Analysis of Fatigue Causes of Ship Officer Based on Ergonomics and Research on Its Prevention and Control

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Abstract: with the increasingly fierce competition in the international shipping industry, in the process of survival and development, the shipping industry has reduced the cost of ship operation and management as much as possible, compressed the crew team as much as possible, coupled with the shortage of crew and the large mobility of crew, the fatigue of crew has become increasingly prominent. Therefore, it is of great significance to strengthen the research on the causes of ship officer's fatigue and adopt targeted debugging measures to improve the crew's health and ensure the safety of shipping. Based on ergonomics, this paper takes ship officer as the research object, and puts forward relevant countermeasures to prevent crew fatigue and crew fatigue through the division of fatigue degree and its impact on safety.

1. Introduction

As we all know, 82% of maritime accidents are related to human factors, and effectively reducing the impact of human factors on maritime safety has become a major topic [1]. With the development of maritime transportation and the continuous progress of navigation technology, the phenomenon of technical attrition has made the problem of crew fatigue increasingly prominent and has gradually become a major hidden danger affecting maritime safety. Therefore, how to successfully reduce human factors in this area has become an important task. For normal people, fatigue may only be a reaction to physical discomfort [2]. However, for ship officer, fatigue often means the decrease of work efficiency, inflexible and maladjusted movements, misjudgment and the decrease of ship operation quality, thus bringing about great hidden dangers to ship safety. The shipping industry has generally recognized that fatigue is one of the main causes of human error. At present, the phenomenon of fatigue and overwork of crew members is not an individual phenomenon, so it has become a problem that must be paid attention to more and more.

Man-machine engineering of ships is increasingly valued by navies of various countries. For example, the u.s. Navy has carried out a large number of special research on ship ergonomics, and has successively promulgated a large number of ship ergonomics standards or documents [3]. In this system, the ship officer should continuously receive external information, monitor the vessel operation, and manipulate the vessel as needed to make it run safely. This paper takes ship officer as the object, analyzes the mechanism of the influence of crew fatigue on maritime safety, and discusses the causes of crew fatigue, in order to provide reference for prevention and control of crew fatigue.

2. Overview of Ergonomics

Ergonomics, also known as human factors engineering, ergonomics, etc., was developed around the 1950s and is a basic applied discipline with strong cross-cutting. Scientific experimental research is an important feature of this discipline [4]. In the process of driving, the ship officer receives various information inside and outside the car, and the central nervous system reacts to direct the hands and feet and other executive organs to operate the car safely. Ergonomics is an interdisciplinary subject involving biological science, behavioral science, physics, mathematics, various engineering technologies, medicine, electronics and other sciences. For example, noise control is a multi-disciplinary problem: the human-machine-environment system is studied as a

unified whole to create mechanical equipment and operating environment suitable for human operation, so that the human-machine-environment system can be coordinated to obtain the highest comprehensive efficiency of the system. The aim is to study how to make the designed mechanical equipment system, man-machine system or man-machine environment system fit for the morphological, physiological and psychological characteristics of human beings to the greatest extent, so as to achieve the goal of safe, comfortable and efficient production and work. From the perspective of man-machine-environment system, the research content of ergonomics is mainly the seven aspects described in Figure 1 [5].

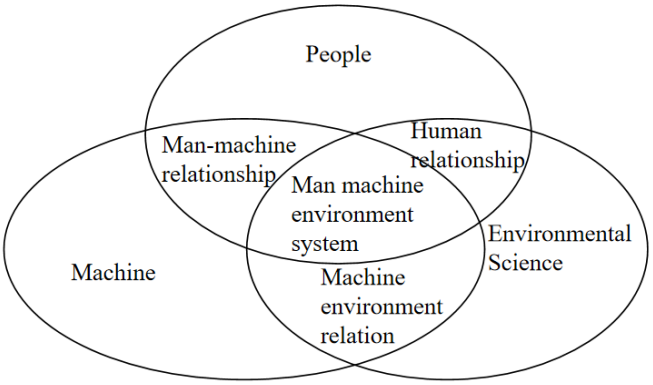

Fig.1 Human-Machine-Environment Relationship

3. Fatigue and Maritime Safety

3.1 Fatigue and Its Characteristics

Under normal circumstances, fatigue is a normal physiological activity and a kind of self-protection of the human body. As fatigue may weaken almost all physiological capabilities of human body, there are great potential safety hazards in working under fatigue state, and the higher the fatigue level, the greater the potential safety hazards. During fatigue, various physiological indexes and behavioral abilities of the human body have negative effects to varying degrees, and such effects tend to rise with the increase of fatigue severity. The crew is not only responsible for the operation control of the ship's deck, but also responsible for a series of work such as custody, cabin inspection, and making the ship's navigation plan. Many crew members do not get a good rest and need to be on duty continuously. Mild fatigue is a normal reaction that occurs after the human body carries out daily work and is within the range of human body. Severe fatigue is beyond the human body's tolerance range and usually cannot be completely eliminated during normal rest periods. It cannot be eliminated within a rotation period, and there is still residual fatigue at the beginning of the new work period, thus posing a greater threat to safety work [6]. The ship's work is very detailed. It has to deal with many tasks such as maritime handling, dock duty, navigation repair, catering, warehouse cleaning, cargo binding, etc. It also has to deal with some inspections, such as port state inspections, etc. The rest time of the crew is often interrupted by temporary work, causing the ship officer's workload to increase suddenly and causing fatigue.

3.2 Relationship between Fatigue of Ship Officer and Maritime Safety

During the navigation of the ship, the ship officer first obtains relevant information from the internal and external environment through various senses, then judges the information, screens out the information affecting the safe navigation of the ship and synthesizes the information so as to make a safe navigation decision. finally, the ship officer operates the ship and checks the effectiveness of the operation to achieve the purpose of safe navigation. this process can be simplified as the model shown in fig. 2 [7]. Literature [8] shows that more than 55% of the human factors causing maritime accidents are fatigue of seafarers. According to statistics in document [9], the factor of “crew fatigue” accounts for 13% of the total human factors in shipwreck collisions and 16% of the key human factors in shipwreck collisions.

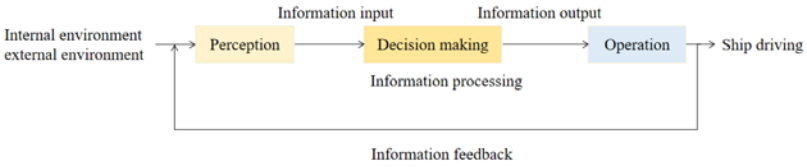

Fig.2 Simplified Model of Ship Driving Process

During the voyage of the ship, the crew must always pay attention to the situation reflected in each link inside and outside the ship, and in the process of their own sensory judgment, they must carry out comprehensive and highly optimized treatment according to the relevant experience and professional skills they have mastered. Especially when the ship encounters severe weather, such as dense fog or heavy wind and waves, the captain must always be in charge of the ship's navigation supervision at the bridge. Only after severe weather can the ship rest and sleep is seriously insufficient. For ship officer, fatigue during sailing duty may easily lead to loss of self-control, neglect of observation, unclear thinking, inflexible and maladjusted actions, misjudgment, deterioration of ship handling quality, difficulty in normal performance of good ship skills, etc., and even cause accidents due to slow response speed for collision avoidance.

4. Analysis of Fatigue Causes of Ship Officer

4.1 Lack of Sleep and Rest

Under normal circumstances, ship officer generally go through three stages in each working cycle (work+rest): fatigue rising stage, fatigue stabilizing stage and fatigue recovery stage. In general, the crew can rely on more abundant rest and sleep to completely eliminate fatigue. In the process of human development, a regular biological clock will be formed to regulate various skills of the human body, and it will continuously cycle back and forth. In some periods of time, the human spirit will be clearer and more energetic. If you don't get enough sleep or rest, the ship's pilots will enter the next working cycle with fatigue, and the fatigue degree will accumulate rapidly on this basis, and the time required for fatigue to return to zero will be longer, even requiring public rest and recuperation, and chronic fatigue may form over time. The physiological and psychological phenomena reflected are the weakening of the function or reaction ability of cells, tissues or organs caused by the over-stimulation of human body. In some periods of time, the human body's energy is in a state of decline and it is relatively tired. In the crew's duty schedule, the duty hours of the chief officer and the second officer are at the low ebb of the biological clock, and the human body functions are in a state of fatigue and poverty, increasing the probability of accidents.

4.2 Working Hours and Workload

Fatigue increases with the increase of working time and workload. Fatigue increases significantly when working continuously for more than a certain period of time (usually 3 ~ 4 h), especially when the workload is large. Fatigue can grow very rapidly, and when the workload and pressure increase, the growth is even more obvious. Crew members, especially the first crew members who set sail on the ship, often suffer from more fatigue due to a longer working front and more work responsibilities.

Stratified sampling and simple random sampling are combined. Based on the accumulated driving time of the day, stratified sampling is conducted in three groups of 0-4, 4-8 and 8-12 hours. Then 25 ship officer are randomly selected from each group. In the experiment, 95% confidence level is taken, and among the four indexes, the minimum allowable error is 0.05, so the D value is 0.05. The minimum sample size for this experiment is estimated as shown in Table 1.

The crew members are far away from their relatives, work on ships for a long time, and wander around. The crew members are a small social group composed of more than a dozen people. Life is monotonous and boring. As time passes, you will feel extremely lonely. Some ships carry out a continuous duty or watch system when they are in port. When the ship sails immediately after

loading and unloading the cargo, it will make the pilot work continuously or even continuously. During the rescue process, due to the influence and limitation of external conditions, the crew were basically in a state of tension, high load and long working hours. In a narrow and closed space, the pressure will be continuously amplified, resulting in loss and fatigue of the crew.

Table 1 Sample Content Calculation Results

	Speed perception difference	Reaction time	Pay attention to the allocation value	Number of correct operations
Standard deviation	0.451	0.092	0.053	10
Absolute allowable error	0.3	0.03	0.02	5
Minimum sample size	25	22	20	18

4.3 Pressure

Stress may be caused by a variety of reasons, including personal and family problems, complex environment, interpersonal relationships on board, etc. Research shows that stress is closely related to work efficiency and fatigue [10]. As for the crew, because they often go to sea and have less contact with their families, the problems that may arise such as incomprehension lead to psychological hidden dangers for the crew. If the degree of automation of the ship is low, many jobs will require the hands of the crew, and the pressure on the crew will be greater. The longer you stay on board, the greater the pressure, and the more frustrated and tired the crew will feel, even losing their enthusiasm for work. The pressure accumulated in the face of the problem causes the crew to sleep poorly, feel uncomfortable and feel restless. It is necessary to explain that some studies believe that when the pressure is too low, ship officer will become sluggish or doze off because monotonous work is not challenging, thus obtaining a U-shaped curve of fatigue changing with pressure [13]. When the pressure is too low, the crew will be mentally retarded due to the lack of certain challenges in their work, which will lead to distraction and even drowsiness. This phenomenon is not directly caused by fatigue itself, and it can quickly return to the normal state.

4.4 Biological Clock and Schedule

Everyone has his own biological clock, thus controlling his own sleep, wakefulness and other physiological rhythms, and everyone's work and rest rules affect his own biological clock. Most people have similar schedules and have formed similar biological clocks. In general, people of the same culture in the same area have more concentrated work and rest rules, so their biological clocks are also relatively close. Therefore, ship officer must constantly change their biological clocks to adapt to these irregularities. However, such long-term irregular changes are extremely prone to fatigue. When the human body works and rests according to this rule, the two will be synchronized: on the one hand, the physiological indexes and sensory functions of the human body at work will be improved; On the other hand, it is to optimize the rest and sleep quality of the human body. If the two do not synchronize or reverse (i.e. sleep in the physiological peak area and work in the physiological valley area), the two will resist each other, resulting in decreased alertness at work, poor sleep quality and impaired circadian rhythm. At this time, the body's energy decreases and drowsiness increases.

4.5 Other Factors

In addition to the above-mentioned important factors, the factors causing fatigue of ship officer include age, family and emotion, interpersonal relationship, adaptability, drug use, ship noise, vibration, internal and external environment and other factors. Relevant personnel should classify and define the types and degrees of fatigue according to the actual conditions of the crew, so as to formulate a more reasonable solution.

5. Measures to Prevent and Control Fatigue of Ship Officer

According to the previous analysis, it can be seen that for physiological fatigue, the best countermeasure is to enhance the rest time and sleep quality of the crew. Among them, for this, should basically do the following three points.

5.1 Reasonable Duration

Due to the working environment and characteristics of the ship, it is often difficult to meet the crew's requirements for adequate sleep. Lack of adequate sleep or low sleep quality is a common problem in the crew industry. An investigation report on sleep shows that at present, the sailors sleep 6.6h hours at sea, and the sleep continuity is poor. The average sleeping time of the personnel on duty is less than 5 hours. Because everyone needs different sleep time in 24 hours, the crew should choose as reasonable a time period as possible to sleep or rest according to their actual needs.

5.1.1 High Quality Sleep

The so-called high-quality sleep refers to “deep sleep”, that is, sleep time that conforms to the characteristics of one's biological clock and its low tide period. By taking a rest during this period of time, you can often get twice the result with half the effort. The labor intensity felt by the ship's pilots is directly related to the complexity of the waters in which the ship navigates. High quality sleep. That is, deep sleep, usually can only be achieved in synchronization with one's biological clock.

5.1.2 Better Continuous Sleep

That is, it can ensure a long period of sleep without interruption in the middle. For the crew who cannot guarantee good sleep quality for the time being, if the sleep time can be increased, it can also play a certain role in buffering the fatigue originally accumulated. Studies have shown that the amount of sleep that can have damaging effects on the working ability of the human body is 4±0.5h, and this effect does not change greatly with the arrangement of sleep time (e.g. noon, afternoon or evening). Good continuity. That is, sleep cannot be interrupted.

5.2 Ship Management

For psychological fatigue and pathological fatigue, crew members need public rest recuperation to relieve them. This requires cooperation in a broad direction. To improve the living environment on board the ship and provide guarantee for the crew to have a good sleep. A good working environment can keep the crew in a cheerful mood, which is of great help to relieve mental fatigue and reduce mental stress. When a ship encounters complicated traffic conditions while sailing at sea, such as sailing in the sea area where fishing boats are highly concentrated or near ports where ships frequently come and go, narrow waterways and harbors, the ship's pilot must pay close attention, observe the adjacent dangers, and deal with changes in the natural environment of navigation for a long time. To improve the living standard and living environment on board, a good working and living environment can make the crew feel relaxed and happy, thus better reducing the degree of psychological fatigue and psychological pressure. Moderate and beneficial recreational activities can help the crew relax physically and mentally, relieve their working pressure and homesickness, and enrich their monotonous and boring work. However, attention should be paid to the selection of positive and healthy recreational methods, such as ball games, chess and card activities, etc. Gambling and other activities that may have strong physical and mental stimulation are strictly prohibited.

5.3 Personal Aspect of Crew

Cultivate a good work and rest rule, determine the work and rest rule according to its own biological clock characteristics, and fix it as much as possible. When sleep is affected by exceptional reasons, strategic nap (no more than 20 min) is a good choice. Eat reasonably, exercise regularly and keep healthy. Good health and physical fitness are the basis for resisting fatigue.

Active self-regulation and positive emotions should be maintained. Crew members should have a certain understanding of fatigue classification and influencing factors. When fatigue occurs, they can take different measures to suit the remedy according to their classification. When you feel tired, you should take time to rest or relax properly. Use communication or recreational activities to relax physical and mental fatigue, maintain a pleasant mood and prevent fatigue accumulation.

6. Conclusion

This paper focuses on the ergonomic analysis of driving fatigue mechanism from the perspective of ergonomics. Organizing ergonomics experiments; Crew fatigue is an important cause of maritime accidents and is also affecting the health of crew. Information from various sources shows that crew fatigue has become a major threat to maritime traffic safety. However, we do not have a scientific, reasonable and accurate method to measure crew fatigue. It is against this background that this article explores the problem of crew fatigue. I hope this exploration can provide basis for judging crew fatigue. Therefore, various aspects of the shipping industry should give enthusiastic attention and appropriate assistance to ensure the safety of maritime transportation and the security of crew's occupation.

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