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ORIGINAL ARTICLE

Assessment of Noise Exposure in Operator Cultivator Tiller

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ABSTRACT

Tiller is a hand-tractor is used in Agriculture. The noise emitted from Tiller may affect auditory system of operators seriously. The purpose of this study was to evaluate the noise exposure in operators of this device. In this study, 36 cultivator tillers were examined. Measurement of sound was conducted in different mode using sound level meter model of cell 450 based on ISO 7216 standards. Assessment of noise exposure was performed in state that tiller was in its maximum of working power, but, frequency analysis and determining of dominant frequency was performed in state that Tiller was in the middle of its working power. In the present study, experiments were conducted in three operational conditions i.e. static and neutral mode (idling), land plowing with gear 1 and land plowing with gear 2. Results of this study showed that 8-hour exposure level with noise in 3 different modes is 90, 94.73 and 95.17 dB respectively, which is more than standard. Results of Frequency analysis indicated that in each 3 modes, frequency 2000 was dominant frequency. In addition, the maximum level of exposure was in this frequency. Exposure to noise at frequency of 2000 in neutral mode, land plowing with gear1and gear 2 was respectively 81.30, 86.97, and 88.11 dB. In all measured situations, exposure to noise was higher than the standard limit and there was risk of hearing loss. Thus, further studies and control measures are necessary.

KEYWORDS: *Tiller, Noise, Hand tractor, Sound pressure level*

INTRODUCTION

Today, large part of workers is working in the agricultural sector. According to data of Statistical Center of Iran, about 20.04 percent of workers in Iran are working in agricultural sector [1-2].

Tillers are small and relatively inexpensive devices and allowed farmers to tillage between the trees in addition to the flat land. Therefore, its use has been expanded so much that today there are more than 120,000 Tiller in Iran [3-4]. Although this device is efficient for tillage, but due to the mechanical structure and openness of its engine, it produces a lot of noise. Farmers are exposed to health and safety risks such as unwanted sound Due to increasing use of agricultural machinery [5-6].

Human exposure to noise can lead to well-known effects and complications including: temporary and permanent hearing loss, neurological and psychiatric disorders, reducing efficiency and increase of hazards [6-7] also noise has indirect effects on human performance, including efficiency and productivity reduction, increase risk of accidents due to lower focusing [8]. WHO estimates that 278 million people in the world have hearing loss from moderate to severe [9]. Sixteen percent of hearing loss is occupational kind and induced by noise in the workplace [10].

Sound of Tiller with 13-hp power at engine speed of 2200 rpm in various gear and asphalt and soil rural road was more than 92dB (A) [11]. Fifty six percent of studied tractor drivers have hearing loss more than 20 dB (A) in the range of 3 to 6 kHz frequency compared to the control group of the same age [12]. Noise pressure level for tractor driver without or with cabin was higher than the standard level and in some cases was much higher than 90 dB (A) [13]. The majority of modern tractors, generate noise level higher than 90 dB (A) While other farm machinery such as self-

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powered combine, corn Chinese machine and hammer mill generate noise levels higher than 100 dB (A) [14]. The sound pressure levels measured in some agricultural equipment, including tractors was exceeded of 100 dB [15].

The study that was done by National Institute for Occupational Safety and Health (NIOSH) about noise level in agricultural machines showed that sound level of this equipment were 91 and 97 decibels [16].While threshold limit value of occupational exposure to noise in Iran, as suggested by the American Conference of Industrial Hygienists are 85dB (A) for 8 hours of work [17-18].

The aim of this study was to investigate level of a sound tillers in different working states.

MATERIALS AND METHODS

In this descriptive- analytical study, the research community was cultivators Tiller operators in Neyshabur City in 2014. For evaluation the noise exposure, 36 tillers were chosen of most common model type that used in the city of Neyshabur. Noise measurement was conducted based on standard of ISO 7216 by using of sound level meter of models 450 CEL made in England. We used from CEL-2.110 to calibrate the sound level meter following manufacturer's instructions.

To evaluate the exposure to noise, measurement was performed in a state that Tiller was working in its maximum of working power. However, to frequency analyze and determines the dominant frequency of noise emitted from Tiller, measurement was done in a state that Tiller was in the middle of its working power.

Based on ISO 7216 standard, to assess exposure to noise, microphone sound meter was placed in height at region of hearing and at distance 25 cm of operator's ear and measurements was done in network A and response time was SLOW. Location characteristics of measurement were selected based on standards of International Organization for Standardization [19]. Reflective surface such as buildings, other cars and trees were in the distance of at least 15 meters from tested Tiller or microphone. When measuring, wind speed was less than 5 m/s and environment sound level was controlled to be less than 10 dB.

Because threshold limit value of noise exposure is presented as 8-hour exposure levels, for comparing the workers' exposure to threshold limit value, measured sound level was converted to 8-hours exposure levels using the Equation 1:

(Equation 1)

$$L_{eq} = 10\ log\left[\frac{1}{T}\sum_{i=1}^{n} t_i 10^{LP_i/10}\right]$$

Finally data were analyzed by SPSS software.

Measurement of noise exposure conducted in three modes:

1. When Tiller was in idle mode (neutral position).
2. Land plowing with gear 1
3. Land plowing with Gears 2

RESULTS

Measurement results of noise exposure in tiller operators in various network is showed in Table 1.

Table 1. Measurement results of noise exposure in Tiller users on different networks (dB)

Gear	8-hour equivalent sound level (dB)	Network measurement	Minimum (dB)	Maximum (dB)	8 hours -Threshold limit value
Neutral gear	90.00	Network A(LA)	82.70	98.3	85
	88.77	Network B(LB)	84.00	96.4	85
	86.06	Network C(LC)	76.10	94.1	85
Gear 1	94.73	Network A(LA)	84.80	103.7	85
	93.46	Network B(LB)	83.80	103.0	85
	78.10	Network C(LC)	78.10	103.0	85
Gear 2	95.17	Network A(LA)	87.90	102.9	85
	94.21	Network B(LB)	94.21	102.3	85
	82.16	Network C(LC)	82.16	101.4	85

According to the results of Table 1, average of operator tiller exposure in network A for state that Tiller work idilling (Neutral gear mode) and plowing the land with gear 1 and gear 2 was equal to 90, 94.73 and 95.17 dB respectively. By increasing the gear, the exposure noise level was increased. Minimum and maximum exposure on the network A in Neutral gear was 82.70 and 98.3 dB, in plowing the land with gear 2 was 84.8 and 103.7 and in plowing the land with gear 2 was 87.90 and 102.9 dB respectively. Noise level is measured also in the network of C & Z. Results of peak level in Network A are shown in Table 2.

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Table 2. Measurement results of noise exposure in Tiller users (peak noise)

Gear	Peak noise level	Network measurement	Minimum (dB)	Maximum (dB)	
Neutral gear	103.88	Network A(LA)	88.5	114.6	**S-TLV=115**
Gear 1	109.44	Network A(LA)	93.3	134.4	
Gear 2	109.97	Network A(LA)	99.2	119.4	

The peak level for different states of neutral gear and plowing the land with gear 1 and gear 2 was obtained 103.88, 109.94 and 109.97dB respectively. Sound frequencies analysis results at frequencies of 125, 250, 500, 1000, 2000, 4000, and 8000 are shown in Figures 1, 2, and 3.

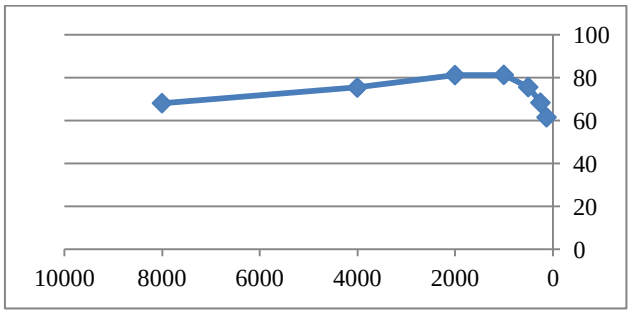

Fig.1. Sound analysis results at different frequencies in neutral gear state

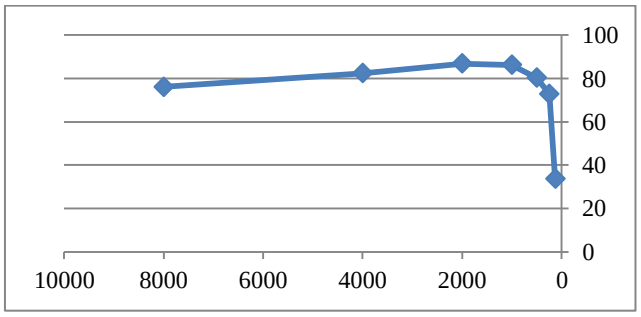

Fig.2. Sound analysis results at different frequencies in state of plowing the land with gear1

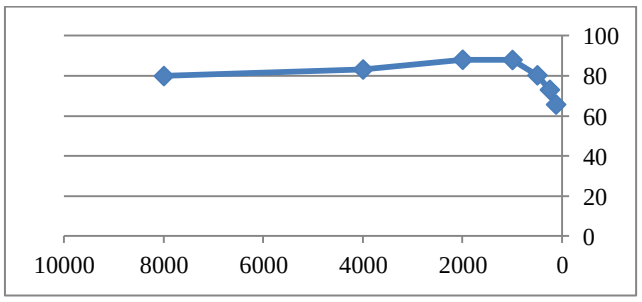

Fig.3. Sound analysis results at different frequencies in state of plowing the land with gear 2

According to Figure 1, in neutral gear highest noise level was at frequencies 1000 and 2000 Hz (81.4 dB.) In plowing the land with gear1, the highest level of exposure to noise was at frequency of 2000 and was equal to 86.97 dB. In addition, the highest sound level in plowing the land with gear 2 was in 2000 HZ with 88.11 and in 1000 frequency with 87.99 dB.

DISCUSSION

The results suggest that operators tiller exposure to noise in all modes (neutral gear, land plowing with gear 1 and gear 2) exceeded of standard and this level was increased with increasing of gear upward. This confirms a previous result [3]. The sensitivity of human ear to sound depends on frequency, so that at some frequencies are more sensitivity. Ear is most sensitive to frequencies 2000 to 5000 Hz particularly in 4000 Hz [20-21]. In frequency of 4000 sound pressure level in neutral gear, land plowing with gear 1 and gear 2 was 75.48, 82.46

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and 83.23 respectively, which is less than the standard level. But in frequencies of 1000 and 2000, sound level in state of plowing the land with gear 1 is respectively 86.308 and 87.994 dB, and in plowing the land with gear2 is 86.308 and 88.113 dB respectively, of which are exceeded the standard values.

Sound level is increased with increase in engine speed [21-22]. According to the results of this study, there are risks of complications and noise-induced hearing diseases in operators tiller. Therefore, you must first apply the sound control on the device and then if it does not reduce the sound operators must use the appropriate earmuff and earplug.

Engine is the main source of vibration in Tiller [23]. Regarding the relationship between vibration and noise of engine, it is probably that the main source of noise in Tiller is its engine too. Since the tiller engine is single cylinder, its balance is not good. The forces that arise during the compression and power by pistons hit several blows in chassis that reason this hits is do not use of vibration damper. These blows moved to the chassis and then to Tiller handle and entered much vibration to hands and arms of operators [24]. Tiller has a single-cylinder diesel engine that has less balance than the multi-cylinder engines.

It seems, manufacturers are regardless about vibration isolation systems in the engine to handle and safety systems, due to cost reduction, speed up the construction and mass reduction in tillers and also for simplifying machine and make it in small Size. Considering that noise level at frequencies, 1000 and 2000 were more than those other frequencies, it should pay more attention to control the sound in this frequency. In this regard, it can be used sound absorber in body of tillers, which has most absorption in this frequency. Exhaust storage (silencer) by creating pressure drop, friction and change in the direction of fluid flow, dissipates total fluid energy and reduce noise intensity. Exhaust storage that have duty to reducing the sound level in exhaust process, is located in the exhaust path. Exhaust storage or sound mufflers are including holes, channels, and chambers in which gases passed of them and amortized hit of gases pressure entered the exhaust, which can occur when opening the exhaust valves [25]. Inappropriate design of silencer in Tiller engine reduces its efficiency greatly. This study proposes carry out scientific studies based on scientific principles to design silencer.

Considering the extent of use of these devices, must be implemented preventive maintenance regular program about this equipment and effective hearing conservation program including audiometric tests, hearing protective equipment and occupational health training for operators Tiller by health authorities in collaboration with the departments of agriculture in areas covered.

CONCLUSION

Tiller operators are exposed to excessive noise and hearing loss of it in all working states, thus engineering measures is necessary to control noise emitted from tillers at source. In all modes, frequency of 2000 was as dominant frequency.

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