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OEE (Overall Equipment Effectiveness) For the Die Cast Process

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INTRODUCTION

OEE, "*Overall Equipment Effectiveness*", is a percentage indicator which represents the global performance of a production resource or set of resources, whether human or technical, during the time in which these are available to produce. The "classic" definition is **OEE = Availability x Performance x Quality**. This "classic" model, however, may become difficult to apply in die casting because of the diversified nature of products and different requirements for single parts. As a response to these requirements OEE, like all efficiency indicators, can be expressed through an OUTPUT / INPUT report. It gives, in fact, an overall indication of the ability of a set of resources to produce value for the customer (output) with a defined number of productive resources available (input). The measurement of these elements (input and output) is defined through the concept of **Working Standard Time (or profitable time)**, it is the time required for the execution of a given operation through known instruments, tools, operational methods and procedures.
The OEE calculation does not automatically improve productivity. It must be combined with a detailed and careful analysis of the reasons for the reduced productivity
Some hints and guidelines for getting suitable OEE indicators over time as applied to die-casting are sketched and presented as simple and powerful instrument to help improving productivity and effectiveness.

OEE, "*Overall Equipment Effectiveness*", is a percentage indicator which represents the global performance of a production resource or set of resources, whether human or technical, during the time in which these are available to produce.
As it can be clearly understood, OEE is the most "demanding" indicator and comprehensive applicable to a process as it is affected by all kinds of inefficiencies that lead to lower productivity: from the lack of materials to poor planning strategies, from setup to downtime, by short downtime fault until re-working for non-compliant parts.
In literature and on the web, the OEE is treated according to a "classical" model that is well suited to the industry process or in any case, on automated production lines. Die-casting embodies one of the model well suited to obtain the related benefits information but above all to act as a flywheel to improve production efficiency.
The definition of "classic" **OEE = Availability x Performance x Quality**.

Being the product of three percentage indicators that represent the three key components of the performance:

- **Availability**: The percentage of the actual activity time in which production resource are available;
- **Performance**: percentage of parts produced compared to the theoretical potential rate when the system is operating (corresponding to actual production rate compared to the nominal rate);
- **Quality**: The percentage of compliant parts over the total number of produced parts.

OEE is therefore a dimensionless number (i.e.,%) which takes into account the three main categories of production losses:

- Faults, setup and tooling;
- Operating work Reduction, downtime and micro downtime ;
- Scrap, re-work and start yield losses.

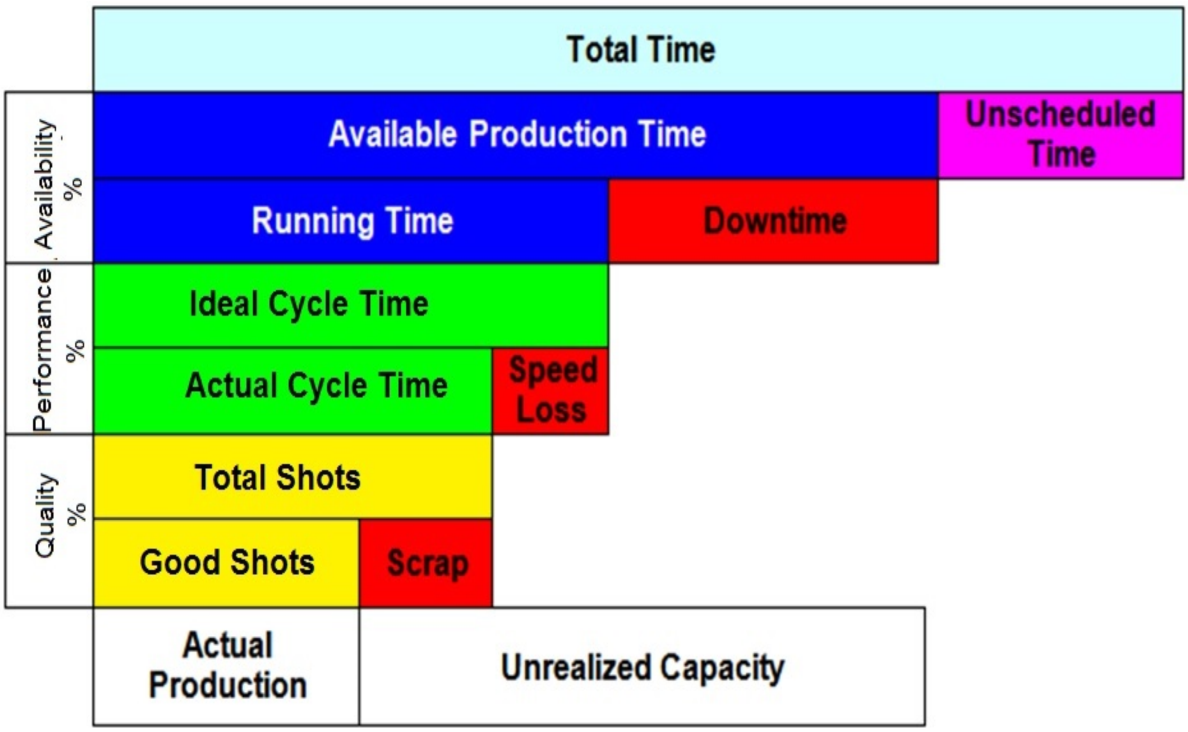

Fig.1

This model, however, may become difficult to apply in the context of production which presents machines with dimensions, (and particularly with cycle times) significantly different. Same critical application could derive from diversified nature of products and different requirements for single parts. A situation which is quite common in die-casting production facilities.

Therefore, it is important and interesting to accurately manage and calculate the three different factors, properly weighting the incidence of the various elements: machines, single parts, and processing cycles.
As a response to these requirements OEE, like all efficiency indicators, can be expressed through an OUTPUT / INPUT report.
It gives, in fact, an overall indication of the ability of a set of resources to produce value for the customer (output) with a defined number of productive resources available (input).
The measurement of these elements (input and output) is defined through the concept of **Working Standard Time**: it is the time required for the execution of a given operation through known instruments, tools, operational methods and procedures.
The standard time is defined by the company for the specific working cycle, manual or automatic, which is: is the "right time" it takes to perform a process (working unit), no more, no less. In this sense, the standard time is approaching (although it is not exactly the same thing) to the concept of value-added time. To avoid ambiguity, we can call it **profitable time**.
Thus, an improved calculation of OEE can be implemented as follows:

$$OEE_{\star} = \frac{output}{input} = \sum_{i=1}^{n} \frac{T_{StdWk} * N_{Compliant\ Parts}}{H_{available}}$$

Fig.2

Being *i* upper formula the variety of different parts/products/productive resources.
The introduction of OEE management/control can have concrete and important effects.
Typically, a production system that has never faced a project to improve efficiency stands at the OEE values of no more than 50-60%.
The best producers, however, achieve and maintain over time an OEE of 85%, considered a "world class" goal.
We emphasize the fact that to achieve the ideal of 100% condition is virtually impossible, as would be a system that never stops and never makes tooling / setup. If the OEE proves greater than 100%, on the contrary, it would be of inaccuracy symptom of the set model (for example, standard times oversized and therefore inaccurate). Also, high values (greater than 70%), if detected in contexts that have never faced a structured process to improve efficiency, must be validated thoroughly.
Reach an OEE of 85% low, for example, from a starting condition of 60% (objective usually reached in a few months and no special investments) means not increase the efficiency of 25%, but by 42%, as the starting point was 60%. In concrete terms, it means to produce 42% more with the same resources, or you can save 42% of the same production resources.
OEE scores provide a very valuable insight – an accurate picture of how effectively your manufacturing process is running. And, it makes it easy to track improvements in that process over time.

What your OEE score doesn't provide is any insights as to the underlying causes of lost productivity. This is the role of Availability, Performance, and Quality.
In the preferred calculation you get the best of both worlds. A single number that captures how well you are doing (OEE) and three numbers that capture the fundamental nature of your losses (Availability, Performance, and Quality).
Here is an interesting example. Look at the following OEE data for two sequential weeks.

OEE Factor	Week 1	Week 2
OEE	80.1%	80.7%
Availability	89.0%	93.0%
Performance	90.0%	94.0%
Quality	91.5%	87.0%

Fig. 3

OEE is improving. Great job! Or is it? Dig a little deeper and the picture is less clear. Most companies would not want to increase Availability by 4.0% at the expense of decreasing Quality by 4.5%.

CALCULATION EXAMPLE

Now let's work through a complete example using the preferred-OEE-calculation. Here is data recorded for the second shift:

Item	Data
Shift Length	8 hours (480 minutes)
Breaks	30 minutes
Down Time	47 minutes
Ideal Cycle Time Ideal Run Rate	57.0 seconds 0,95 shots / minute
Total Count	394 shots
Good Count Scrap Count	362 shots 32 shots

Fig.4

PLANNED PRODUCTION TIME

The OEE-calculation begins with Planned Production Time. So first, exclude any Shift Time where there is no intention of running production (typically Breaks)

Planned Production Time = Shift Length – Breaks = 480 – 30 = 450 minutes

RUN TIME

The next step is to calculate the amount of time that production was actually running (was not stopped). Stop Time should include both Unplanned Stops (e.g., Breakdowns) or Planned Stops (e.g., Changeovers). Both provide opportunities for improvement.

Run Time = Planned Production Time – Downtime = 450 – 47 = 403 minutes

GOOD COUNT

If you do not directly track Good Count, it also needs to be calculated.

Good Count= Total Count − Scrap Count = 394 − 32 = 362

AVAILABILITY

Availability is the first of the three OEE factors to be calculated. It accounts for when the process is not running (both Unplanned Stops andPlanned Stops).

A = Run Time / Planned Production Time = 403 / 450 = 0,8955 = 89.55 %

PERFORMANCE

Performance is the second of the three OEE factors to be calculated. It accounts for when the process is running slower than its theoretical top speed (both Small Stops and Slow Cycles).

P = Ideal Cycle Time x Total Count / RT = 57.0 x 394 / (403 x 60 seconds)
= 0,9287 = 92.87%

Performance can also be calculated based on Ideal Run Rate. The equivalent Ideal Run Rate in our example is 0,95 shots per minute.

P = (Total Count / RT) / Ideal Run Rate = 394 / 403 x 0,95 =

QUALITY

Quality is the third of the three OEE factors to be calculated. It accounts for casting parts that do not meet quality standards.

Q = Good Count / Total Count = 0,9187 = 91,8%

OEE

Finally, OEE is calculated by multiplying the three OEE factors

OEE = A x P x Q = 0,8955 x 0,9287 x 0,9187 = 0,7640 = 76,40 %

OEE can also be calculated using the simple calculation.

OEE = Good Count x Ideal Cycle Time / PPT = 362 x 57.0 / (450 x 60 sec)
= 0,7640 = 76,40 %

The result is the same in both cases. The OEE for this shift is 76,40 %.

CONSTANT MONITORING OF OEE

As previously set out, a practical manner and particularly efficient to control the OEE indicators it is to follow a temporal monitoring scheme.

It is intuitive to dynamically executed OEE analysis in order to highlight changes over time and the aberrations in order to intercept them in real time and take corrective measures.

So it appears simple and practical to have as a guideline the OEE indicators respectively calculated

- Since the Beginning of Production
- Since Shift start (or possibly since the beginning of the work day)
- Since last hour

This way you have a panoramic dynamic, and adhering to the process in real time.

Fig. 5

A PRACTICAL EXAMPLE:

Last hour OEE:

DCM is in production (DCM is assumed to work): Planned Production Time = 60 min
DCM has been down only for 17 min during last hour
(Run Time = 43 min)
DCM has an ideal cycle time of 58.5 sec
DCM has done 43 shots
DCM has done 40 good shots and 3 scrap
A = 43 / 60 = 0.7166
P = 58,5 x 43 / (43 x 60 sec) = 0.975
Q = 40 / 43 = 0.9302

OEE (hour) = 0.7166 x 0.975 x 0.9302 = 0.6499 64.99 %

Last shift OEE:

DCM is assumed to be operating Planned Production Time = 60 min x 8 = 480 min
DCM has been down for 64 min during shift (Run Time = 416 min)
DCM has an ideal cycle time of 58.5 sec
DCM has produced 408 shots
DCM has produced 380 good shots and 28 scrap
A = 416 / 480 = 0.8666
P = 58,5 x 408 / (416 x 60 sec) = 0.9565
Q = 380 / 408 = 0.9313

OEE (Last Shift) = 0.8666 x 0.9565 x 0.9313 = 0.7720 77.20 %

OEE calculated from Production Beginning

Production began 2 weeks ago.
DCM was assumed to be operating 5 days/week on 3 full shifts
Planned Production Time = 480 x 3 x 5 = 14400 min
DCM has been down for 1964 min (Run Time = 12436 min)
DCM has an ideal cycle time of 58.5 sec
DCM has produced 11859 shots
DCM has produced 11444 good shots and 415 scrap
A = 12436 / 14400 = 0.8636
P = 58,5 x 11859 / (12436 x 60 sec) = 0.9297
Q = 11444 / 11859 = 0.96500

OEE (Production) = 0.8636 x 0.9297 x 0.965 = 0.7747 77.47 %

A quick consideration: the process is having a loss of performance during current shift and particularly during last hour.

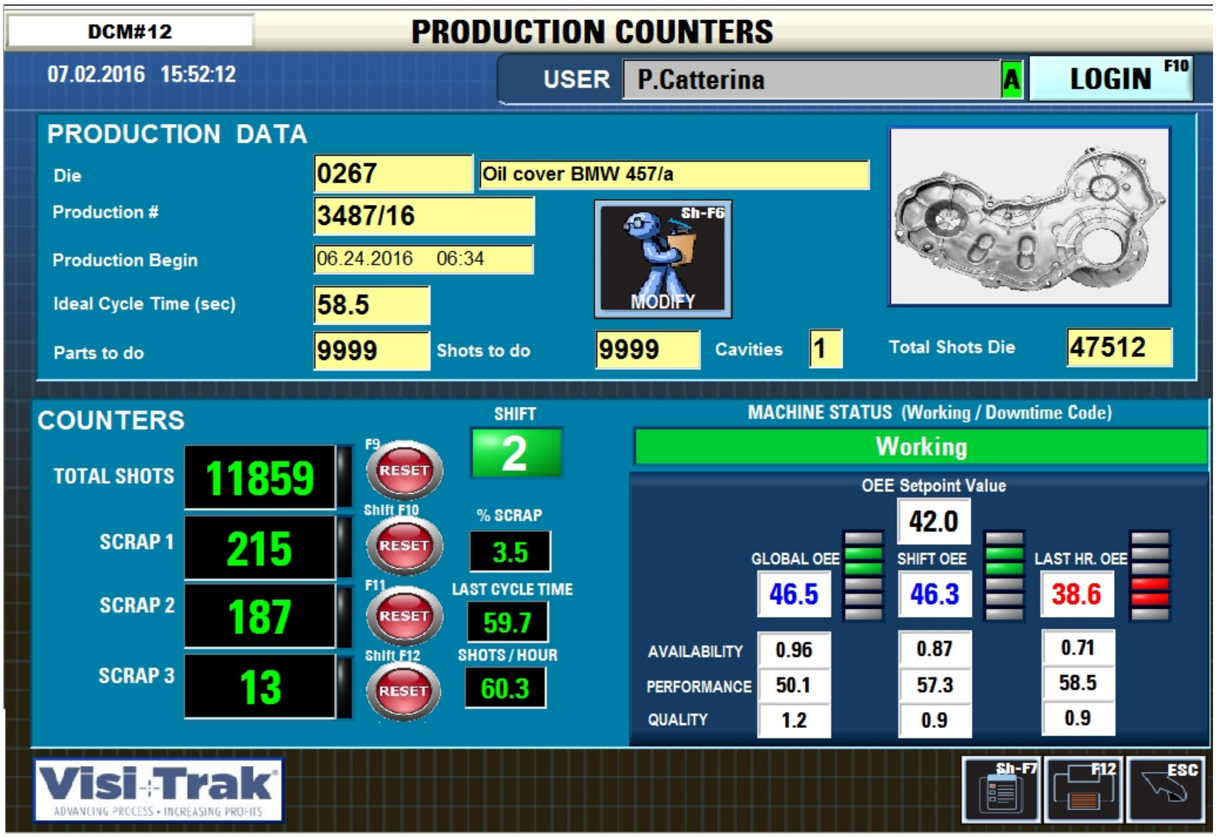

Fig.6

CONCLUSIONS

After having described OEE benefits and calculations examples particular attention must be paid to the practical application of this indicator in monitoring the process and reality of the production of foundry.

The OEE calculation does not automatically improve productivity. It must be combined with a detailed and careful analysis of the reasons for the reduced productivity

Here below some specific indications to implement actions for improving OEE index specifically for Die Casting.

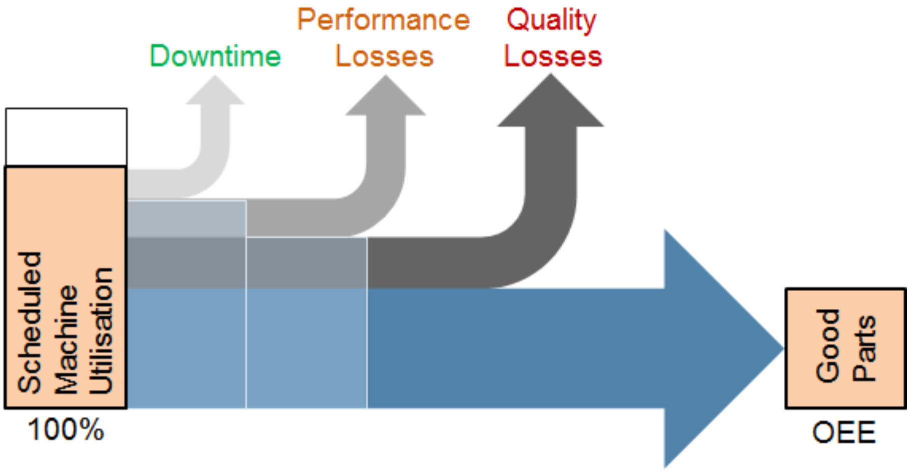

Fig..7

WAYS TO IMPROVE UPTIME

- Effective preventive maintenance
- Shot control: enforce repeatability for shot velocity and pressure vs. position
- Increase tool life (i.e. reduce impact shock using systems to smooth impact stage)
- Monitor and control die temperature using heat units
- Decrease setup time: use Master shot trace and improve die recipes storage and process values variation tracking
- Accurate Downtime Analysis (implement Pareto Analysis over Downtime)
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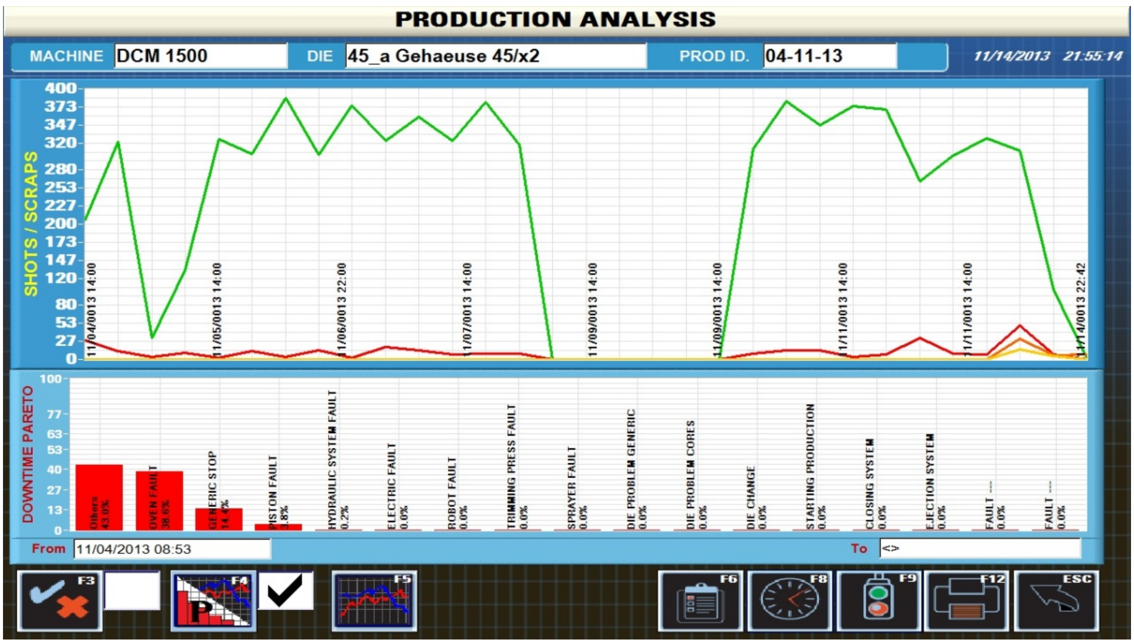

Fig. 8

WAYS TO IMPROVE PERFORMANCE

- Decrease cycle time. First implement systems for cycle time analysis dividing cycle time into technical steps (clamping, pouring, injecting, opening, extracting, spraying, trimming etc.)
- Minimize brief interruptions. Analyze short downtime origins. Decrease flashing with low impact.
- Process control and temperature control: manage thermal balance in die with thermographic monitoring systems.

WAYS TO IMPROVE QUALITY

- Detect problem in real time using process control systems.
- Set high/low limits to key parameters and then countermeasures in a timely manner
- Repeatability: use closed loop shot control to increase repeatability of the process
- Implement data collection and SPC Statistical Process Control to detect process variations.
- Implement Pareto Analysis over Scrap.

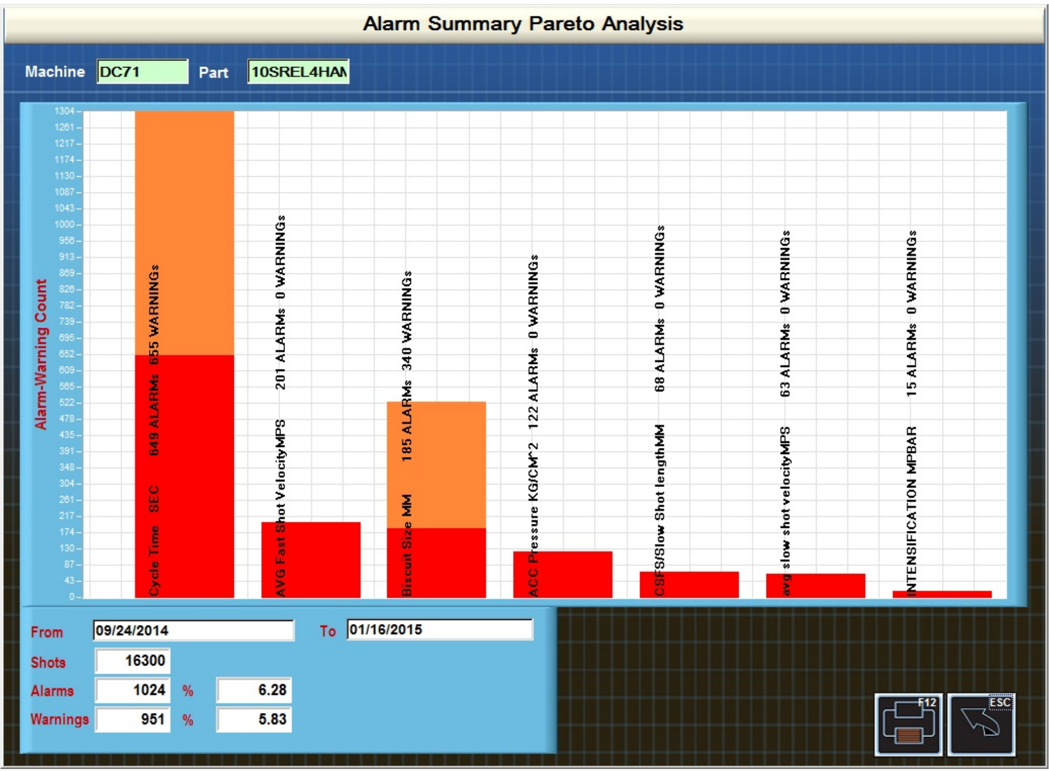

Fig.9

In a few words producing economically in high pressure die casting means

- understanding the cost portions of a die casting production
  (Operating, manufacturing, capital, investment, depreciation, interest, energy, personnel, external services, allocated costs, metal, tools and dies, peripheral work etc…)
- knowing the sensitivities for cost reduction
  requires having the right systems to survey and control the process and production, since most of these concepts passes from a constant monitoring and awareness of OEE indicators.

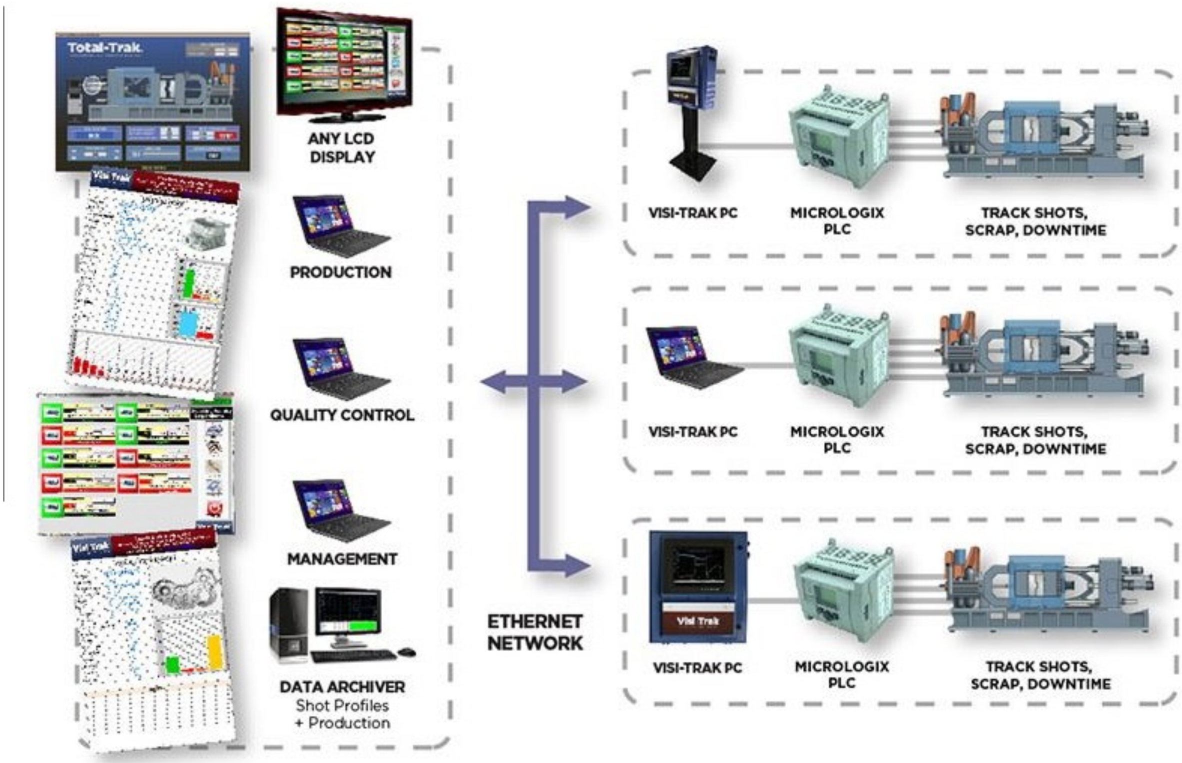

Fig. 10

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