TOYO SPECIAL STEEL CO., LTD. (A)

Mr. Akira Ishii, manager of the Production Control Section at the Nagoya Plant of Toyo Special Steel Manufacturing Co., Ltd. came to doubt about the current way of production control which seeked after minimization of inventory. His doubt could be summarized in that the plant could achieve more improvement in cost reduction and productivity while satisfying short-notice customer orders better if it would reserve some extra inventory of semifinished products.

COMPANY PROFILE AND MARKET CONDITION

COMPANY PROFILE

Toyo Special Steel Co., Ltd. was one of the leading special steel manufacturers in Japan. Its sales for 1986 amounted to about 150 billion yen and profit 4 billion yen (before tax). Toyo's major product line was hot-rolled special steel items and its sales had been remaining stable for the past few years affected by the maturation of automobile, electric appliance and machine tool industries which were the main customers of the company.

As of early 1987, the company had three plants for production of various special steel products. The Nagoya Plant, one of the three plants, assumed charge of melting and rolling of stainless steel products which accounted for more than one third of the company's total sales. The current monthly output of the Nagoya Plant was about 12,000 tons.

PRODUCTS AND MARKET

Special steel in general was defined as "steel having special characteristics to suit certain uses by means of containing alloy compounds". (For example, engine valves of automobile required special steel with high heat resistance containing a lot of manganese, nickel and chromium.)

While ordinary steel, which was mass-produced by giant iron and steel manufacturers (e.g. Shin Nippon Steel Corporation or Nippon Kokan K.K.) was used for construction of buildings, hulls of ships, vehicle bodies or the like, special steel was used for engine parts, ball bearings, and some parts of electric appliances which were required to have high degree of resistance against heat, corrosion, shock, wear and tear, etc. Since special steel was mostly used under severe conditions, stricter standards than those for ordinary steel were required on ingredient composition, product size, mechanical characteristics (hardness, viscosity, etc.), surface condition and others. Because of such strict standards, a slight change in specification of a finished product often led to a modification in specification of special steel, the material. Accordingly, specifications of special steel had been less standardized as compared with those of ordinary steel, and special steel tended to be produced in small lots of varied types. Among of all, stainless steel, the product of the Nagoya Plant, extensively had such tendancy.

Special steel ordered by one customer for certain use had some specifications different from those of special steel required by other customers for the similar use, while they often shared other common specifications. It was not seldom that either of ingredient composition, product size, surface condition, etc., was same if a use or a client was common. Because the steel produced by the Nagoya Plant was

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This case was prepared by Professor Keinosuke Ono of Keio Business School, and Lecturer Tatsuyuki Negoro of Sanno College and Mr. Hirofumi Inoue of Keio Business School, as a basis for class discussion. Names and figures are disguised. (April, 1987; Revised in Feb., 1993)

widely used as material for various parts of mass-produced industrial goods, customer orders for each specific steel usually came repeatedly.

Partly because most of the special steel was produced based on each customers' specification, "production to order" was the dominant practice in the special steel industry. It was a traditional practice in this industry to place orders for one-month requirement usually one or two months prior to the date of delivery. (However, minor changes of received orders were accepted as far as possible.)

CHANGES IN COMPETITIVE ENVIRONMENT

As the market of special steel had enjoyed a relatively higher growth rate than the ordinary steel market and various technological advancements in production facility had made the delicate workmanship less important for special steel production, giant manufacturers of ordinary steel, had turned to advance to the special steel market. Thus, competition in the special steel market was growing more intensive than ever.

Under these circumstances, the competition in product characteristics such as product quality or accuracy of size had already become so extensive that the major focus of future competition would shift to delivery lead time and price aspects.

PRODUCTION PROCESS AND ORDER HANDLING

PRODUCTION PROCESS OF SPECIAL STEEL PRODUCTS

An outline of the production process of stainless steel products, the major product line of the Nagoya Plant, was as follow (see Exhibit 1: for a detailed description, see Appendix A.):

At the steel-making process, stainless steel scrap, ferro-chrome alloy, nickel alloy, etc., were molten in an electric furnace (20 ton class), and then impurities in the molten steel were removed with an argon oxygen decarburizing furnace (AOD). The molten metal was then transformed into billets (semi-finished prodcuts, weighing about 1 ton each) by either ingot-casting method or continuous casting (CC) method. In the ingot casting method, the molten steel was once casted into ingot (about 20 tons each) and then reduced into billets, while the molten steel was directly formed into billets by continuous casting method.

In continuous casting (CC), any number of charges of the molten steel, if they were of the same steel type (or ingredient composition) could be connected to each other for continuous production (it is called continuous CC). In CC processing, homogenization of steel structure was more difficult as compared with the ingot casting. Some customers required certain steel types to be produced by the ingot casting, due to this quality reason. About a half of the products manufactured in the Nagoya Plant (or 6,000 tons/month) were being processed by CC. The ingot casting required about 7 days and the continuous casting about 5 days as the physical working time including billet cooling time for conditioning and inspection of quality.

At the rolling process, billets were deformed into the size specified by each customer. The billets were hot-rolled after being heated to 1,100 to 1,300 degrees centigrade. A mill to be used for the hot rolling differed in accordance with size (large diameter, small diameter or wire rod) and shape of the product (bar or wire). The rolled products were stocked in a warehouse and shipped to the customers, while some products required certain heat-treatment and/or cold finishing in the secondary processing shop.

ORDER ENTRY AND PRODUCTION LEADTIME

At the Nagoya Plant, the time schedule from order entry through product delivery was roughly as shown in Exhibit 2. Customer orders were classified into two types, i.e. "monthly orders" and "spot orders".

Most of the monthly orders were repeatedly placed by regular customers. The Sales Department collected these orders from the customers by the 20th of each month and requested the plant for production (input to the customer order file). On the other hand, the spot orders included short-notice one-shot type orders which came in after the close of the monthly-order receiving, regular orders which the customers missed to place as the monthly orders, and others. Upon requested for production on monthly orders, the Nagoya Plant worked out a production schedule of each process for the next month, in which they included certain capacity allowance for spot orders which would jump in at any time. As shown in Exhibit 2, rolling operations for monthly orders were performed about 25 days at earliest and 55 days at latest after the close of order receiving.

Orders with the same ingredient specification were grouped and processed collectively for melting. Some types of steel might be molten 2 to 10 times a month if they had large demand. On the other hand, in the rolling process, there was only one chance in a month for the products of a specific product size to be rolled. In order to supply all the necessary types of billets to the rolling process which offered only one chance a month for a specific product size, there had to be a certain time-lag between the start of the melting and that of the rolling processes. In the Nagoya Plant, this time-lag was set as 15 days based on the experience.

In 1987, the Nagoya Plant had three rolling mills each of which was equipped with 3 to 15 rolls stands to gradually reduce the diameter of billet into a required size. In this system, calibers of the rolling mills must be replaced in order to change the rolling size into required one. It took about 30 minutes on the average for this set-up (varied from 10 minutes to 6 hours: depending on the positions of replacement or the type of change). To reduce such set-up time without deteriorating the accuracy of size (within ±0.1 to 0.05%), it was most effective to gradually reduce the size of the products to be rolled. For this reason, the plant would not roll the products of the same size more than once a month in principle.

Spot orders meant, as stated above, the orders which were not given in time for the closing of monthly orders and would miss the delivery timing requested by the customers if they had been carried over to the next month rolling. The spot orders usually included short-notice orders, orders slipped off from regular monthly orders or the like. There were some customers who usually fixed their production schedule after Toyo Special Steel had closed to receive regular monthly orders (on the 20th of each month). Such a customer would place an interim monthly order and then switch it into a confirmed one when the production schedule was finalized. Furthermore, delivery under the so-called "kanban system" was adapted by some auto-industry customers. In such cases, an order was not finally confirmed until the corresponding kanban was received (for example, 2 days prior to the date of delivery). Until then, the company had to work under an assumed order which was prepared by the Sales Department based on the customers' monthly requirement guideline. As a result, the once entered orders might require some modifications which would bring about some changes in quantity as well as additional spot orders into the monthly production schedule of the Nagoya Plant.

The Sales Department input information of such spot orders into the received orders file one by one upon request by the customers. When receiving the information from the Sales Department, the Plant examined whether it would be practicable or not to include those spot orders in the production schedule without delay. If it would, the orders were accepted and added to the production schedule and if it would not, the Plant asked the Sales Department to cancel them. If the ordered steel type was for wide use, and the order was placed more than one week prior to the appropriate rolling chance, it was usually possible to add it to the production schedule. If the spot orders were given during the period undoubtedly busy or after the appropriate rolling chance, the Sales Department sometimes turned them down at its own discretion on the production schedule received from the Plant. The volume share of spot orders was relatively stable on the average level around 20% of all the orders received every month.

Toyo Special Steel tried as much as possible to accept changes in ordered quantity, cancellation or other amendments either for monthly orders or spot orders until the melting process of the concerned steel was started. Such changes usually took place for around 30% of the total orders. The most frequent changes were those in ordered quantity. However, most of such changes remained a slight adjustment within plus or minus 10% of the ordered quantity.

PRODUCTION LOT SIZE AND COSTS

Toyo Special Steel Co., accepted orders usually in tons but 20 ton unit was applied for certain types of steel which could not be used for other orders. The standard batch size for melting was 20 tons, but it was desirable that the same steel type should be continuously molten as much as possible in order to take maximum advantage of the CC process. In the rolling process where billets were processed in tons, 15 to 400 tons of billets were rolled for each product size.

Exhibit 3 shows how variable costs and productivity in each processing stage were affected by production lot size. As shown in Exhibit 5, a larger production lot would save variable costs as well as set-up time in the CC process and reduce set-up time also in the rolling process.

DISCUSSION AT PRODUCTION CONTROL SECTION

PRELIMINARY TALK ON THE SEMIFINISHED PRODUCT INVENTORY SYSTEM

Under the influence of the "streamlining" management policy following the so-called Toyota Production System, inventories of finished or semifinished products were considered evil at Toyo Special Steel. On the other hand, the sales people insisted that shortening the lead time from order receiving to delivery was one of the major focuses of the future competition. One sales executive even said, "In the future, we should treat all customer orders as spot ones and the monthly order system must be abolished."

In January 1987, Mr. Ishii, manager of the Production Control Section, was discussing about the mechanism for linking received orders to the production activities with his subordinates, Mr. Matsuzaka (assistant manager in charge of the steel making process) and Mr. Nomura (assistant manager in charge of the rolling process.)

Ishii: After all, it is the matter of timing to link received orders to the production activities, isn't it?

Nomura: It is when roll-operation orders are issued that a customer lot is explicitly linked to a production lot. These orders are issued for respective production numbers arranged in the sequence of rolling. Each of such orders has a corresponding customer order number.

Ishii: It's at the rolling stage, as you said, that received orders are explicitly linked to the production orders. But we assume specific customers even at the melting stage as a matter of fact. If the furnace is melting some steel for two customer orders or more at one time, every part of the steel has already a determined customer. In other words, we are producing to orders even at the first stage of melting process where the received orders are immediately connected to the production activity.

Matsuzaka: In the steel making process, we do not have much flexibility in arranging the melting sequence in order to assure the precise ingredient specification of each steel type, because the furnace holds the remnant of molten steel carried forward from the previous melting. Besides, we must pay attention to the next coming rolling process. If we miss a once-a-month rolling chance, the delivery will be late for sure. In the CC process, furthermore, we often process some types of steel in amount for half a month or one month requirement at one time to save variable costs. Therefore, we can not start the production without knowing what we are going to produce.

Ishii: That is exactly what I meant. But, I want you to think that such restrictions are peculiar to the order-based production and we could remove some of them if we intentionally hold some inventory of semifinished products (billets). Though it's taboo to speak for increase of semifinished products in stock. . . . If we can have enough billet stocks, we don't have to worry too much about rolling timing and we can run the melting process in a more convenient way, can't we?

Matsuzaka: I think that is correct under the current system, we can start the melting process 15 days at the earliest prior to the following rolling process. With this timing allowance we try to work out the most rational melting schedule to produce all the received orders for the coming month. However, 15 days are just 15 days, not a month. They do not give us complete freedom to decide the melting sequence. Therefore, we often have to divide the melting of certain steel type into a few occasions to meet the rolling timing even when the continuous melting of the whole amount would be obviously better for reducing cost. If the production capacity in the melting process is well over the rolling capacity, we could cope with such conditions, but the reality is not so. Besides, we must add spot orders to the melting schedule timely. I think the current way of production is far from the ideal one.

Ishii: Isn't it very convenient in various ways to have some billet inventory for the rolling process, too?

Nomura: Yes, certainly. Mr. Matsuzaka said he has to pay attention to the rolling schedule for controlling the melting process. But, we have the same problem on our side, too. We are always in fear of shortage of necessary billets to meet the rolling chances. We have to confirm the steel making people at every moment if we can get necessary billets. There are some cases that a melting lot is found to miss the specification of a specific steel come late due to some technical troubles in steel-making process. At the nearest moment to the rolling schedule, when such things happen, the rolling must be carried over to the next month because we have no time for remelting (which means missing the delivery date). Works at the rolling process will be very much easier if billets with certified quality are always available for the rolling. But, . . .

Ishii: But . . . what?

Nomura: But, our plant is producing a quite lot of steel types. Even confining to those processed by the CC, we must produce about 120 steel types on the average every month. This means we roll about 7 steel types on average for each rolling chance (specific product size). If we had to carry billets for all of these steel types in stock, they would be extremely bulky. There would be no enough space to store them.

Ishii: It's enough to stock only such steel types with large benefit, isn't it? Though it is difficult to judge which type has larger benefit than others instantly. How about producing one month in advance some selected steel types, the CC items which are molten less than 5 charges at one melting chance currently? For example, in case of a certain steel type which are currently melting one charge at the beginning and another at the end of each month, and two charges in the following month, we will melt 4 charges collectively once every two months.

Matsuzaka: In that case, the benefit will not be limited to the easier operations at melting and rolling processes. We are currently turning down quite a few spot orders because no melting chance is available in time even when there are some time allowance for rolling chances. We will be able to accept those kinds of orders if we have appropriate billet inventory.

Ishii: Exactly. . . No, not only that. If the orders are for the steel types of billets in stock, we will be able to reduce for sure the lead time from order receiving to delivery. It may do much for the competition for orders though we have to check the Sales Department view on this point. In my opinion, the effect of promoting the spot order business will be far from negligible.

Matsuzaka: In that sense, we must select steel types with a higher ratio of spot orders.

Ishii: That's right.

Nomura: We have found lots of advantages in holding billets inventory so far, but there are also disadvantages without doubt. Since there is not sufficient space for inventory in the plant, we will have to pay, in addition to the capital cost for the inventory holding, warehouse charges as well as off-line transportation costs between the warehouse and the plant. We must also take into consideration the possibility that the stocked steel types become unnecessary and the obsolescence loss may be incurred, though it depends on our selection of the steel types. There is also a saying that inventory covers up problems.

Ishii: We must think over such disadvantages, of course. But most of our customers are so-called regular customers who have continuous trade relation with us. Therefore we are producing many types of products every month for the monthly orders. Even for spot orders, many steel types are produced repeatedly almost every month. In case of such steel types, fluctuation in the ordered quantity per one month remains within ±30%. Therefore, if we hold planned inventory of these steel types, the risk of dead stocks will be very little. Anyway, let us hold a further discussion again early next week on the advantages and disadvantages of holding the planned inventory of billets.

Nomura: But , what will the department manager say on this matter? He has been giving a command of squeezing inventory in every meeting and his policy has, as a matter of fact, just started to get desirable results.

Ishii: That's the point. He will not give us O.K. easily. Well, . . .anyway, we must examine the matter well. It's the only thing we can do at present. If we can find it preferable after sufficient examination, I will tell him so.

ANALYSIS OF ADVANTAGE AND DISADVANTAGE OF HOLDING BILLET INVENTORY

Next week, Mr. Ishii and the other two started the examination. They assumed, as the basis of analysis, that they would hold the planned inventory of semifinished products (billets) for 20 steel types selected from the CC items with high spot order ratio as well as big CC advantage expected. For the 20 steel types, 0.8 to 7.9 charges per type were molten on the average every month (1 charge = 20 tons) and the total number of charges on the monthly average for the 20 types was 50 charges (about 1,000 tons). Following is the summary of their analysis.

[1] Reduction of "missed rolling chances due to delayed steel supply"

Mr. Ishii and his subordinates assumed that there would be no missing of rolling chances for the steel types having billet inventory and then asked the sales persons how much effect could be expected on increase of spot order business for such steel types. Although some of the sales persons interviewed agreed that the orders would increase to some extent, their judgment differed from one another due to their own experience whether they had troubles with their customers on the missed rolling chances recently. According to the sales persons answering positively for the effect, an expected rate of order increase would be on the level of 5% of the current order volume (1000 tons). Mr. Ishii's judged the situation as at most 1 to 2% increase could be expected for all of such steel types.

As of the early 1987, the profit contribution of spot-ordered products (sales price –variable costs) was estimated at approximately 70,000 yen per-ton, when the CC process was employed.

[2] Improved acceptance of short-notice spot orders.

In the present situation spot orders were accepted only when they were inquired more than one week prior to the relevant rolling chances. On the other hand, if the plant carries billet inventory of certain steel types, customer orders of these steel types could be accepted even one day before the relevant rolling chances. Manager Ishii and his men conducted the same kind of examination as in [1] to the sales people. As a result, many sales persons answered that the current customer orders (total: 1000 tons/mo.) could be increased by 5% or around if flexibility in handling the spot orders was improved as stated above.

[3] Reduction of CC set-up time through expanded application of continuous CC

If the steel types having billet inventory were produced collectively for 2 months requirement, some CC set-up time would be saved with expansion of the continuous CC operations. This should bring about reduction of the total operation time for the same output, or increase of net production capacity.

In the beginning of 1987, about 50 minutes were required for one CC set-up operation on the average at the Nagoya Plant. It was estimated if the assumed 20 steel types were produced with the batch size of every 2 months, about 20 set-up operations would be saved every month.

The CC process was in full operation at that time and quite a few orders were unavoidably forwarded to the ingot casting. Besides, the melting and the rolling processes had some allowance in their production capacity. If the steel now unavoidably processed by the ingot casting was processed by the CC, most of them were to be processed by single CC charge operation. Even so, about 10,000 yen per ton of CC merit (cost saving) was expected. For a single CC charge, necessary production time for one charge was 45 minutes for casting time plus 50 minutes for set-up time (95 minutes in total).

[4] Reduction of variable costs through expanded application of continuous CC

According to the Ishii group's estimate, about 15 million yen was expected to be saved annually through the yield improvement and the reduction of T/D (tundish) cost for the assumed 20 steel types with billet inventory on the whole when they were produced with the batch size of two months requirement.

[5] Increase in inventory carrying costs

(1) Warehouse charge and off-line transportation cost

The Nagoya Plant was already jammed up with scrap steel material, additive alloys, billets waiting for rolling chance, pressing rollers of various sizes, finished products ready to be shipped (in an amount for a half month on average) and the like. Under such circumstances, it was difficult to find a sufficient space for additional inventory on the plant site. However, for the planned inventory of billets, it would be possible to additionally rent a warehouse located at about 2 km away from the plant,which was sometimes used to store over-flowed products.

According to the examination conducted by the Ishii group, if 2 month requirement of billet was produced at one time for each of the proposed 20 steel types, it would increase about 500 tons of billet inventory on the average which was equivalent to a half of the averaged monthly requirement of such steel types. In reality, in addition to the said 500 tons, about 250 tons would be kept in stock for safety to satisfy the increased spot orders (see Exhibit 4). The sum of the warehouse charge and the off-line transportation cost to be incurred by the new system throughout the year was estimated at around 6 million yen in total.

(2) Capital cost for holding inventory

The variable cost for the billet inventory of the 20 steel types was estimated at 200,000 yen/ton on the average and an actual interest rate to be born by Toyo Special Steel was estimated at 5% annually.

(3) Obsolescence risk

In the case of special steel, there was little risk of physical quality deterioration for inventory holding. However, if a customer would decide to stop using certain steel type, the stocked billets of the steel type might become useless for anybody because most of the special steel was produced according to the customer specifications.

Manger Ishii and his group judged that such obsolescence risk would happen only for one-shot or unstable orders often placed by casual customers. They could assume that the regular customers would inform of such changes on repeating orders at least 3 months in advance. Because all of the 20 steel types assumed for the billet inventory could be deemed as the steel types with repeating orders, Mr. Ishii and his group felt no fear of obsolescence for this additional inventory under consideration.

Exhibit 1 Production Process

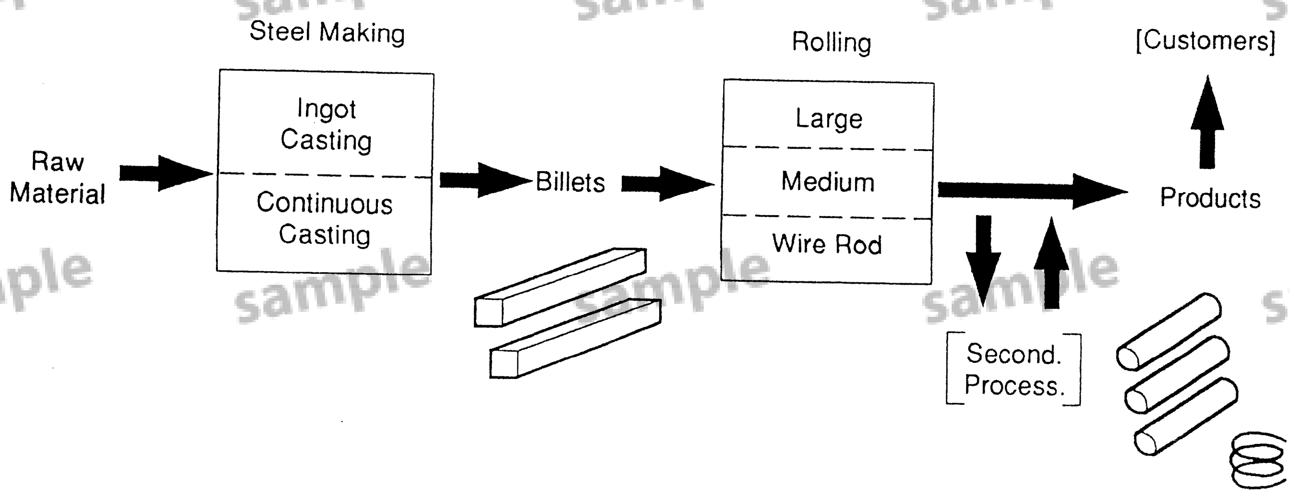


Exhibit 2 Standard Time Scheudle for Order Entry and Production

Month	(N)	(N + 1)	(N + 2)
Monthly Order Acceptance	due 20th ◎		
Monthly Production Schedule			
Steel Making			
Rolling		15th	15th
Secondary Process and Delivery			
Spot Order Processing			

Exhibit 3 Production Lot-size and Process Productivity

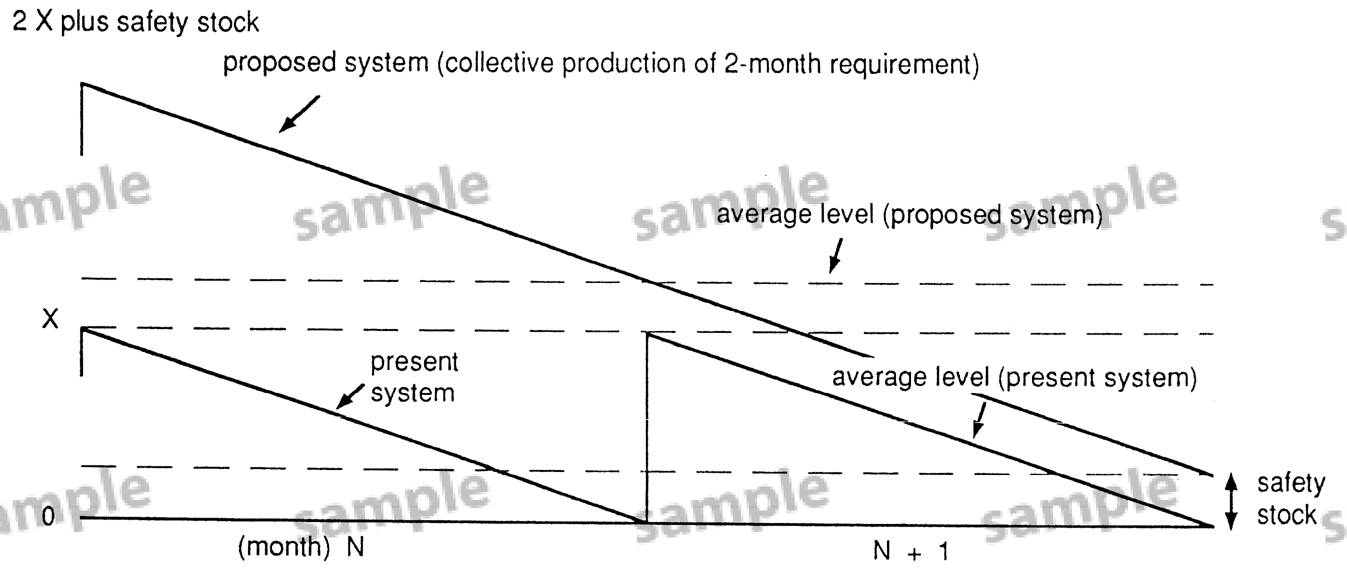
Lot-size	Melting	Casting (Ingot)	Continuous Casting	Rolling
0 t ▶	Excessive under-loading is technologically inappropriate	same	Continuous operation of CC shall lead to higher yield, less T/D cost, and less set up cost as stated with notes 1, 2 and 3	No change in variable costs
20 t ▶	Little saving in processing time by continuous melting	same		

	(Note 1) Yield* 1	(Note 2) T/D Cost* 2	(Note 3) CC Set-up Time
1 CC	97.1%	4,000 ¥/t	50 min/charge
2 CC	98.0%	2,000	25
3 CC	98.4%	1,333	16.7
4 CC	98.5%	1,000	12.5
5 CC	98.6%	800	10

*1 Shows "2 CC : 98.0%", for instance, means an average yield of continuously casted two charges was 98.0%.

*2 T/D cost means a cost of fireproofing material for a CC tundish. For example, "2 CC : 2,000 ¥/t" shows the T/D cost per average ton for continuously casted 2 charges was 2,000 yen per ton. Because the same tundish (a dish for intermediately receiving molten steel during the continuous casting) can be used for the same steel type up to 5 charges.

Exhibit 4 Comparison of Inventory Behavior



QUESTIONS

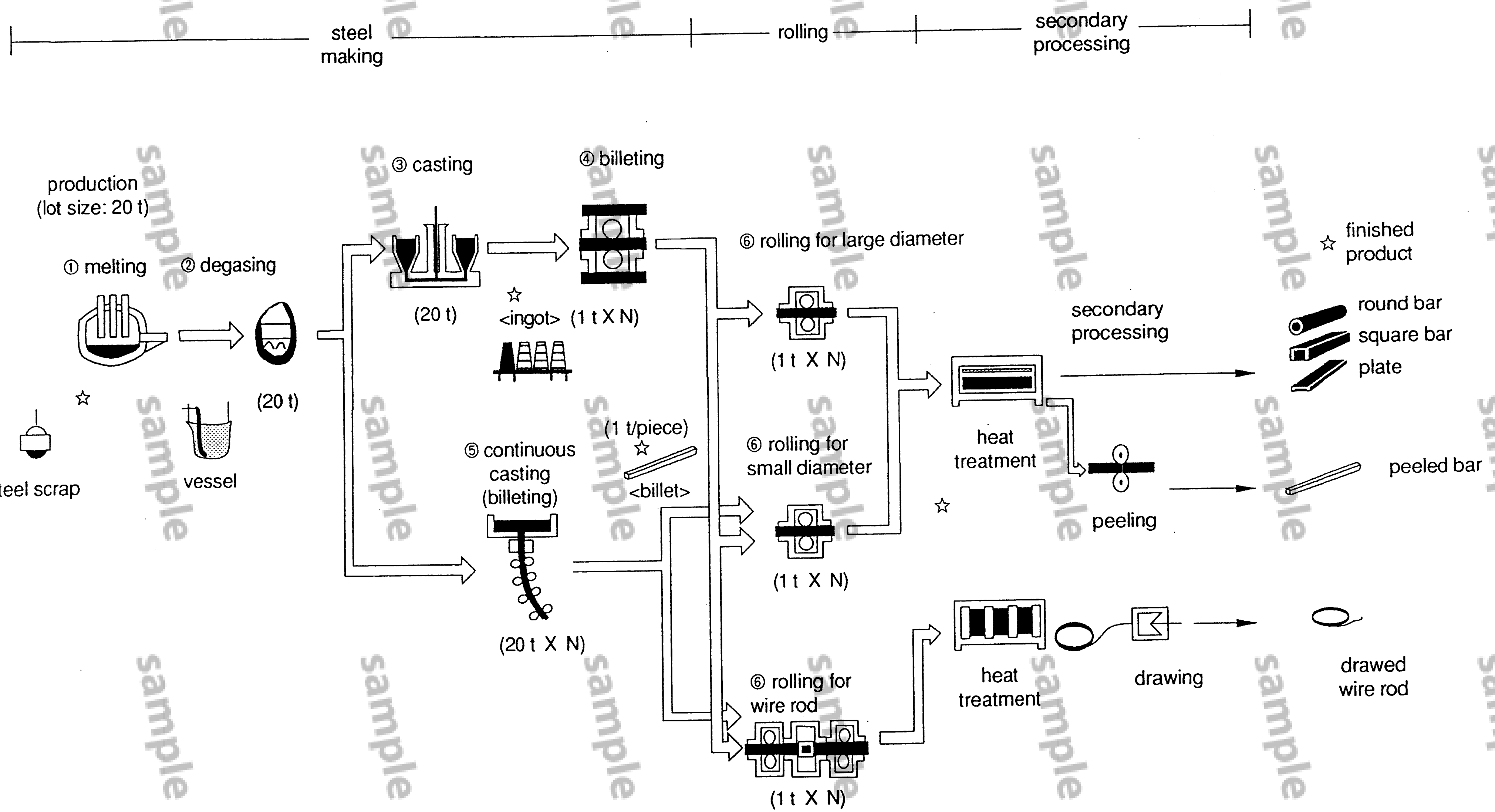
Q1. What are the key features of Toyo's production planning and control system?

Q2. What changes are Mr. Ishii and his subordinates proposing to introduce to the production planning and control system? How do they expect the changes affect the profit of the company?

Q3. If you were the manager of the Production Control Department, how would you respond to the proposal made by Mr. Ishii and his subordinates? Why?

Appendix A

Production Process of Special Steel Products
(stainless hot-rolled steel)



☆ stock point

(note) weight figures are stated as expected finished products