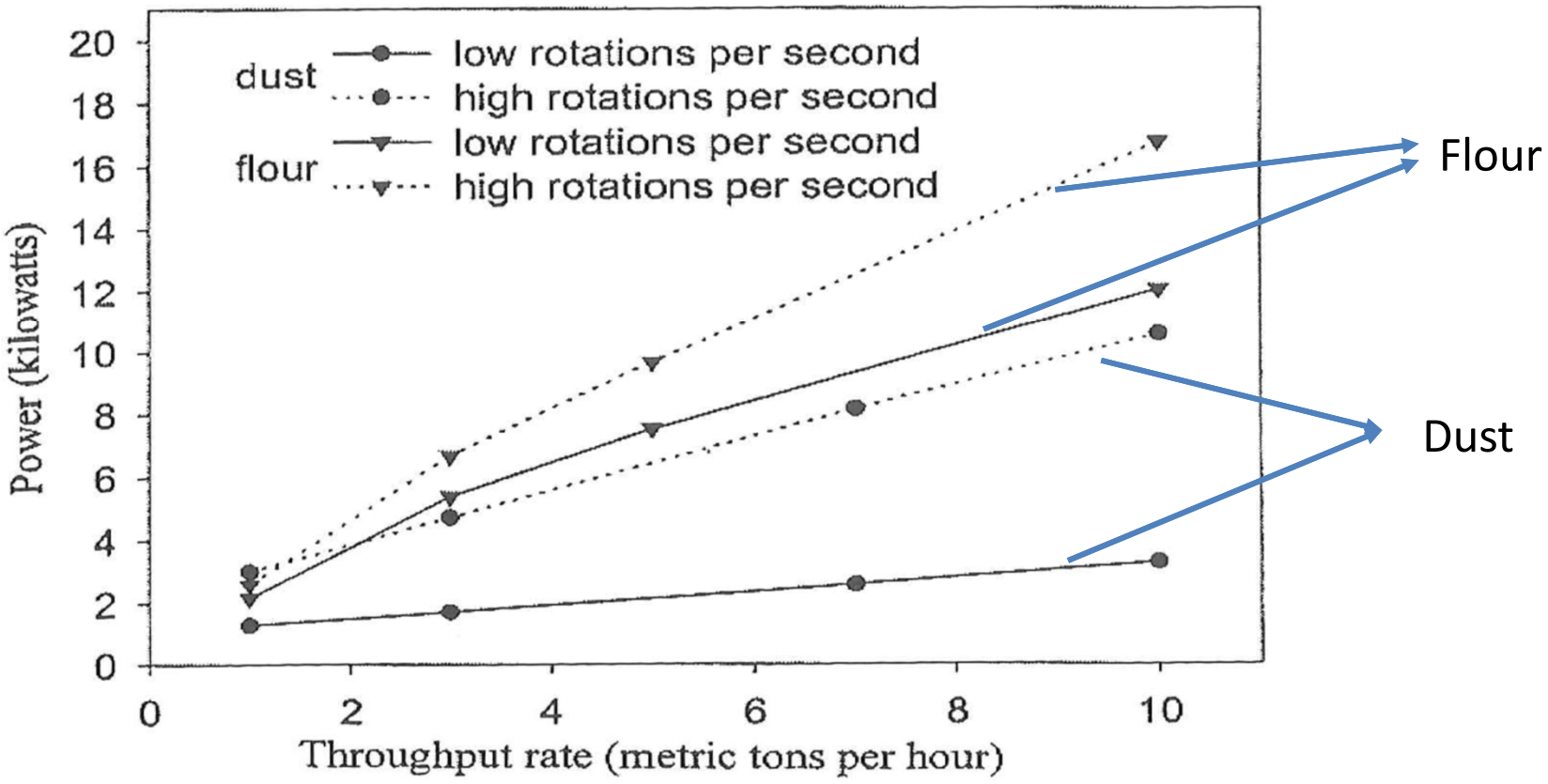


Figure 6 Velocities and throughput rates on power requirements. *Source*: Tognazza (1983)

Reason for installing impact machines

factors can be eliminated by the sowing of pure seed and the handling of each class of wheat separately.

Smut in wheat is of frequent occurrence and is apparently on the increase. Because of the difficulty of removing it and because of its possible harmful effect on the flour, smut lowers the market value considerably; the market discounts for such wheat usually range from a few cents to 20 cents or more per bushel. Smut may be prevented by treating the seed with certain chemicals. One method of treatment recommended is that of dusting the seed with copper-carbonate dust.

Weevily wheat is wheat infested with live weevils or other insects injurious to stored grain. The losses resulting from this factor are considerable. These insects, which multiply rapidly in warm weather, eat the center portion of the wheat kernel and in other ways seriously damage the grain. Sometimes they make it unfit for milling purposes. Proper fumigation of infested grain kills these insects. It should be done as soon as possible after the wheat becomes infested.

Garlic is a factor of considerable importance in the grading of soft red winter wheat but is almost entirely absent in other classes of wheat. The quantity of wheat affected by it and the area of infestation appear to be on the increase. Its objectionable odor is difficult to eliminate and the bulblets tend to clog the corrugations of the break rolls used in milling. It has been demonstrated that through planting of clean seed and the use of proper cultivation methods this weed can be eradicated.

J. H. SHOLLENBERGER.

Impact machines

- First marketed in 1940 in US by Entoleter Co.
- Revolutions per minute-1750-3500 rpm
- Converting rpm (revolutions per minute) to tangential velocity (V) in meters per minute
- V = (22/7 or Π) x rotor diameter in meters x rpm
- rpm=revolutions per minute
- V = meters/minute (1 minute=60 seconds)
- V = meters/60 = meters/second
- Other uses-particle size reduction, mixing, scouring, degerming, and dehulling

Problems and Solutions

- You have 3 variables in the equation
- Π or Pi is constant, 22/7
- Given any 2 variables one should rearrange the equation to calculate the third variable
- Remember: Rotor diameter is always in meters (on a metric scale). If I give radius (r) in inches, one can calculate diameter as 2r, and convert inches to meters (1 inch=0.0254 meters)

Example 1

- Calculate velocity in meters/second given a rotor radius of 14 inches and a rpm of 2500.
- Velocity/minute= 22/7 x (2x14x0.0254* meters) x 2500
- Velocity/minute=5,588
- Velocity in meters/second=5588/60=93.1

*1 inch=0.0254 meters—convert inches to meters

Example 2

- Calculate rpm given a velocity of 40 meters/second and a rotor diameter of 0.6858 meters
- Convert velocity in meters/second to meters/minute
- 40 meters/second x 60 seconds=2400 meters/minute
- 2400=22/7 is 3.14x 0.6858 x rpm
- rpm=2400÷(3.14x0.6858)
- rpm=1114.51

Example 3

- Given velocity in meters/second and rpm calculate rotor diameter in inches
- Velocity=40 meters/second and rpm=1750
- Convert meters/second to meters/minute
  - 40 meters/second x 60 = 2400 meters/minute
- 2400=22/7 x rotor diameter in meters x 1750
- Rotor diameter in meters=2400÷(22/7 x 1750)
- Rotor diameter in meters=2400÷(3.14x1750)
- Rotor diameter in meters=2400÷5495 = 0.4367 meters
- 0.0254 meters=1 inch; 0.4367 meters = ?
- Rotor diameter in inches = 0.4367 meters÷0.0254 meters/inch
- Rotor diameter=17.19 inches

- Flour and Semolina (65-100 m/s flour, 39 m/s semolina)
  - Very effective on all life stages of insects
  - Semolina will abrade waxy coating of insects
  - Very little reduction in particle size
- Whole grain
  - 90% of adults in grain can be killed at 25 m/s
  - Internal infestation cannot be controlled without damaging the kernel
  - Grain moisture will affect breakage and mortality

George Smutny's (1961) observations

- To kill internal insects
- Use two-stage process
- Use 3500 rpm unit with 10.75 inches rotor diameter to break open a tempered kernel (17% moisture)
- Next use 1750 or 2100 rpm unit to kill insect extricated by impact
- Fragment counts = 1 per 50 g of flour
- For flour, use 3500 rpm unit with 14 inch rotor
- Or 27 inch rotor with 2225 rpm (98% kill)
- Feed rate-9000 to 16000 lb/hour
  - Increase hp from 2 to 10
  - 2 hp (25 cwt); 50 hp (500 cwt); current models (150 hp)

Removal of impacted kernels and insect fragments

- After impact grain has to be aspirated to remove insect fragments and broken kernels
- Rice weevil adults contributed to more fragments followed by three week old larvae and one week old larvae
  - Adults produce more fragments than larvae
  - Dead (brittle insects) contribute to more fragment counts

Companies That Make Impact Machines

- Strutevant
- Alapala
- Ocrim
- Buhler
- Spomax
  - 5,000 – 150,000 lb/hour

Are impact machines still needed?

- No
  - If you have a better integrated insect management program (chemical and non-chemical) for wheat storage and your mill
  - We have several tactics to manage insects in wheat
  - If you can source wheat with less insect-damaged kernels or live insects (contracts)
- Yes
  - If you are sourcing infested wheat (32 IDK/100 g of wheat)
  - If your fragment counts exceed 75/50 g of flour
  - If you are regularly finding insects in your grain and mill

FGIS standards for number 1 HRW wheat versus millers' contract specifications

Quality factor	FGIS	Millers
Insect damaged kernels per 100 g	32	7.2
Foreign material per cent	1.0	1.5
Live insects (1000 g)[a]	2.0	0.2
Pesticide residues (ppm)-malathion	8.0	0.0

[a] The presence of two or more live insects injurious to stored grain or one live weevil will cause wheat to be graded 'infested'. The numerical grade is not affected. Based on 32 respondents.

FGIS is Federal Grain Inspection Service

Kenkel, P., Noyes, R. T., Cuperus, G. W., Criswell, J., Fargo, S., & Anderson, K. (1994). US stored-wheat pest management practices: Producers, elevator operators, and mills. In *Proc. Sixth International Working Conference on Stored-Product Protection* (pp. 935-9). Wallingford, UK: CAB International.

How about using them to kill flour beetle eggs?

- Ardent Mills study
- 233 samples from 11 mills
- 3 kg samples collected before and after rebolt sifter, before and after impact machine
- Samples sifted immediately, and incubated for 8 weeks
- Only 2 samples each had 1 dead confused flour beetle and 1 dead red flour beetle

THANK
YOU!