Sponsors

University of Minnesota
College of Veterinary Medicine

College of Agricultural, Food and Environmental Sciences

Extension Service

Swine Center

Using process optimization to design farms

Chalard Duangkaew, DVM, Ph.D. Candidate[1]; Gary D. Dial, DVM, Ph.D., MBA[2]; Yuzo Koketsu, DVM, MS, Ph.D.[1]; David G Thawley, DVM, Ph.D.[1]

[1]Department of Clinical and Population Sciences, College of Veterinary Medicine, University of Minnesota, St. Paul, MN, [2]Iowa Select Farm

Part I: Bottleneck identification

Introduction

The most common way to determine the output of a breeding herd is to use the female efficiency, i.e. farrowing rate, alone. However, one manufacturing concept suggests that the maximum output rate of a breeding herd is determined as the maximum output rate of its bottlenecked station[2] (**Figure 1**). In order to maximize the output rate of a breeding herd, the relative output rate for each station in a breeding herd must be determined and used subsequently to identify the bottleneck. The objective of this study was to apply the fundamental concepts of factory physics to do part of a full model to increase the output rate of commercial swine farms.[3]

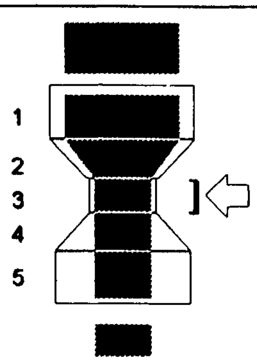
Materials and methods

Thirty-nine of forty-eight farms under a large integrated pig enterprise having approximately 100,000 breeding females in the United States were used in this study. Herd size groups were 1,200 sows (13 farms), 2,000 sows (22 farms), and 4,000 sows (4 farms). Under an integrator, these 39 farms were using the same diets and similar herd operations. Facilities and spaces within a herd size group were built to be identical.

Four stations in a breeding herd were defined:

- breeding station (wean to breed)
- pregnancy check station (breed to pregnancy check)
- gestation station (pregnancy check to pre-farrow)
- farrowing station (pre-farrow to wean).

FIGURE 1: The maximum output rate of a process is determined as the maximum output rate of a bottleneck station



Raw data were obtained and extracted from their computerized production information system (PigCHAMP' and from farm schedules for a one year period.

The process time of each group passing through each station was calculated as the total female days/group at each station divided by the total number of females entering that station. The station rate for each station was then calculated as the total number of spaces divided by the process time at each station. Furthermore, the station rates from gestation stations to farrowing stations were mathematically adjusted for the number of females entering from previous breeding stations to give the adjusted station rate.

Because all 39 farms were being operated on a weekly schedule, 52 process times and 52 station rates at each station, and 52 adjusted station rates for gestation and farrowing stations on 39 farms were obtained.

An example of both average station rates and average adjusted station rates are shown in **Figure 2**. Using adjusted station rates, we have determined the lowest adjusted station rate was a bottleneck on each farm.

Results

A bottleneck at the gestation station was found on 12 farms with 1,200 sows, while the remaining 1,200-sow farm had a bottleneck at the farrowing station (**Table 1**). Of 22 farms having 2,000 sows, two farms had a bottleneck at the breeding station, one farm had a bottleneck at the preg-

FIGURE 2: Comparing adjusted station rates of each station in a swine breeding herd to determine a bottleneck.

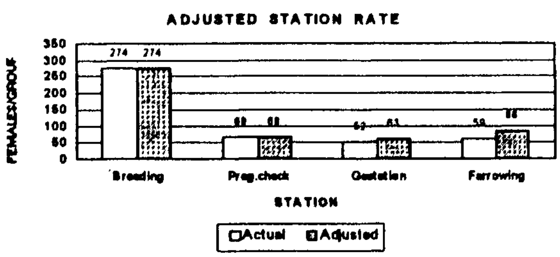


Table 1. Frequency distribution of farms with bottleneck stations by herd size

	Bottleneck found at			
Herd Size	Breeding Station	Preg.Check Station	Gestation Station	Farrowing Station
1,200	0 farm	0 farm	12 farms	1 farms
2,000	2	1	19	0
4,000	0	0	3	1

nancy check station, and nineteen farms had a bottleneck at the gestation station (**Table 1**). Of 4 farms having 4,000 sows, three farms had a bottleneck at the gestation station, and one farm had a bottleneck at the farrowing station.

Discussion

Our observations indicate that:

- A bottleneck of a breeding herd operation can be at any station.
- An occurrence of the bottleneck depends, at least in part, upon the number of spaces allocated to each station and average female days that the females spend at a station.
- The location of a bottleneck varies from farm to farm, even though the farms have near identical designs.

Using the bottleneck information and other information from an information system such as capacity utilization of each station will help us to optimize the breeding herd output with the same set of facilities.

Part II: Bottleneck solving and balancing process

Introduction

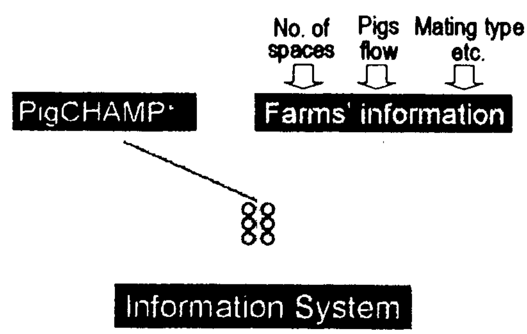
One of the objectives of the swine breeding herd is to produce as many weaned pigs as possible, commonly called output.[1] The major factors affecting the number of weaned pigs output is the total number of females bred and the proportion of these that are subsequently farrow and weaned. Typically, a breeding herd has the four processes or stations as defined above in Part I.

The capacity or maximum output rate of sows farrowed and weaned of a breeding herd is determined by the station rate of the station having the lowest rate of processing, called the bottleneck.[2] Herd capacity is calculated by taking the station having the lowest station rate and applying that to the entire breeding herd. For a given set of facilities, widening the capacity of the bottleneck station alone may increase the capacity of the entire breeding herd. The Capacity Utilization Bottleneck Solving and Balancing Process (CUBS/BP) has been developed with this in mind.

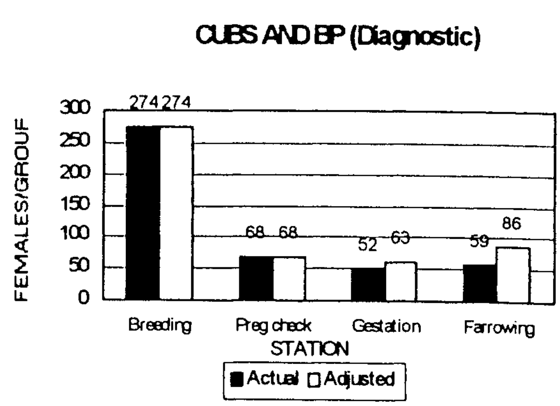
Procedures for CUBS/BP

The CUBS/BP computer model includes 4 parts:

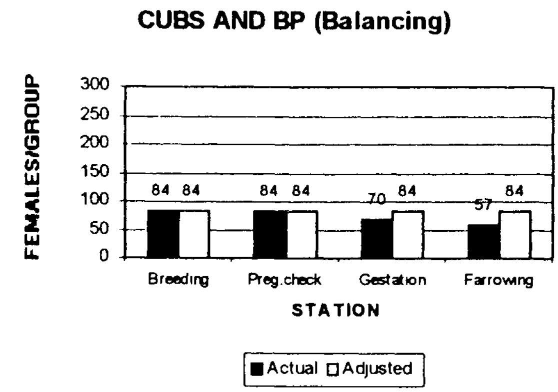
Data extraction. Exported data from PigCHAMP® include weekly production records, farm schedules and the number of spaces at each station. The data were then set up in the spreadsheet templates which provided the formulas for calculating process times, station rates, and adjusted station rates. Characteristics of process time as well as capacity utilization at each station were also obtained. All information was organized so that it could be accessed by the model. (See **Figure 3**.)



Bottleneck identification. The exported and organized data that were extracted were used to determine a farm-specific bottleneck. (See **Figure 4**.)



Balancing process. Using the information from the above two steps, the process times and the number of spaces at each station were adjusted to become balanced relative to each other. (See **Figure 5**.)



Process arrangement. The final outcome of the CUBS/BP will provide the new arrangement for number of spaces and the pig flow schedule of each station. This will help the swine breeding herd to optimize the output with the same set of facility. (See **Figure 6**.)

FLOW PIGS	Breeding	Preg Check	Gestation	Farrowing		
No. of spaces	84	224	723	192		
Process Time	7	28	72	23	131	Days
Schedule Time	7	29	80	23	140	Days
		4.2%	10.1%			

Discussion

This model has been developed to manipulate the relationship between process times, spaces, and some characteristics which occurred during the time when breeding females passed through the process. One of the most important pieces of information to obtain from this model is the station rates at each station. These station rates determine the maximum throughput, called the capacity, of each station but not the maximum throughput of the process. Also, this model will help us.to determine the capacity utilization at each station as well as the bottleneck station. This gives us an idea of how many opportunities to increase throughput of the process a farm has.

For example, a swine breeding operation had total of 1,060 spaces, and its process time for all processes was 131 days. We found the lowest station rate and the lowest adjusted station rate at gestation station were 52 and 63 females/week, respectively (**Figure 2**). By using CUBS/BP, this example farm can increase weaned pig output up to 5% compared to the previous output with the same process time, and almost the same number of facilities (add 26 more spaces to the original). That is one of the objectives of factory physics: increase output with the same set of facilities.

Factory physics tells us that the real potential of a swine breeding farm to optimize overall output lies not only in the ability of the breeding females, but also in the ability of managers to appropriately arrange facilities.

Acknowledgments

Thanks to the people at Brown's of Carolina, Inc. for fruitful cooperation and support; to Dr.Gary Dial's family for warm hospitality while conducting studies in NC; to Phan Anh Thai from Information Services, U of MN, for the great idea on how to manage data; to PigCHAMP®, the best software to gather data; to Waresara Weerawat from the Dept. of Industrial Engineering, U of MN, for the best suggestion; and especially to my wife Lerpen Duangkaew and my daughter Potjanaporn Duangkaew who were my energy and my willpower while working on this project.

References

1. Dial, G.D., Duangkaew, C., King, V. and Rademacher, C. (1996) The Influence of the Gilt Pool on Weaned Pig Output. *Allen D. Leman Swine Conference*, 23, 39–41
2. Konopka J. M.(1995) Capacity Utilization Bottleneck Efficiency System-CUBES. *Proc. IEEE IEMT*, 18(3), 484–491
3. Hopp W.J. and Spearman M.L. (1995) Factory Physics – The Foundations of Manufacturing Management. *Georgia Tech. Press.* Georgia, USA